ASSESSMENT OF NUTRITIONAL RICKETS AMONG ACUTE MALNOURISHED CHILDREN 6-59 MONTHS IN MBAGATHI HOSPITAL, NAIROBI, KENYA.

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DECLARATION OF ORIGINALITY

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DEDICATION

This dissertation is dedicated to the memory of my beloved mother, Diana Wangeci Kamau and to my late grandfather Charles Kamau Njurumi who single handedly brought me up.

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LIST OF ABBREVIATIONS/ACRONYMS

AM	Acute Malnutrition
BMI	Body Mass Index
ENA	Emergency Nutrition Assessment
FFQ	Food Frequency Questionnaire
FGD	Focus group Discussion
GAM	Global Acute Malnutrition
IMAM	Integrated Management of Acute Malnutrition
KII	Key Informant Interview
KNH	Kenyatta National Referral Hospital
MAM	Moderate Acute Malnutrition
MCH	Maternal and Child Health
MIYCN	Maternal Infant and Young Child Nutrition
MUAC	Mid Upper Arm Circumference
NR	Nutritional Rickets
POPC	Paediatric Out-Patient Clinic
RTA	Renal Tubular Acidosis
RTI	Respiratory tract infections
RUSF	Ready to use supplementary food
RUTF	Ready to use therapeutic food
SAM	Severe Acute Malnutrition
SMART	Standardised Monitoring and Assessment of Relief and Transition
SPSS	Statistical package for social sciences
VDD	Vitamin D Deficiency
UNICEF	United Nations Children's Fund
WHZ	Weight for Height Z-score
25(OH)D	25-hydroxyvitamin D
WHO	World Health Organisation

DEFINITION OF TERMS

Acute Malnutrition: In this study, it was the main inclusion criteria and referred to wasting due to recent disease, inadequate food intake or both. It was defined by a mid-upper arm circumference (MUAC) of less than 12.5cm and/or a weight for height/length standard deviation (SD) score of less than negative 2 and/or bilateral pitting oedema. It was categorised into:

Moderate acute malnutrition (MAM): This was defined by a weight-for-height z score of greater than or equal to negative three to less than negative two of the international standards or by a mid-upper arm circumference of 11.5cm to 12.4 cm.

Severe acute malnutrition (SAM): It was defined by a weight-for-height z score of less than negative three, MUAC of less than 11.5cm and/or bilateral pitting oedema.

Anthropometric measurements: In this study, it was defined as body measurements that were used to assess the nutritional status of children. It included MUAC, oedema, weight and height or length.

Birth weight: It was defined as the first weight of a child atbirth. Children born below 2500grams are considered low birth weight.

Gestational length: In this study, it was defined as how far along the pregnancy a foetus was at birth. Gestational length is measured in weeks, from the first day of the woman's last menstrual cycle to the current date. A normal pregnancy can range from 38 to 42 weeks. Infants born before 37 weeks are considered premature or preterm.

Height for age: This was defined as the height of a child in reference to the age. Height for age is an indicator of chronic nutrition status or stunting and is often used for long-term planning of policies and intervention programs in non- emergency situations.

Mid upper arm circumference (MUAC): In this study, it was defined as the diameter of the left upper arm, measured at the mid-point between the tip of the shoulder(acromion) and the tip of the elbow (olecranon). It is a good predictor of mortality for children between six and fifty-nine months of age.

Nutritional rickets (NR): also referred to as osteomalacia. It is a condition caused by vitamin D deficiency. In this study, rickets was defined as positive biochemical results of alkaline phosphatase (ALP) more than 400 IU/500IU/L, calcium less than 2 mmol/L, phosphate less than 1.45 mmol/L, 25 hydroxyvitamin D (OH) D level is below 20 ng/ mL) and/or the presence of radiological changes of cupping or fraying and/ or metaphyseal thickening.

Skin colour: It referred to the colouring of a person's body which ranges from the darkest brown to the lightest hues. In this study, it was defined based on the child's race and was categorised into three: black, white and brown.

Weight for height/length: It referred to the weight of a child at a specific length/height. It was used as an indicator of current nutritional status/wasting.

Weight for Age: It was defined as the body mass relative to chronological age which is influenced by both the height (height-for-age) and weight (weight-for-height) of the child. It was used a measure of underweight.

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ABSTRACT

Introduction: Globally, in the years between 1940 and 1970 nutritional rickets had been phased out following the discovery of vitamin D from ultra violet sun rays and with increased vitamin D food fortification practices. It was also considered rare in cases of acute malnutrition as it is a disease related to growth. However, in the 2000s, there has been a resurgence globally, with cases of rickets being reported among both chronic and acutely malnourished children. The resurgence has mainly been observed among children in urban areas as a result of minimal sunlight exposure, air pollution and other confounding dietary and maternal factors.

Aim: This study sought to assess the burden of nutritional rickets among acutely malnourished children aged 6 to 59 months at Mbagathi hospital in Nairobi and to explore associated maternal, child and health system risk factors.

Materials and Methodology: This was an analytical cross-sectional study targeting acute malnourished children 6-59 months. It was carried out at Mbagathi Hospital which is a referral hospital in Nairobi County, mainly serving households from the urban poor and middle class. Simple random sampling was used to select the study participants. The study utilized mixed methods to collect quantitative and qualitative data on child and maternal characteristics, knowledge, attitude and practices and; infant and young feeding practices were collected through the Kobo toolbox ODK platform. Nutritional rickets was defined as positive biochemical results of alkaline phosphatase (ALP) more than 400 IU/500IU/L, calcium less than 2 mmol/L, phosphate less than 1.45 mmol/L, 25 hydroxyvitamin D (OH) D level is below 20 ng/ mL) and/or the presence of radiological changes of cupping or fraying and/ or metaphyseal thickening. Data collection methods included interviews with the caregivers and health care providers, focus group discussions

with select caregivers and a review of the policy guidelines used in the management of acute malnutrition in Kenya. Data analysis was conducted using SPSS version 23, ENA for Standardized Monitoring and Assessment of Relief Transitions software and excel. Qualitative data was analyzed through theme categorization excel.

Results: A total of 362 children 6 to 59 months were enrolled in this study. However, only 352 questionnaires were used in analysis. The proportion of acute malnourished children with nutritional rickets was 53.7%, 56.6% of which were not enrolled in nutritional rehabilitation programmes. The odds of testing positive for nutritional rickets reduced if the sex of the child was female, the child was still breastfeeding, had consumed infant formula and, consumed blue band/margarine in the past 7 days at 0.6, 0.6, 0.2 and 0.4 times respectively holding all other predictor variables constant. The odds of testing positive for nutritional rickets increased 4.1, 1.9, 1.6 and 1.9 times if the child was mainly taken care of by another person who was not the mother, the mother had not heard about vitamin D, the child was not supplemented with calcium or the child was exposed to less than one hours daily respectively for each predictor holding all other predictor variables constant. The proportion of children with severe acute malnutrition, stunting and underweight among the rickets cases were at 47.1%, 34.9% and 69.3% respectively.

Conclusions: More than half of the acute malnourished children enrolled in this study had a positive rickets test result. However, the cases are missed out as clinical assessment is not done at admission and follow up due to lack of a clinician based at the nutrition clinic; and the registration fees required before receiving services at the Pediatric outpatient clinic. Continued breastfeeding, consumption of infant formula, consumption of blue band/ margarine in the 7 days preceding the interview, knowledge on vitamin D, main household breadwinner and main caregiver during the day were found to be associated with nutritional rickets. Increasing population in Nairobi County

has led to congestion of both storey and non storey houses due to limited space. This has in turn led to low penetration of sunshine in houses. Further, high cost of living has led to caregivers being required to work all day to fend for the family which affects child care practices for instance not having time to sit out with their children and dietary diversity among others. Among acute malnourished children, there are many missed opportunities in prevention and early diagnosis of nutritional rickets at the community and nutrition clinics level. Therefore, there needs to be more deliberate effort to address nutritional rickets in children.

Policy and Practice Recommendations: There is need to improve prevention of nutritional rickets through health education and; active screening and treatment for nutritional rickets at both the community and facility level. Further, there is need to make medical assessment for acute malnourished children admitted in nutrition programs free and mandatory. This could be achieved by having a registration fee wavering system for all management of acute malnutrition beneficiaries in all the clinics and hospitals. Nutritional rickets screening and other growth disorders should be captured in the IMAM guidelines to ensure holistic treatment for beneficiaries.

CHAPTER 1: INTRODUCTION

1.1. Background

Nutritional rickets (NR) is a type of metabolic bone disease resulting from vitamin D, phosphate or calcium deficiency or a combination of both calcium and vitamin D deficiencies (El-Hajj Fuleihan, 2009). Globally, nutritional rickets remains the most prevalent form of growing bone disease and a major pediatric disease in both developed and developing countries (Bishop, 2006; Fischer, Thacher, & Pettifor, 2008) (WHO, 2019a). In the periods between 1920 and 1930 the prevalence of nutritional rickets was reported to be 75-98% in Europe. However, with vitamin D supplementation programs the rates reduced significantly.

In the last 10 to 20 years, there has been a resurgence of nutritional rickets both in the developed and developing countries. In the United States of America (USA), the rate of nutritional rickets in 1970 was 0 per 100,000 while in the 2000s the rate increased to 24 per 100, 000 (Shelke et al., 2012). Furthermore, hospital studies conducted in England documented increased rates of nutritional rickets in the 2000s (Goldacre et al., 2014). In developing countries, prevalence rates of up to 10–70% among children and adolescents have been reported (Prentice, 2013). In Africa, nutritional rickets is reported to occur mainly in settings where uptake of calcium rich foods is inadequate. This is as a result of minimal consumption of dairy products and consumption of foods rich in substances that bind calcium reducing its bioavailability such as tannins in tea, phytic acid found in grains, saturated fat in palm oil and oxalates from green leaves (Pettifor, 2006). However, other studies indicate that nutritional rickets especially in children less than 18 months old in North African countries is primarily occasioned by vitamin D deficiency. In Nigeria and South Africa, rickets in children less than 2 years has been attributed to deficits in calcium intake (Pettifor, 2006).

Kenya is one of the countries experiencing a surge in cases of nutritional rickets. In a study carried out in Embu County to assess nutritional rickets in preschool children, 28 cases of rickets (8.6% of the total sample) were reported in 2013 compared to zero cases reported in a similar study in 2000 (Bwibo et al., 2013). According to a research study carried out by the Kenya Medical Research Institute (KEMRI) in 2017 in Kenya to assess the prevalence of rickets through secondary data analysis of data from a multi-hospital clinical network in three regions (Nairobi, western and central region), Nairobi County had the highest cases with a proportion of 4.0%, central region had a proportion of 0.9%. The prevalence in western region was found to be lower with only one case of rickets diagnosed out of the 9,756 admissions (Karuri et al., 2018).

Nutritional rickets in children under 5 years results from a combination of various factors which include; maternal vitamin D and calcium intake when pregnant and lactating; child feeding practices: exclusive breastfeeding, child vitamin D and calcium intake and lacking vitamin D supplementation; behavioral and customary practices: inadequate sunlight exposure for young children (due to traditional practices of clothing children while covering most body parts except hands and the face) or dark colored skin; gastrointestinal disease preventing absorption of calcium, phosphate and/or vitamin D and prematurity (Edwards, Thiongó, Bergh, et al., 2014). However, these factors which have been attributed to rising incidence of nutritional rickets vary across the globe. It is worth noting that vitamin D deficiency associated rickets normally presents between 6 months to 2 years of age while calcium deficiency related nutritional rickets normally occurs in children who are older when breastfeeding stops (WHO, 2019b). Rickets has devastating effects such as stunted growth, bone pain, muscle weakness, dental anomalies, restlessness and poor sleep among others (Tezer et al., 2009).

Nutritional rickets was previously reported infrequently in cases of malnutrition as it is a disease of growth. However, in the last decade it has been reported to be a common condition in malnourished children (Ngari et al., 2018) in both acute and chronic malnutrition resulting in increased lengths of hospital stay for both malnourished children. Growth failure in acute malnourished children affects all tissues including the bones. This impairs bone mineralization predisposing affected children to diseases such as rickets (Chowdhury, 2015). In a study carried out in Kenya, rickets was found to be common among complicated severe acute malnutrition cases mainly residing in urban sites, and was associated with higher mortality risk (Ngari et al., 2018).

Acute malnutrition (AM) remains a significant public health concern which mainly affects people in low and middle income countries (LMICs)(Kimani & Sharif, 2009). Various interventions have been implemented to prevent and treat acute malnutrition, including supplementation of affected children with fortified foods at health facilities in Kenya. Rates of child malnutrition in Kenya remain high with a national global acute malnutrition (GAM) rate of 6% (Of, 2009). Nairobi County has a GAM rate of 3.9% according to a SMART survey carried out in February 2020 by Concern Worldwide (*NAIROBI COUNTY SMART SURVEY REPORT*, 2020).

This study sought to explore the burden of rickets among acute malnourished children aged 6 to 59 months receiving services at Mbagathi hospital in Nairobi, and to explore associated risk factors ranging from child, maternal and health system related factors.

1.2. Problem statement

Nutritional rickets had been phased out globally following the discovery of vitamin D from ultra violet sun rays and also with the fortification of foods with vitamin D (Prentice, 2013). Since it is a disease related to growth, rickets was also considered infrequent in cases of acute malnutrition. In the recent years however, there has been a resurgence of rickets cases mainly in urban cities as a result of minimal sunlight exposure, air pollution and other confounding dietary and maternal factors. It has also been reported to be a common condition in malnourished children (Ngari et al., 2018).

Kenya is one of the countries that is experiencing increasing trends in rickets. In a study carried out at Kenyatta National Hospital (KNH) to investigate predisposing factors of rickets in infants and children less than five years admitted in the facility, the prevalence of rickets in premature infants was reported to be 60% (John & Nairobi,2009 n.d.). In a systematic review conducted out by KEMRI, the estimated prevalence of nutritional rickets in Nairobi was reported to be 4.0 % compared to 0.9% in Central Kenya and 0.0% (1 out of 9756 total admissions) in western region (Karuri et al., 2018). It is worth noting that a prevalence of nutritional rickets above 1% warrants public health action (Roth et al., 2018).

Childhood acute malnutrition is among the top five causes of under-five mortality both in developed and developing countries and a major public health concern globally (Bourke et al., 2016).Chronic and acute malnutrition have been reported to be common in children with rickets and vice versa. In a study carried out in Karachi, Pakistan to investigate the prevalence of stunting and micronutrient deficiencies in children under 5 in a tertiary care hospital, 44% of the stunted children and 33% severe acute malnourished children were reported to have coexisting rickets

(Rahman et al., 2016). A vitamin D deficiency prevalence of 30.6% was reported in malnourished children in a tertiary care center of a national hospital (Walli et al., 2017). In Kenya, 39.0% of rachitic children, less than 5 years were found to have a mid-upper arm circumference (MUAC) of less than 12.5cm in a study carried out in Kibera slums (Ngari et al., 2018). Rachitic children have a low immunity and are prone to upper respiratory tract infections (Haider et al., 2010). Rickets in Kenya is mainly attributed to vitamin D deficiency affecting both calcium and phosphorus absorption (Ngari et al., 2018).

While there have been studies that have explored prevalence of rickets in children under five and others assessing the effect it has on growth and morbidity of recovering children with complicated severe acute malnutrition in Kenya, there is a paucity of studies investigating the prevalence and risk factors of rickets among acute malnourished children which is one of the high risk groups with increased mortality risk of 3 and 9 times higher for moderate and severe malnutrition respectively (Kimani & Sharif, 2009)(Of, 2009). As such, this study explored this gap and sought to make recommendations that can be further explored to improve the management of acute malnutrition.

1.3. Justification

Diseases and inadequate diets are the immediate causes of malnutrition in both children and adults. As such, management of acute malnutrition requires both health assessment and management in addition to nutritional rehabilitation (therapeutic and supplementary feeding). However, despite the association of rickets with acute malnutrition which is one of the key contributors to childhood mortality, there is a paucity of data on the burden of rickets on children with acute malnutrition and regularity in assessment of rickets during admission of children in IMAM programs.

There is therefore need to understand the current prevalence and factors fueling the reemergence of nutritional rickets in this target group in Kenya. This information will support development of targeted interventions by relevant stakeholders to aid in eliminating nutritional rickets in Kenya and consequently reduce the health burden associated with nutritional rickets. Further, it will provide useful information at all levels of care and to the policy makers on improvement in the quality of care for acute malnourished children. For Kenya, this would aid in achievement of sustainable development goal 3.2 on reducing under 5 mortality to at least as low as 25 per 1,000 live births (United Nations General Assembly, 2015).

The study was conducted in a level four referral hospital because tier 2 and 3 facilities in Kenya do not have equipment and laboratories equipped to assess nutritional rickets. The study focused on acutely malnourished children since they are a very high-risk group with three- and nine-times higher chances of mortality compared to children who are well nourished (Kimani & Sharif, 2009) (Of, 2009). The other government referral hospitals in the county for management of acute malnutrition are Mama Lucy Hospital and Kenyatta National hospital.

1.4. Conceptual framework

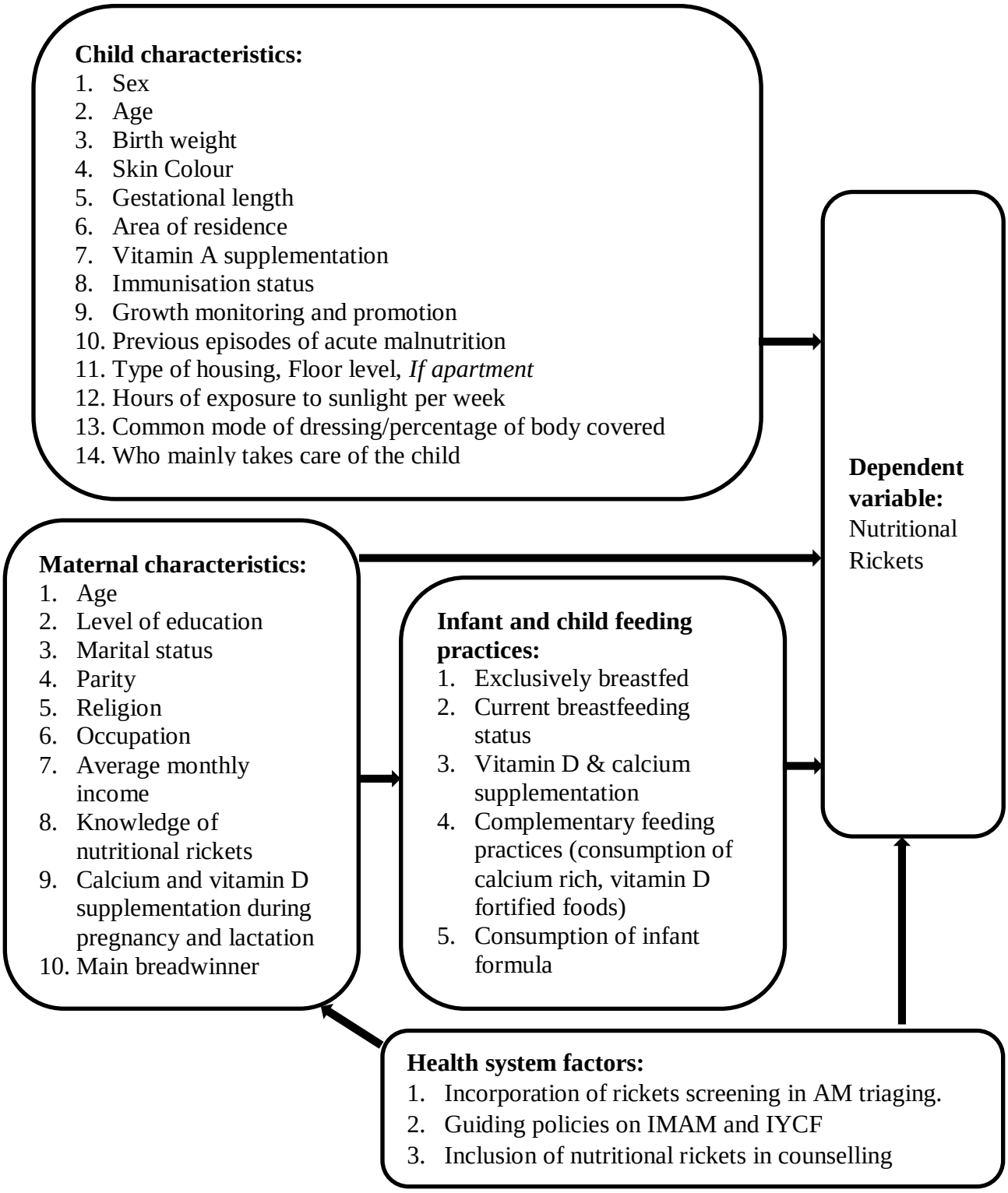


Figure 1: Conceptual framework, Source: Author,2021

1.5. Theoretical framework

All forms of malnutrition have their causes classified into immediate causes: disease and inadequate food intake; underlying causes: household food security, child care practices, health services and environment and; basic causes: potential resources (Unicef, 1991). The causes of rickets, a micronutrient deficiency disorder range from maternal, child feeding and care practices, sociodemographic (Ngari et al., 2018) and health system factors.

Maternal factors which range from education and income level, religion, health and nutrition status have been known to impact the health and nutrition status of the fetus and ultimately the child (Hovel et al., 2001). The levels of income and education are key determinants in child care and feeding practices affecting both health seeking behavior and optimal feeding(Ministry of Health, 2017) (Chakona, 2020) (Oddo & Ickes, 2018) (Vita et al., 2019). If the caregiver is aware of nutritional rickets and the predisposing factors, there are high chances that they will embrace preventive measures for example sunlight exposure, supplementation and feeding on vitamin D and calcium rich foods while avoiding inhibitors (Thacher et al., 2016). However, this might be hindered by religious and cultural practices for example, keeping children indoors to protect them from 'evil eye' and religious practices requiring whole body covering (Edwards, Thiongó, Van den Bergh, et al., 2014).

Health system factors play a critical role in addressing public health issues. In Kenya, the health system comprises of the community as tier one where health and nutrition programming is supported by community health workers and volunteers alongside other community groups. Level of awareness of the health workers and community health workers determines the health messaging that is done at both the community and facility level. The quality of services given is

also influenced by the guiding policies for the specific conditions besides availability of required infrastructure. Inclusion of nutrition rickets and its risk factors in routine health messaging would play an important role in improving knowledge/awareness and potentially improvement in child care practices. Based on a study conducted in Gaza strip assessing the magnitude of nutritional rickets among children under five years, high rates of nutritional rickets were reported among children whose caregivers did not receive medical education (Yassin, 2010). In a study done in the Middle East, Asia and Africa to assess nutritional rickets in immigrant and refugee children, nutrition education programs were reported to significantly reduce the severity of rickets (T. Ahmed et al., 2012). Public awareness campaigns on the importance of vitamin D which is a risk factor of nutritional rickets resulted to a significant decline in vitamin D deficiency from 120 to 49 per 100,000 among children aged below 5 years in the United Kingdom (UK) (Moy et al., 2012).

Treatment of acute malnutrition in Kenya is guided by the integrated management of acute malnutrition guidelines issued by the ministry of health. However, the guideline does not include screening for rickets during triage. There is also no inclusion of rickets and, importance of vitamin D and calcium supplementation for children in routine health messaging. Health education programs to improve caregivers' awareness on rickets have been recommended with risk of rickets reported to be 41.3 times higher among children of mothers who did not receive health education in a study aimed at assessing the social dilemma and vitamin D deficiency in children 6 to 24 months in Pakistan (S. et al., 2019).

Child characteristics and child care factors play an important role in the development of nutritional rickets. During pregnancy, the vitamin D and calcium level of the foetus are entirely dependent on maternal factors. However, during exclusive breastfeeding, this can be supplemented by sunlight

exposure of the child and/or micronutrient supplementation (Ruangkit et al., 2021). While Kenya has relatively adequate hours of sunlight exposure in a day, certain factors limit the amount of sunshine a child is exposed to. With the emergence of high-rise buildings, overcrowding and lack of proper house designs especially in urban areas, the amount of sunshine children are exposed to in the house and day care centres are not adequate. Children are also kept indoors because of caregivers being busy, security concerns and cultural practices and when they are left outside, they have clothes covering almost the entire body (Edwards, Thiongó, Van den Bergh, et al., 2014). Prematurity and underweight in infants has also been identified as a risk factor for development of rickets in children and recommendations of supplementation for these children have been made (WHO, 2019a).

1.6. Study significance

Findings from this study will provide insight on the proportion of rickets in acute malnourished children 6-59months receiving services in Mbagathi hospital and further provide information on the levels of awareness of rickets by both caregivers and health care providers. It is expected that this will contribute to improved management of acute malnutrition by incorporating assessment of nutritional rickets into diagnosis and triage for acute malnutrition in the facility and also in the routine nutrition education sessions. The findings can be extrapolated to referral hospitals in urban cities in Kenya.

1.7. Research questions

1. What proportion of acutely malnourished children 6-59 months receiving services at Mbagathi hospital have nutritional rickets?

2. What maternal, infant and young child factors are associated with nutritional rickets in acute malnourished children?
3. What is the level of awareness of risk factors of nutritional rickets among caregivers of acute malnourished children in Mbagathi hospital?
4. What health care factors affect provision of services for acute malnourished children 6-59 months with nutritional rickets at Mbagathi hospital?

1.8. Objectives

1.8.1. Main Objective

To assess nutritional rickets among acute malnourished children 6-59 months receiving services at Mbagathi hospital.

1.8.2. Specific Objectives

1. To determine the proportion of nutritional rickets among acute malnourished children 6-59 months receiving services at Mbagathi hospital.
2. To assess maternal, infant and young child factors associated with nutritional rickets among acute malnourished children 6 to 59 months receiving services at Mbagathi Hospital.
3. To assess level of awareness of nutritional rickets among caregivers of acute malnourished children 6-59 months receiving services at Mbagathi Hospital.
4. To assess the health care system factors influencing care for acute malnourished children 6-59 months with nutritional rickets receiving services at Mbagathi Hospital.

1.8.3. Hypotheses

Null hypothesis (Ho)

1. There are no cases of nutritional rickets among acute malnourished children receiving services at Mbagathi hospital.
2. Maternal, infant and young child factors have no influence on occurrence of rickets among acute malnourished children 6-59 months receiving services at Mbagathi hospital.
3. Caregivers of children with acute malnutrition 6-59 months receiving services at Mbagathi hospital have no knowledge on nutritional rickets.
4. Health care factors have no influence on occurrence of nutritional rickets among acute malnourished children 6-59 months receiving services at Mbagathi hospital.

CHAPTER 2: LITERATURE REVIEW

2.1. Rickets

Rickets is a deficiency disease which affects young people during the phase of skeletal growth and is characterized mainly by softening and deformation of bones. This is as a result of calcium, vitamin D or phosphate deficiency; or a combination of both calcium and vitamin D deficiencies(VDD) (El-Hajj Fuleihan, 2009). Failure of the body to take up and use phosphorus and calcium normally occurs as a result of inadequacies in vitamin D from either inadequate sunlight exposure or other factors (Thandrayen & Pettifor, 2018). Diagnosis of rickets is based on physical examination, assessing an individual's dietary history, biochemical testing and by radiograph confirmatory tests (Kutilek & Skalova, 2017) .

2.1.1. Sub types of rickets

Rickets can be broadly classified into two: calcipenic and phosphopenic rickets. Phosphopenic rickets is characterized by low phosphate levels in the serum which is as a result of phosphate wasting in the kidneys. Calcipenic rickets that is characterized by low calcium serum levels is caused by either inadequate dietary intake or absorption of vitamin D, or calcium in some cases. Rickets can be further categorized into three sub types: renal rickets, nutritional rickets and hypophosphatemia rickets. Rickets is mostly common in infants 6-24 months and causes softening and weakening of bones (Sahay & Sahay, 2013).

Hypophosphatemia rickets also referred to as Vitamin-D-resistant rickets is as a result of chronically low blood phosphate levels. The most common condition contributing to this is the genetic dominant X-linked gene. This affects the renal control of quantities of phosphorus in urine, whereby, calcium and phosphate are absorbed in the gut normally but the absorbed phosphate is

lost to urine in the kidneys. This condition can be acquired or inherited and is not as a result of deficiency in Vitamin D. Hypophosphatemia rickets results in bones becoming painfully soft and pliable. Symptoms of this form of rickets are obvious at twelve months of age. Treatment is usually by use of calcitriol (activated vitamin D) and phosphate (Jagtap et al., 2012).

Renal rickets also referred to as renal osteodystrophy or renal tubular acidosis (RTA), is caused by kidney disorders. Kidneys control the quantities of electrolytes excreted through urine among them being phosphorus and calcium. Individuals with kidney defects are therefore not able to regulate these electrolytes leading to deficiencies. Treatment of this form of rickets involves treatment of the underlying kidney complication coupled with nutritional supplementation (Sahay & Sahay, 2013).

Nutritional rickets also referred to as osteomalacia, is caused by inadequate intake or impaired absorption of Vitamin D, calcium, or phosphorus (Pettifor, 2006). Vitamin D is a type of fat-soluble vitamins and is crucial in the optimal formation of teeth and bones. It is necessary for absorption of calcium and phosphate in the bowels. Vitamin D is mainly synthesised naturally by skin cells in the presence of sunlight exposure but also occurs in very small quantities in some foods for example saltwater fish: sardines , salmon, fish liver oils and herring (Nield et al., 2006). Its metabolism involves conversion of vitamin D into 25-hydroxyvitamin D (25(OH) D), which is then converted to 1, 25-dihydroxyvitamin D. The primary role of 1, 25 dihydroxy vitamin D is to maximise calcium absorption from the gut. Serum 25 (OH)D concentrations is the best indicator of vitamin D deficiency. A serum concentration of below 5 ng/ml (12.5 nmol/L) is usually associated with vitamin D deficiency (Pettifor, 2006). Vitamin D is acquired through two ways: from consumed foods which contributes to 10–20% and through synthesis by the skin cells under the action of sunlight which account for 80–90% (Mithal et al., 2020).

2.2. Prevalence of nutritional rickets

There has been a resurgence of nutrition rickets in developing and in high income countries where it had been considered eliminated before (Pettifor, 2006). The burden is however higher in developing countries where it is often ignored or underreported. Geographical differences in the epidemiology of nutritional rickets can be attributed to various factors: differences in skin pigmentation, exposure to ultra violet light, community beliefs or religious based customs and diets.

A resurgence of nutritional rickets has been reported in developed countries due to noncompliance to food fortification, changes in lifestyle where children spend most of their time indoors and migration by people to different geographical areas (Carol et al., 2019; Ward, Gaboury, Ladhani, & Zlotkin, 2007). Relatedly, in the United Kingdom the resurgence of nutritional rickets has been reported in children of African, South Asian, Afro- Caribbean and Middle Eastern origin (S. F. Ahmed et al., 2010). Similarly studies conducted in the USA and England have documented an increase in nutritional rickets in the 2000s (Goldacre et al., 2014; Shelke et al., 2012).

Globally, the burden of nutritional rickets is highest in Africa, Middle East and Asia with a prevalence of 10-70% reported (Prentice, 2008; Prentice et al., 2007).These countries have key proportions of their population undernourished . Based on a study done in Yemen, the prevalence of nutritional rickets among unhealthy symptomatic infants was estimated to be about 95% (Mohanna, 2015). Relatedly in Qatar which is a sun rich country, the rate of nutritional rickets among children under five years of age was 23.9% (Abdulbari Bener & Hoffmann, 2010). Based on a study done in rural Gambia aimed at estimating the magnitude of nutritional rickets in children 0.5 to 17.5 years the prevalence of nutritional rickets was about 3.7% (H. L. Jones et al.,

2015). An annual incidence rate of 10% has also been reported in children under five years of age in a cross sectional study conducted in an maternal and child welfare clinic in rural Egypt (El-Hajj Fuleihan, 2009).

In Africa, nutritional rickets is reported to occur mainly in settings where consumption of calcium rich foods is not adequate. This is as a result of minimal consumption of dairy products and consumption of foods rich in substances that bind calcium reducing its bioavailability: tannins from tea; Phytic acid found in grains; saturated fat in palm oil and; oxalates from green leaves (Pettifor, 2006). However, other studies indicate that nutritional rickets especially in children less than 18 months old in North Africa countries is primarily as a result of vitamin D deficiency as a result of reduced sunlight exposure (Roth et al., 2018). In Nigeria and South Africa, rickets in children less than 2 years has been attributed to deficits in calcium intake (Pettifor, 2006).

In Kenya, rickets is reported to be mainly caused by vitamin D deficiency (Karuri et al., 2018). The main source of vitamin D is sunlight exposure accounting for to up to 90% of total daily intake (Edwards, Thiongó, Van den Bergh, et al., 2014). The other 10% is from diet. The prevalence of nutritional rickets is higher in urban compared to rural areas (Karuri et al., 2018). A prevalence of nutritional rickets above 1% warrants public health action (Roth et al., 2018).

2.3. Risk factors of Nutritional rickets

2.3.1. Child factors

2.3.1.1. Child's Age

Globally, the peak incidence of nutritional rickets is among infants and young children aged 6-23 months and adolescents aged 12 to 15 years (Carol L. Wagner & Greer, 2008). This however varies among regions. Studies conducted in Egypt, India and Yemen have reported that nutritional rickets

is more prevalent among children aged 3-18 months (Aidah & Mohanna, 2016) (Mahmoud et al., 2016)(Kumar, 2010). Based on a study conducted to assess nutritional rickets and associated risk factors among children aged 0 to 5 years in primary health clinics in Qatar, the mean age of children with nutritional rickets was 3.78 years (Abdulbari Bener & Hoffmann, 2010). Similarly in a study carried out to assess nutritional rickets in children less than five years around the world, the mean age of children who had rickets in Gambia was 3.4 years (Prentice, 2013). In Turkey, nutritional rickets was reported among infants below the age of 3 months and this was attributed to limited sun exposure and low maternal vitamin D levels (Hatun et al., 2005). Furthermore in Ethiopia high prevalence of nutritional rickets were recorded among children under the age of 5 years who had pneumonia (Muhe et al., 1997). Based on studied conducted in North Africa and Nigeria the occurrence of rickets in children under 18 months is attributed to vitamin D deficiency while in children over 2 years is attributed to calcium deficiency (Thacher et al., 2006).

2.3.1.2. Sex

Sex has been reported to significantly influence the rates of nutritional rickets among children. Studies have documented high rates of nutritional rickets in males as compared to females (Mohanna, 2015). To the contrary, findings of a study conducted in Nigeria showed that, girls had a higher rate of nutritional rickets compared to boys (Fischer et al., 2000). Similarly in a study carried out in Qatar assessing rickets in children under five in primary health care centres, nutritional rickets was found to be higher in females as compared to males (Abdulbari Bener & Hoffmann, 2010). However, there is no study that conclusively shows biological factors of being male or female as a predisposing factor for rickets, rather, the findings are as a result of the sex composition of the study groups and also because of cultural practices requiring women to cover most parts of their bodies in the study regions for example Qatar (Elidrissy et al., 2012).

2.3.1.3. Preterm birth and low birth weight

Accretion of bone minerals usually occurs in the last trimester of pregnancy. Low birth weight and preterm babies do not go through this process hence, predisposing them to metabolic bone diseases. Bioavailability of minerals for the infants is also affected as their organs have not yet fully developed. As such, the infants develop osteopenia or rickets of prematurity (Embleton & Wood, 2014). Infants with very low birth weight have been reported to have a 55% prevalence of rickets (WHO, 2019a) . In a study carried out at Kenyatta National Hospital (KNH) to investigate predisposing factors of rickets in infants and children less than five years admitted in the facility, the prevalence of rickets in premature infants was reported to be 60.0% (John & Nairobi, n.d.). There has been recommendations by the WHO on vitamin D supplementation for low weight infants for six months with daily doses of between 400 and 1000 IU (WHO, 2019a).

2.3.1.4. Household factors associated with nutritional rickets

2.3.2.1.1. Level of income

Level of income is an indicator of household poverty level. Nutritional rickets has been reported to be associated with poverty. This has been mainly attributed to children from low income families not accessing vitamin D and calcium rich and fortified foods. Based on a study conducted in Turkey, nutritional rickets was labelled as a disease of the underprivileged with a strong correlation with poor social background (Adbulbari Bener et al., 2008). Similarly a study conducted in Lebanon reported that children from high socio economic families were more likely to consume calcium and vitamin D fortified foods (Cesur et al., 2008). However, in studies done in some countries like Saudi Arabia and Egypt assessing rickets in children under five, levels of income were not associated with the risk of developing rickets with a significant number of children in

Egypt from higher income families reported to have rickets (Elidrissy et al., 2012) (Abdulbari Bener & Hoffmann, 2010). This is because of the cultural and religious practices in these countries which limit endogenous vitamin D synthesis. Relatedly, children from low economic status families were reported to get more exposure to sunlight as they were allowed to play outside as compared to children from high income countries (Bahijri, 2001).

2.3.2.1.2. Religion

In the middle east countries, religious and cultural practices emphasize covering of entire body apart from the face and hands. This significantly influences the endogenous synthesis of vitamin D and consequently contribute to nutritional rickets (Mohanna, 2015). For instance, based on a study conducted in Gaza strip which is dominated by Arabs high rates of nutritional rickets were reported among children who were fully dressed as per religious practices. Relatedly in a study conducted in Turkey low levels of vitamin D were reported in women who covered themselves (Yassin, 2010). Similarly based on a study conducted in the USA the rising cases of nutritional rickets were reported among Muslims, Arabs and African Americans (Lazol et al., 2008).

2.3.2.1.3. Type of housing

Urbanization has led to congestion and reduced space in dwelling places as characterized by people living in flats as opposed to open spaces in the countryside. Furthermore as a safety precaution most parents living in flats restrict their children from playing outside and this further reduces exposure to sunlight (Yassin, 2010). Houses with poor exposure to sunlight contribute significantly to development of nutritional rickets. For instance a study conducted in Saudi Arabia confirmed that living in flats with poor exposure to sunlight leads to the pathogenesis of rickets and thus the study recommended the creation of play areas in residential areas (Elidrissy et al., 2012). Relatedly

researchers have cited living in urban centres with tall buildings as a major factor influencing the development of nutritional rickets (Balasubramanian & Ganesh, 2008)(Elidrissy et al., 2012)(Edwards, Thiongó, Van den Bergh, et al., 2014)(Carol L Wagner et al., 2019)(WHO, 2019a).

2.3.4.5. Child care practices associated with nutritional rickets

2.3.4.5.1. Exclusive breastfeeding

WHO recommends exclusive breastfeeding of children for the first six months of life. However, human milk has been reported to be an insufficient source of vitamin D. Maternal vitamin D levels during pregnancy and lactation determine the amounts of calcium available for the growth of the fetus and neonate. While adaptations in pregnancy provide adequate calcium levels to the fetus independent of maternal vitamin D levels, the infant doesn't get adequate vitamin D due to poor penetrance of vitamin D and 25-hydroxyvitamin D [25(OH)D] into milk (Hollis et al., 2015)(Pehlivan et al., 2003). This indicates that breast milk cannot be depended upon as the main source of vitamin D with recommendations being made on supplementation for children less than 6 months (Bishop et al., 2018) (Balasubramanian & Ganesh, 2008). It's been reported that breast milk of a mother with adequate vitamin D contains around 20 to 60 IU/l of vitamin D which is below the recommended 400IU per day (C. L. Wagner & Greer, 2008). Hypovitaminosis D prevalence of 82% in United Arab Emirates, 52% in Pakistan and 20% in China were reported in exclusively breastfed infants (Balasubramanian & Ganesh, 2008). In populations at high risk of vitamin D deficiency, exclusive breastfeeding for long periods has been related to increased risk of developing nutritional rickets with recommendations of high doses of vitamin D supplementation for lactating mothers being made (WHO, 2019a).

2.3.4.5.2. Complementary Feeding Practices

Optimal complementary feeding is recommended in addition to continued breastfeeding for children from six months of age. Dietary diversity and timely introduction of complementary foods are key components of optimal complementary feeding and play an important role in prevention of both macro and micronutrient deficiencies (Ministry of Health, 2017). Poor feeding practices often coupled will diseases often result in childhood malnutrition which may catalyse progression towards nutritional rickets (S. et al., 2019). Findings of a study conducted in Gaza strip targeting pre-school children revealed high rates of nutritional rickets among children who were not fed fish, eggs and milk. Similarly mothers who did not eat fish, eggs and milk were reported to significantly predispose their children to nutritional rickets (*492-499.pdf*, n.d.). Practices such as vitamin D supplementation and consumption of vitamin D fortified foods have been shown to positively correlate with prevention of nutritional rickets among children. It is worth noting that foods naturally rich in Vitamin D and vitamin fortified foods are limited (WHO, 2019a) and only accessible in the most developed countries and to people of high economic status while in developing countries exposure to sunlight is highly depended to ensure adequate vitamin D status (Thacher et al., 2006).

In Africa, nutritional rickets is predominant in areas with low calcium intake. In areas with elevated occurrence, there normally there is minimal intake of dairy products and considerably high intake of diets that reduce the bioavailability of calcium (Thacher et al., 2006). Based on a study conducted in Gambia it was concluded that inadequate calcium intake by children significantly influenced the rates of nutritional rickets (Fischer et al., 2000). Furthermore calcium deficiency may be caused by reduced absorption rate as a result of competing dietary factors, parasitic infestation and altered colonization of intestinal bacteria (Prentice, 2013). Furthermore

complementary feeding with low nutrient dense foods have significantly led to high rates of calcium deficiency in children (Kimmons et al., 2005). Additionally studies have recommended the need of diversifying food intake among children as a strategy of preventing and reducing the rates of nutritional rickets among children (Bromage et al., 2016).

2.3.4.5.3. Exposure to sunlight

Exposing children to sunlight is a care practice that helps in preventing nutritional rickets. For example studies have cited confinement of children in houses during the day as a determinant of development of nutritional rickets (Balasubramanian & Ganesh, 2008). Exogenous vitamin D which is synthesised by the skin cells as a result of exposure to ultra violet rays accounts for 80 to 90% of the total vitamin D in the body 0–90% (Mithal et al., 2020). The effect of sunshine on vitamin D synthesis has also reduced because of a number of factors. Children get less exposure to sunshine as a result of high rise buildings that bar the sun rays, confinement in the houses during the day as a result of childcare, custom and religious practices, use of sun screens and use of clothing that cover the whole or almost the whole body while outside (Balasubramanian & Ganesh, 2008)(T. Ahmed et al., 2012)(Mahmoud et al., 2016)(Edwards, Thiongó, Van den Bergh, et al., 2014). The required minimum exposure time of infants to sunshine varies depending on what percentage of the body is exposed. If only the face is exposed, then a minimum of two hours is required weekly. If both the lower and upper extremities are exposed, then one hour per day is adequate (Balasubramanian & Ganesh, 2008). Dark skin pigmentation and use of sun screen also decreases the effect of sunlight exposure. Air pollution also reduces the ultraviolet light exposure which affects vitamin D production by the skin (Balasubramanian & Ganesh, 2008). Intense exposure to ultra violet rays has been however highlighted as a risk factor for developing melanoma and basal cell carcinoma. In a study carried out to determine the burden of Vitamin D

Deficiency and its associations with skin color in pregnant women in the first trimester in a sample from Switzerland, it was reported that vitamin D deficiency varies by light and dark skin photo types with dark skin color being more significantly associated with vitamin D deficiency. (Richard et al., 2017).

2.3.3. Maternal level of education

Evidence on influence of maternal level of education on the occurrence of nutritional rickets shows mixed findings. In a study conducted in the United Kingdom assessing rickets in children under five years of age, maternal education was recommended as an intervention to control nutritional rickets among children (Thacher et al., 2016). Relatedly, low levels of education have been documented to be a risk factor to low maternal vitamin D levels which further translates to vitamin D deficiencies in breastfeeding children (Pehlivan et al., 2003). In a 2017 global publication highlighting the need for vitamin D in children and maternal health globally, it was recommended that increased food fortification should be coupled with caregiver nutritional education through either public campaigns and/or health workers in reduction of nutritional rickets (Fiscaletti et al., 2017). In a study carried out in People's republic of China in May 2018 assessing the linkage between maternal nutritional knowledge, attitude and practice (KAP) and serum vitamin D levels, the findings indicated a positive linkage between maternal KAP and improved vitamin D levels and further recommended augmented nutritional education as a key intervention (Liang, Y., Ren, H.-Y., & Zuo, P.-X. (2018). However a study conducted in Almadinah Almunawwarah, Saudi Arabia to assess VDD rickets, maternal education status was reported to have no significant influence on nutritional rickets with prevalence of 25%, 44% , 12.5%) and 15.4% reported for children with mother's whose levels of education were classified as higher education, graduates of secondary or intermediate schools, able to read and illiterate respectively (Elidrissy et al., 2012).

2.3.4. Healthcare system factors associated with nutritional rickets

Health care systems comprise of all the stakeholders, resources and people that work together with the primary purpose of improving health. Health systems deliver promotive, preventive, rehabilitative and curative interventions (WHO, 2010). Policies and guidelines play a critical role in service delivery.

With previous eradication of nutritional rickets, there is lack of clear guidelines and recommendations by the government and professional associations on timely diagnosis and management of rickets. This has led to minimal or no vitamin D supplementation interventions for infants and mothers. While WHO acknowledges lack of clear guidelines on how to prevent nutritional rickets from a public health perspective, it also recommends that more research should be done in this area to come up with clear guidance on recommended supplementation and confirmatory test guidelines. Relatedly, dietary intake guidelines set by relevant agencies are not enforced or even followed in most countries (Arnaud et al., 2007).

Counsel provided by doctors and child care workers to mothers has been recommended a as a critical step in addressing public health issues and in reduced the rates of nutritional rickets (WHO, 2010)(WHO, 2019a). Additionally, development of health education programs focussed on promoting behavioural change among mothers have been as a strategy of preventing and reducing rates of nutritional rickets (Yassin, 2010).

2.3.5. Level of awareness on nutritional rickets among caregivers

The awareness of nutritional rickets and its determinants goes a long way in helping to reduce its prevalence. For instance, based on a study conducted in the UK public awareness campaigns on the importance of vitamin D which is a risk factor to nutritional rickets resulted to a significant decline in vitamin D deficiency from 120 to 49 per 100000 among children aged below 5 years

(Moy et al., 2012). Similarly, based on a study done in Gaza strip, high rates of nutritional rickets was reported among children whose caregivers did not receive medical education (Yassin, 2010). In a study done in Bangladesh nutrition education programs were reported to significantly reduce the severity of rickets.

2.4. Diagnosis of rickets

Rickets is diagnosed by conducting a complete physical, medical and nutritional history assessment. The confirmatory tests are X rays and assessment of serum vitamin D, alkaline phosphatase, parathyroid hormone and electrolytes levels. This includes indirect measurements of kidney function (BUN and creatinine) (El-Hajj Fuleihan, 2009). The radiographic changes caused by rickets i.e. the widening of the growth plate and irregularities in the zone of provisional calcification are best observed in the regions where the growth is the most active (such as the knees, proximal humeri and wrists). Classic radiographic findings are fraying and widening of the metaphysis, widening of the distal physis and angular deformities of the arm and leg bones.

2.5. Nutritional Rickets and acute malnutrition

Initially, rickets was considered infrequent in cases of acute malnutrition since it is a disease of growth. However, recent studies indicate that chronic and acute malnutrition are common in rachitic children and vice versa. In a study carried out in Karachi, Pakistan to investigate the prevalence of stunting and micronutrient deficiencies in children under 5 in a tertiary care hospital, 44% of the stunted children: 29% mildly stunted, 34% moderately stunted and; 33% severely wasted children were reported to have coexisting rickets (Rahman et al., 2016). In Tanzania, a vitamin D deficiency prevalence of 30.6% was reported in malnourished children in a tertiary care center of a national hospital. Out of the malnourished children in the center, 74 were marasmic

with 31 (41.9%) and one (6.2%) kwashiorkor case having vitamin D deficiency. Additionally, Six (16.2%) of the total children with marasmic kwashiorkor had VDD (Walli et al., 2017).

In Kenya, 39% of rachitic children less than 5 years were found to have a MUAC of less than 12.5 in a study carried out in four level 4 hospitals to assess the effect of rickets on morbidity and growth among complicated cases of severe malnutrition (Ngari et al., 2018). In a study carried out to assess the burden of nutritional rickets amongst children living in an informal settlement in Nairobi, Kenya, it was reported that rickets was associated with acute malnutrition and developmental delay (Edwards et al., 2014). Rachitic children have a low immunity and are prone to upper respiratory tract infections (Haider et al., 2010).

2.5.2. Acute malnutrition

Acute malnutrition, also referred to as wasting is a sub category of under nutrition which can be categorized into moderate acute malnutrition and severe acute malnutrition. Wasting occurs as a result of an abrupt weight loss as a result of inadequate food intake and/or illness. Malnutrition is a key contributor to under five morbidity and mortality and hence, remains an important public health issue (Kimani & Sharif, 2009). According to WHO, 45% of all deaths among children less than 5 years can be attributed to malnutrition globally.

According to UNICEF and WHO 1000 days publications, the burden of wasting for children less than five years globally was estimated to be 50 million in 2012. In 2015, it was reported that every fourth child worldwide suffers from acute malnutrition (Chowdhury, 2015). The prevalence is especially high in Asia and Africa with just over one quarter of all malnourished children globally living in Africa. In Kenya, the prevalence of wasting is 4% according to the 2014 Demographic and health survey (Kenya National Bureau of Statistics & ICF Macro, 2014) with a GAM

prevalence of 4.6% in Nairobi county (Survey et al., 2017). Various interventions have been set in place over the years to address the chronic high GAM rates ranging from nutrition sensitive to nutrition specific programming.

In Kenya, introduction and implementation of Integrated Management of Acute Malnutrition (IMAM), though faced by different challenges, has been effective in treatment of acute malnutrition over the years. Provision of IMAM services is now available in most level 2 ,3,4,and 5 facilities in Kenya (Report, 2012). However, some of these facilities lack capacity to conduct a thorough assessment of malnourished children at enrollment due to lack of equipment posing a challenge to treatment and increasing the lengths of stays of children in the programmes.

Vitamin D supplementation is not among the routine medication given in management of acute malnutrition as per the Kenyan IMAM guidelines which is the blueprint against which acute malnutrition is managed hence there lacks clear guidelines on how it should be addressed. Vitamin D plays an important role in the immune system and acts as modulator for the immune system (Haider et al., 2010). Ready- to- use therapeutic foods and ready to supplementary foods used for SAM and MAM management are manufactured to internationally accepted compositional specifications but do not provide adequate dosages of vitamin D. They are also not provided for adequate durations to treat rickets and to achieve catch up growth with discharges being based on anthropometric indices (Munns et al., 2016). According to a study carried out in four level 4 referral hospitals in Kenya, deficiency in vitamin D was reported to be common while Ready-to-use therapeutic food (RUTF) which is the standard treatment therapy for SAM cases was reported to contain only modest amounts of vitamin D that do not reliably correct deficiency (Ngari et al., 2018). The study further pointed out the possibility of incorporation of high-dose vitamin D

supplementation as an inexpensive intervention, being a game changer for treating severely malnourished children.

2.6. Knowledge gap

Despite the known association of rickets with acute malnutrition which is one of the key contributors to childhood mortality, there is paucity of evidence on the burden of rickets on malnourished children in Mbagathi hospital and associated risk factors. This study sought to address this knowledge and evidence gap.

CHAPTER 3: METHODOLOGY

3.1. Study design

This was a cross sectional analytic study adopting mixed methods in data collection. Both quantitative and qualitative data were collected. The data collection tools included questionnaires, key informant interviews (KIIs) and focus group discussions (FGDS).

3.2. Study area

The study was conducted at Mbagathi County Hospital, which is a government referral hospital for complicated cases of acute malnutrition (inpatient care) for tier 3 and 2 facilities in Nairobi County. It also serves as an outpatient nutrition site for children within the catchment area. The facility has a catchment population of around a million people and serves mainly the urban poor.

Nairobi County is Kenya's capital city lying at a latitude of 1.3° South. It has a subtropical highland climate with two rainy seasons running between March to May and October to December. The daily average number of sunshine hours is highest in February at 9.5 hours per day, and dropping to 4.1 hours per day in August. The annual average is 6.8 hours of sunshine per day(World Meteorological Organization, 2010) (K. D. J. Jones et al., 2018) (Onyango, A. O.; Ongoma, V. (2015) (Yesserie, 2015).

3.3. Study population

The study population comprised children aged 6 to 59 months who were diagnosed with acute malnutrition through recommended WHO anthropometric cut offs for moderate and severe acute malnutrition (Kimani & Sharif, 2009)(Of, 2009).

3.3.1. Inclusion criteria

i. Acute malnourished children 6 to 59 months as identified through WHO recommended nutritional indices: Mid upper arm circumference (MUAC) of less than 12.5cm, bilateral pitting oedema and/or weight for Height/Length Z score of less than negative two standard deviation.
ii. Primary caregivers who gave informed, written consent.
iii. Health workers providing nutrition services in the facility.

3.3.2. Exclusion criteria

i. Children whose caregivers did not consent to participate.

3.4. Sample size determination and sampling strategy

3.4.1. Sampling procedure

Simple random sampling was used to select study participants for quantitative data collection. The sampling frame comprised all acute malnourished children whose caregivers consented to be included in the study until the minimum sample size was achieved. KIIs were conducted with focal staff in the nutrition clinic who consented to participate in the study. A total of four KIIs were conducted. Four focus group discussions with caregivers were also conducted segregated based on nutritional rickets test results.

3.4.2. Sample size determination

Fisher's formula was used to calculate the sample size with a precision of 5% and 95% confidence level (Pourhoseingholi et al., 2013).

$$n = \frac{Z_{1-\alpha/2}^{\ 2} p(1-p)}{d^2}$$

Where;

n = sample size required for a population of more than 10,000 people. The population of acute malnourished children 6 to 59 months in Nairobi county. This was estimated as 4%*90%*20%*total population in Nairobi (National Bureau of Statistics-Kenya and ICF International, 2015) (Survey et al., 2017).

P= prevalence of nutritional rickets in acute malnourished children 6 to 59 months in Kenya. The prevalence was estimated at 30.6% based on prevalence of vitamin D deficiency reported in a study carried out in a tertiary care center in Tanzania in the same target group (Walli et al., 2017).

Z= Z value. A confidence level of 95% will be used giving a z value of 1.96.

d = is the absolute error or precision. The precision for this study will be 5%.

Therefore; **n** = $(1.96^2 * 0.306 * 0.694)/ (1-0.95)^2$ **n** =327

Assuming a 10% non-response rate/lack of compliance, the sample size was be increased to 360 acute malnourished children 6 to 59 months.

3.5.Variables

3.5.1. Child anthropometric measurements

1. MUAC (Cms)
2. Weight (Kgs)
3. Height/length (Cms)
4. Bilateral pitting oedema

3.5.2. Dependent variable

Nutritional rickets

3.5.3. Child characteristics

1. Sex
2. Age

3. Birth weight
4. Gestational length
5. Skin colour
6. Immunisation status
7. Vitamin A supplementation
13. Enrolment in an IMAM programme
8. Previous episodes of acute malnutrition
14. Hours of sunlight exposure per week
9. Area of residence
15. Main breadwinner
10. Type of housing
16. Common mode of dressing
11. Floor level, If apartment
17. Percentage of body covered
12. Growth monitoring and promotion
18. Who mainly takes care of the child

3.5.4. Maternal characteristics

1. Age
4. Number of children/parities
2. Marital status
5. Religion
3. Highest level of education
6. Occupation
7. Knowledge of calcium, vitamin D and nutritional rickets
8. Average monthly income
9. Calcium and vitamin D supplementation during pregnancy and lactation

3.5.5. Infant and child feeding practices

1. Exclusive breastfeeding
2. Current breastfeeding status
3. Vitamin D and calcium supplementation
4. Consumption of infant formula

5. Complementary feeding (consumption of calcium and vitamin D rich and fortified foods)

3.5.6. Health system factors

1. Incorporation of nutrition rickets screening in acute malnutrition triaging.
2. Guiding policies on IMAM and IYCF
3. Inclusion of nutritional rickets in counselling guidelines used.

3.6. Data collection

Child data were collected using structured pretested questionnaires which were administered to caregivers by research assistants. The research assistants screened the children for malnutrition in the maternal child health department, the nutrition clinic and paediatrics out-patient clinic (POPC). Screening for nutritional rickets was done by a trained clinician in the POPC who would then refer the children to the laboratory for testing following the facility system. The data collection tools are appended: appendix 1 to 4.

3.6.1. Quantitative data collection

Quantitative data were collected using the Kobo toolbox open data kit (ODK) platform using android mobile phones. The completed questionnaires were automatically uploaded on the server. The questionnaire was categorized into six sections and captured both child and maternal data. In the kobo toolbox platform, the assistants and children had unique identifiers.

3.6.1.1.Anthropometric measurements

Age and anthropometric screening formed the first part of data collection and formed the basis for sampling frame identification. The children screened were referred from the community by community health workers (CHWs), referred from other facilities, various departments in the

facility or self-referrals. The admission criteria were: MUAC and/or weight for height z score. There were no children admitted based on oedema. Classification into either moderate acute or severe acute malnutrition was based on the worse off index. Weight and height measurements were taken using calibrated weighing scales and WHO stadiometers available at the facility respectively. MUAC measurements were done using United Nations Children's Fund (UNICEF) MUAC tapes. Pre-printed weight for height z score reference charts were provided during data collection. The z score cut offs were further confirmed using ENA for SMART software during analysis for accuracy. The measurements were done as illustrated below:

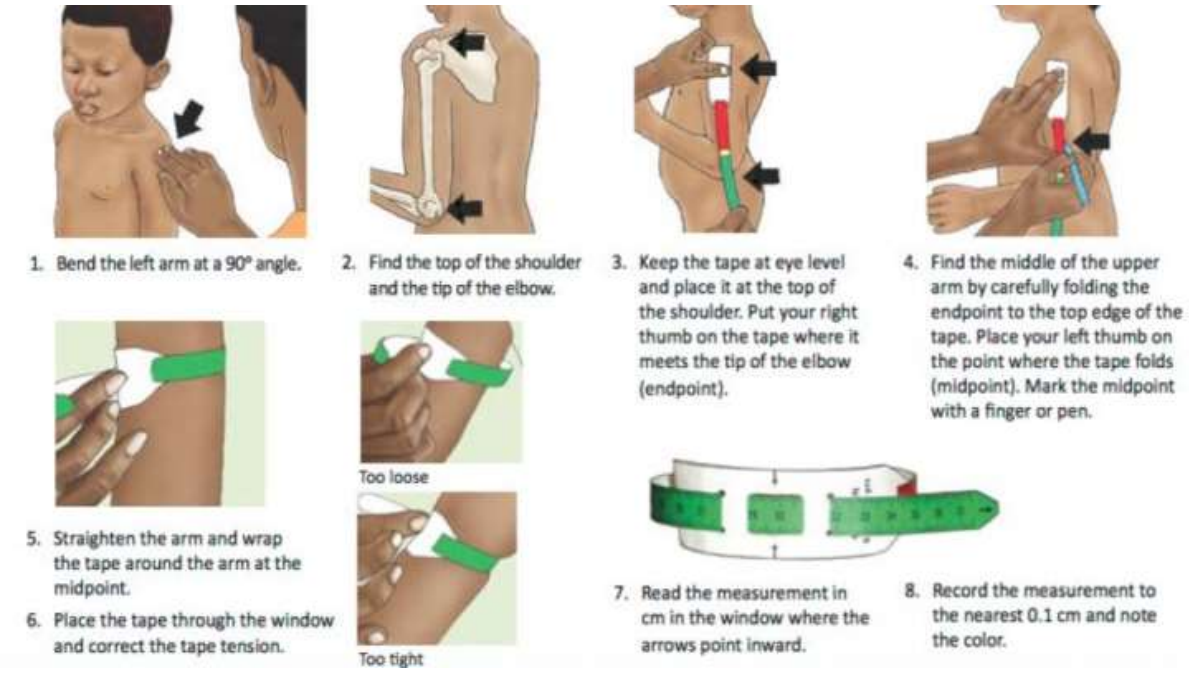


Figure 2: Taking MUAC measurements (Lillie et al., 2018)

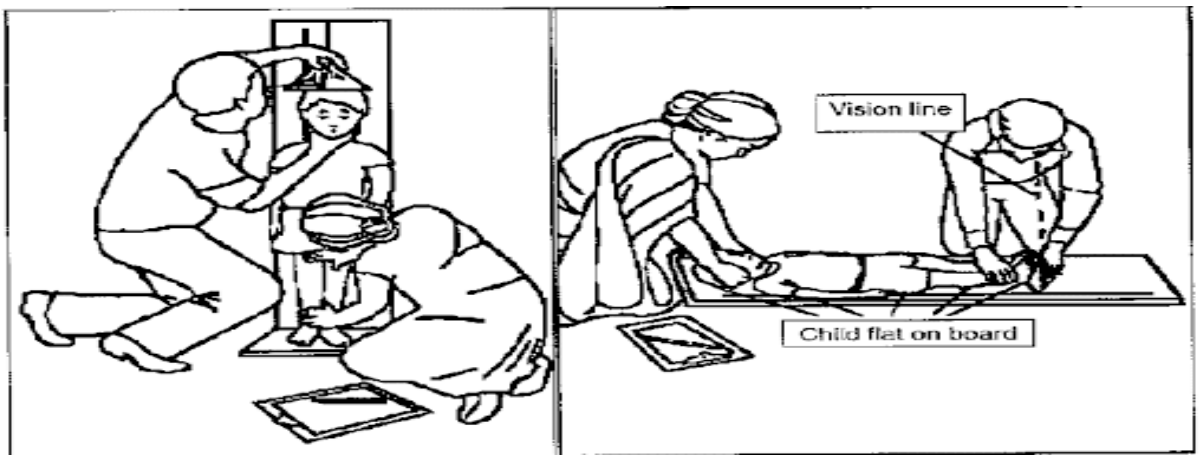


Figure 3: Height measurement in standing and lying position

Figure 4: Weight measurement using electronic mother/child and infant scales

3.6.1.2. Screening for rickets

Physical and chemical assessment of all children for rickets was done by qualified clinicians and laboratory technicians in the facility as per the Kenya Ministry of Health guidelines. Blood sample was drawn by the clinician. The laboratory where the tests were done is ISO 15189:2012. Physical signs of rickets included: delayed teething, craniotabes, rosary rickets, wide fontanel, carious teeth, kyphoscoliosis for children above two years, bowed legs for infants who had started walking, hypotonia, caput quadratum, extremity pain, hypocalcaemia convulsions, greenstick fractures, deformities of the chest, and/or frontal blossing. Nutritional rickets was defined as alkaline-

phosphatase (ALP) of greater than 400 IU/500IU/L, calcium of less than 2 mmol/L, phosphate <1.45 mmol/L, 25(OH) D level of below 20 ng/mL (Mohanna, 2015)(Mahmoud et al., 2016).

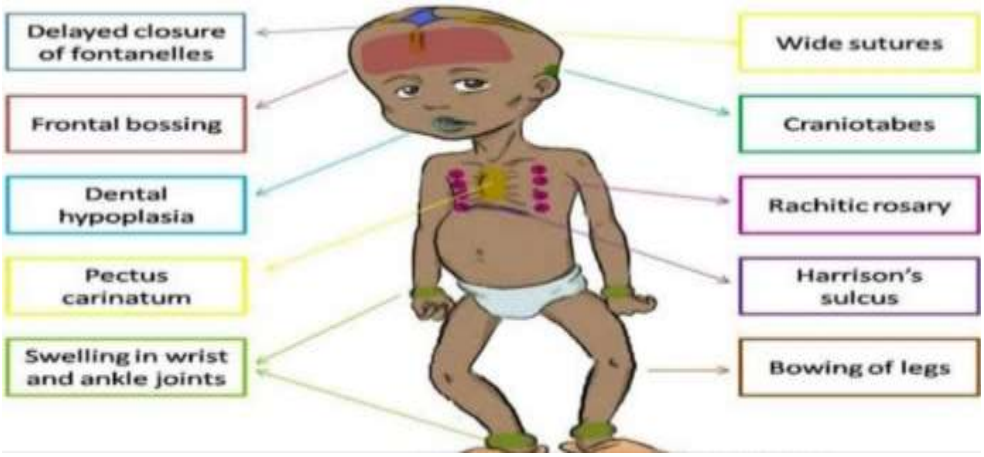


Figure 5: Ten important clinical features of rickets (https://qsota.com/rickets-in-children/)

3.6.1.3.Infant and young child feeding practices

Infant and young child feeding practices were assessed using three indicators: exclusive breastfeeding, timely introduction of complementary feeding and continued breastfeeding to two years and beyond. These indicators were borrowed from the ten set of WHO indicators for assessing infant and young child feeding practices(Guide, 2010). Retrospective individual based dietary assessment method was used to assess the consumption pattern and frequency of select foods over the seven days preceding the interview. This was through food frequency questionnaires.

3.6.1.4.Child and maternal data

The main source of maternal and child data was the MCH booklets or cards. Where this was not available, recall was used. To minimise recall bias, the research assistants were trained on probing skills and pictures were used where necessary. Maternal age, marital status, highest level of

education and number of children the caregiver had was based on the caregiver's interview report. MCH booklets or cards capture antenatal, post-natal and growth monitoring data of index child up to five years of age. The booklets and cards were used to confirm immunisation and vitamin A supplementation status. Skin colour which was defined based on the child's race was categorised into three: black, white and brown based on race. Children of original African origin were classified as black, Asian origin classified as brown while Caucasians were classified as white. Other skin disorders for example albinism would be captured under others and the specific disorder recorded.

3.6.2. Qualitative data Collection

3.6.2.1. Health workers Key Informant Interviews

The interviews targeted nutrition workers in different departments. The KIIs were facilitated by the research assistants using a standard guide. The discussion focused on assessing whether nutritional rickets screening was part of the medical assessments done before enrollment of children into IMAM, and incorporation of nutritional rickets as a health topic during facility health talks and nutrition counseling. The KIIs also sought to determine from perspective of respondents whether nutritional rickets is a common phenomenon in the facility and barriers and facilitators to routine screening. Four KIIs were conducted with nutrition workers in the facility who were all women aged 20-40 years. The staff had worked in the facility for one to 5 years. A desk review was also conducted to assess whether there are guidelines on nutritional rickets screening and vitamin D and calcium supplementation.

3.6.2.2. Caregivers FGDs

Focus group discussions comprised of 6 to 10 participants each. The FGD participants were primary caregivers of the children and were not segregated based on sex. The FGDs were conducted in English and in Kiswahili in the facility by the research assistants based on consensus by the participants on what language to use. The FGDs explored the caregivers' knowledge, attitude and practices. Barriers and boosters to sunlight exposure, uptake of vitamin D and calcium supplements and fortified foods were also assessed. The FGDs were conducted in adherence to the MoH coronavirus disease of 2019 (COVID-19) guidelines of social distancing, sanitization and use of face masks. The FGD participants were all female aged 20 to 40 years and with children with 3 being men. The children were aged 18 months to 36 months.

3.7. Recruitment of research assistants and pretesting

Qualified nutritionists with prior working experience in the Mbagathi IMAM programme were recruited and trained for three days on taking anthropometric measurements and the study protocol. Further, they were trained on data collection and submission using the ODK platform. The training was conducted by the principal investigator. Pretesting of the questionnaire and anthropometric standardisation tests were also conducted before commencement of data collection at Mbagathi Hospital.

3.7.1. Quality assurance

Structured pretested questionnaires were used for data collection to minimize bias and errors. Prior to commencement of data collection, the research assistants were trained on questionnaire administration for clear and uniform understanding of the questions. Clinical and laboratory

assessments were conducted by trained physicians and laboratory technicians working in the facility. Restriction of data entry fields and logical skipping on the ODK platform was also done to control for data accuracy and completeness of questionnaires.

3.7.2. Pretest results

A standardization test was conducted to assess the enumerators' anthropometric measurement skills with a focus on precision and accuracy. The principal researcher and enumerators took measurements of ten children 6 to 59 months regardless of their nutritional status at Mbagathi hospital. Each enumerator took measurements of the same child twice and analysis was done using ENA for SMART software,2020. Precision was assessed using percentage technical error of measurement (%TEM) and coefficient of reliability (R). Percentage total intra and inter TEM was good for MUAC and height; and acceptable for weight. Coefficients of reliability were good for weight and height and acceptable for MUAC. The supervisor's TEM was rated as good and acceptable; hence the supervisors' measurements were used as a reference for bias analysis. Bias was good for all the measurements for both the enumerators and supervisor. The results of the standardization test are as presented in appendix 5.

3.8.Ethical considerations

3.8.1. Approvals

Prior to data collection, ethical clearance was sought from the KNH-UoN ethics and research Committee (P359/07/2020). A research license was also obtained from National commission for science, technology and innovation (NACOSTI/P/21/9509) Consent to conduct the study in the hospital was sought form the Nairobi Metropolitan services (NMS) and Mbagathi County Hospital.

3.8.2. Consenting Procedures

Participation in the study was voluntary and based on informed consent in a language the caregiver would understand. Emphasis was made on privacy and confidentiality at the time of consenting. Those who did not consent were not included in the study but were referred to the nutrition clinic. Names of the respondents were used during data analysis. The study was also conducted in adherence with Kenya ministry of health COVID-19 guidelines. All cases that tested positive for either acute malnutrition or nutritional rickets were referred for treatment in the hospital.

3.9. Data analysis and processing

Data cleaning and analysis was conducted using Kobo, ENA, Excel and SPSS v.23 software. Univariate analysis was summarised using frequency distribution tables. Pearson's Chi-square test of significance and odds ratio (OR) were used to assess bivariable relationship between the predictor and dependent variables based on a 90% confidence interval. Multivariable analysis was conducted using logistics regression and results for the nine predictor variables with a significant relationship summarised in the formula below.

log(p/1-p) = b_0 + b1*x1 + b2*x2 + b3*x3 + b4*x4 + b5*x5 + b6*x6 + b7*x1 + b8*x8 + b9*x9

Where:

P is the probability of testing positive for rickets.

B_0 is the coefficient of the constant or the intercept

B: Is the amount of decrease (if negative) or increase (if positive) in the predicted log odds of nutritional rickets that would be predicted by a unit decrease or increase in the predictor, holding all other predictors constant.

Comparison of the predictor variables between children who tested positive and negative for nutritional rickets was also conducted. The data from both focus group discussions and key informant interviews was first transcribed and content analysis conducted.

3.10. Limitations of the study

This study was carried out in an urban setting; hence the results cannot be extrapolated to rural settings where socio-demographic and behavioural factors are different. It was also carried out in a referral hospital hence the findings cannot be extrapolated at the population level. Dietary recall was based on how much the caregiver could remember. However, research assistants were trained on probing skills and common terms for foods to facilitate interviews and enhance recall. Pictures were also used where necessary.

CHAPTER 4: RESULTS

4.1. Introduction

This chapter presents in details, the findings obtained from the study. It presents children and maternal data: child characteristics, maternal knowledge, attitudes and practices (KAP), infant and young child feeding (IYCF) practices, anthropometric and nutritional rickets status. Descriptive and inferential statistics were used to summarize the data. Data collection was conducted in May, June and July 2021.

4.2. Response rate

The minimum sample size calculated using Fischer's formula was 327 children 6-59 months with acute malnutrition. A 10% non-response rate was accounted for increasing the total sample size to 360. A total of 362 questionnaires were filled in but only 352 were used for data analysis. Ten questionnaires were excluded from the study as they were incomplete. This was as a result of unprocessed rickets results due to lack of reagents in the laboratory when the samples were collected and errors in weight for height Z score classifications. The response rate as calculated from the complete questionnaires was 97.2%. This was above the 60.0% response rate required for social and scientific researches (Response Rates and Responsiveness for Surveys, Standards, and the Journal, n.d.).

4.3. Univariate analysis

4.3.1. Maternal characteristics

4.3.1.1. All caregivers

Table 1 presents maternal characteristics assessed. All the caregivers were female with 92.0% residing in Nairobi County. They were all within the reproductive age bracket of 15 to 49 years. Young mothers 15 to 29 years were 55.7% while 44.3% were at least 30 years old. The mean age of the caregivers was 29.0± 5.9 years. Majority (80.1%) of the caregivers were married with 19.9% being single or divorced.

Most of the caregivers (68.8%) had attained at least primary school education and progressed to either secondary or tertiary level. Christians formed 96.0% of the respondents with Muslims and other religions forming 3.4% and 0.6% of the respondents respectively. Multiparity was reported by 79.5% of the caregivers with 20.5% being primiparous.

Maternal breadwinners were 17.3%. Majority (67.9%) of the households had an average monthly income of less than 10,000 Kenya shillings (Ksh) with 3.7% having an average monthly income of greater than Ksh.30,000. Caregivers' occupation varied across the respondents with 22.7% being in formal employment and 77.3% not being formally employed.

4.3.1.2. Caregivers of nutritional rickets cases

Young mothers formed 58.7% of the caregivers of children with a positive rickets test result. Further, the caregivers resided mainly in Nairobi County (92.6%) and had at least primary school education (67.2%). Majority of the caregivers were Christians, married and multiparous at 94.2%, 82.0% and 82.5% respectively. Mothers formed 11.6% of the household main breadwinners. Casual work and self-employment were the main sources of income for the households with 76.7%

of the caregivers being in non-formal employment. Most (68.3%) of the households had a monthly income of less than ten thousand Kenya shillings.

4.3.1.3. Caregivers of non-rickets cases

Similarly, majority of the caregivers of children who did not test positive for rickets were young mothers (52.1%), had at least primary school education (70.6%) and were residents of Nairobi County (91.4%). Further, 76.1% of the caregivers were multiparous with two and more children. Christianity was the main religion reported at 98.2%. Married caregivers were 77.9% with fathers being the main breadwinners of the families at 69.3% while mothers formed 23.9% of the breadwinners. Majority of the households had non-formal employment (77.9%) as the main source of income and had an average monthly household income of less than Ksh 10,000 (67.5%).

Table 1: Maternal characteristics

Variable	Category	Rickets cases N (%)	Non-rickets cases N (%)	All children N (%)
		Frequency (N=189)	Frequency (N=163)	Frequency (N=352)
County of residence	Nairobi	175(92.6)	149(91.4)	324(92.0)
	Outside Nairobi	14(7.4)	14(8.6)	28(8.0)
Age	15 to 29yrs	111(58.7)	85(52.1)	196(55.7)
	30 to 49yrs	78(41.3)	78(47.9)	156(44.3)
Marital status	Single or divorced	34(18.0)	36(22.1)	70(19.9)
	Married	155(82.0)	127(77.9)	282(80.1)
Parity	Primiparous	33(17.5)	39(23.9)	72(20.5)
	Multiparous	156(82.5)	124(76.1)	280(79.6)
Religion	Christian	178(94.2)	160(98.2)	338(96.0)
	Muslim	10(5.3)	2(1.2)	12(3.4)
	Other	1(0.5)	1(0.6)	2(0.6)
Highest level of education	Primary and below	62(32.8)	48(29.4)	110(31.2)
	Post Primary	127(67.2)	115(70.6)	242(68.8)
Main breadwinner	Mother	22(11.6)	39(23.9)	61(17.3)
	Other	167(88.4)	124(76.1)	291(82.7)
Occupation of the breadwinner	Formal employment	44(23.3)	36(22.1)	80(22.7)
	No formal employment	145(76.7)	127(77.9)	272(77.3)

Household's average monthly income	< 5,000	54(28.6)	50(30.7)	104(29.5)
	5,000-10,000	75(39.7)	60(36.8)	135(38.4)
	11,000-20,000	34(18.0)	35(21.5)	69(19.6)
	21,000-30,000	17(9.0)	14(8.6)	31(8.8)
	Above 30,000	9(4.8)	4(2.5)	13(3.7)

4.3.2. Child characteristics

4.3.2.1. All sampled children

Table 2 shows a summary of the child characteristics assessed. More than half (58.0%) of the children enrolled in the research had moderate acute malnutrition while 42.0% had severe acute malnutrition. None of the children admitted in this study had bilateral pitting oedema. Underweight and stunting rates were at 72.2% and 32.7% respectively.

Boys were more than girls at 55.4% and 44.6% respectively. The ratio of boys to girls was 1.2. The 6 to 23 months age group formed 85.2% of the sample with 14.8% being between 24 and 59 months. The age category ratio was 5.8 with a mean of 15.3±8.2 months. All the respondents and children were of African origin with a black skin color.

Children born with a normal weight of at least 2500 grams and at a gestational length of at least 37 weeks formed 82.4% of the sample with 17.6% being either underweight and/or premature. The rates of underweight and prematurity at birth were 85.8% and 87.5% respectively. Children born both underweight and pre-term were 9.1%. The main source of gestation age and length data were Maternal Child Health (MCH) booklets at 55.1%.

All the children had attended growth monitoring and promotion (GMP) in child welfare clinics with 93.2% still attending GMP sessions at their respective clinics. Majority (98.3%) of the children were fully immunized across the two age categories. The 1.7% who were not fully immunized were six, seven, ten, eleven and twenty-four months old. Further, they all tested

positive for rickets. Majority of the children (94.9%) had received vitamin A supplements in the last 6 months.

About a third (30.1%) of the children had been enrolled and discharged from a management of acute malnutrition (MAM) program which indicates previous episodes of acute malnutrition. At the time of data collection, 56.5% of the acute malnourished children were not enrolled in MAM program while 43.5% were already receiving nutrition rehabilitation services in various hospitals. This indicates that the IMAM proxy coverage in this study was 43.5%.

More than half (53.7%) of the children enrolled in this study tested positive for rickets. These were both newly diagnosed and old cases of rickets under medication and on follow up. Clinical signs of rickets were visible in 43.2% of all the children enrolled in the study while 56.8% had no visible signs and symptoms of rickets. Children who had had a previous rickets test were 41.5%.

Exclusively breastfed children were 70.7%. More than half (59.4%) of the sampled children had timely introduction of complementary foods at 6 months of age while 11.4% had late introduction. Consumption of infant formula was reported by 9.1% of the children: 13 consumed for less than 1 month, 5 for 1 to 2 months, 10 for 3 to 4 months and; 4 children for more than 4 months. Mothers formed 91.5% of the main care takers of the children during the day. Most (75.6%) of the respondents resided in non-storey houses which comprised of shanties in the non-formal settlement.

Table 2: Child characteristics

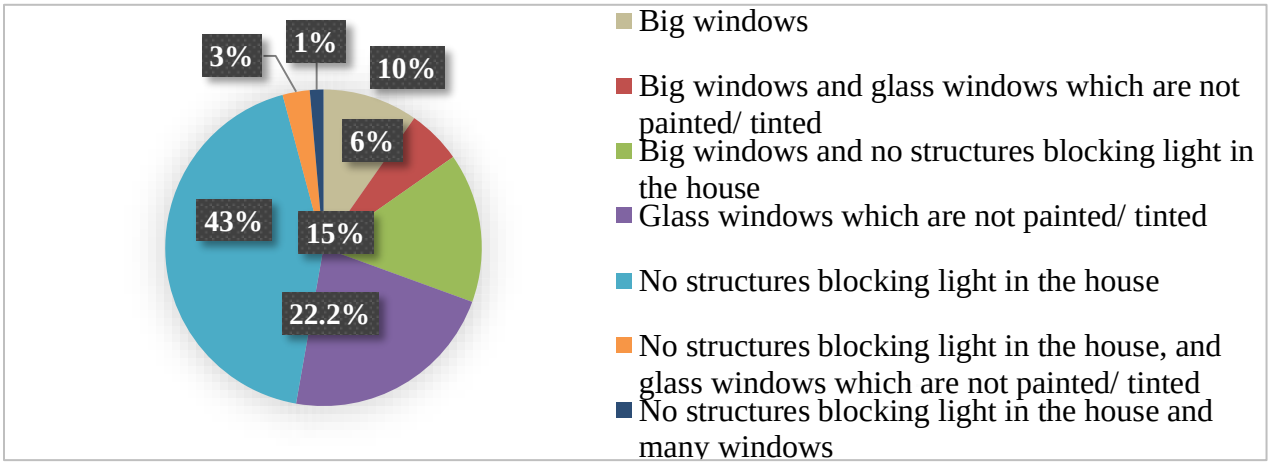
Variable	Categories	Rickets cases N (%) Frequency (N=189)	Non-rickets case N (%) Frequency (N=163)	All children N (%) Frequency (N=352)
Acute malnutrition	SAM	89(47.1)	59(36.2)	149(42.3)
	MAM	100(52.9)	104(63.8)	203(57.7)
Chronic malnutrition	Stunted	66(34.9)	49(30.1)	115(32.7)

	Not stunted	123(65.1)	114(69.9)	237(67.3)
Underweight	Underweight	131(69.3)	123(75.5)	254(72.2)
	Normal weight	58(30.7)	40(24.5)	98(27.8)
Sex	Female	75(39.7)	82(50.3)	157(44.6)
	Male	114(60.3)	81(49.7)	195(55.4)
Age	6 to 23 years	165(87.3)	135(82.8)	300(85.2)
	24 to 59 years	24(12.7)	28(17.2)	52(14.8)
Birth weight	At least 2500gms	155(82.0)	147(90.2)	302(85.8)
	Below 2500gms	34(18.0)	16(9.8)	50(14.2)
Gestational length	At least 37 weeks	161(85.2)	147(90.2)	308(87.5)
	Below 37 weeks	28(14.8)	16(9.8)	44(12.5)
Gestational length and weight	Normal	147(77.8)	143(87.7)	290(82.4)
	Premature/ Underweight	42(22.2)	20(12.3)	62(17.6)
	Premature and underweight	20(10.6)	12(7.4)	32(9.1)
Source of data	MCH booklet	90(47.6)	104(63.8)	194(55.1)
	Recall	99(52.4)	59(36.2)	158(44.9)
Skin color	Black	189(100.0)	163(100.0)	352(100.0)
Previous MAM admission	No	127(67.2)	119(73.0)	246(69.9)
	Yes	62(32.8)	44(27.0)	106(30.1)
In IMAM programme	No	107(56.6)	92(56.4)	199(56.5)
	Yes	82(43.4)	71(43.6)	153(43.5)
Routine GMP	Stopped	14(7.4)	10(6.2)	24(6.8)
	Ongoing	175(92.6)	153(93.9)	328(93.2)
Fully immunized	No	6(3.2)	0(0.0)	6(1.7)
	Yes	184(97.4)	162(99.4)	346(98.3)
Vitamin A supplementation	No	8(4.2)	10(6.1)	18(5.1)
	Yes	181(95.8)	153(93.9)	334(94.9)
Housing	Storey house	46(24.3)	40(24.5)	86(24.4)
	Non storey house	143((75.7)	123(75.5)	266(75.6)
Daytime caretaker	Mother	179(94.7)	143(87.7)	322(91.5)
	Not the mother	10(5.3)	20(12.3)	30(8.5)
Adequate sunshine in the house	No	120(63.5)	88(54.0)	208(59.1)
	Yes	69(36.5)	75(46.0)	144(40.9)
Sunlight exposure	No	8(4.2)	14(8.6)	22(6.3)
	Yes	181(95.8)	149(91.4)	330(93.8)
Daily hours of sunlight exposure	Less than 1hr	136(72.0)	134(82.2)	270(76.7)
	At least 1hr	53(28.0)	29(17.8)	82(23.3)
Nutritional rickets	Positive	189(100.0)	0(0.0)	189(53.7)
	Negative	0(0.0)	163(100.0)	163(46.3)

Visible signs of rickets	Yes	110(58.2)	42(25.8)	152(43.2)
	No	79(41.8)	121(74.2)	200(56.8)
Previously tested for rickets	Yes	81(42.9)	65(39.9)	146(41.5)
	No	108(57.1)	98(60.1)	206(58.5)
Previous positive rickets test results	Yes	81(42.9)	31(19.0)	112(31.8)
	No	108(57.1)	132(81.0)	240(68.2)
Exclusive breastfed	Yes	139(73.5)	110(67.5)	249(70.7)
	No	50(26.5)	53(32.5)	103(29.3)
Still breastfeeding	Yes	149(78.8)	114(69.9)	263(74.7)
	No	40(21.2)	49(30.1)	89(25.3)
Complementary feeding	Before 6 months	50(26.5)	53(32.5)	103(29.3)
	At 6 months	113(59.8)	96(58.9)	209(59.4)
	At 7 months	24(12.7)	14(8.6)	38(10.8)
	Beyond 7 months	2(1.1)	0(0.0)	2(0.6)
Child fed on infant formula	Yes	24(12.7)	8(4.9)	32(9.1)
	No	165(87.3)	155(95.1)	320(90.9)
Calcium supplementation	Yes	79(41.8)	71(43.6)	150(42.6)
	No	110(58.2)	92(56.4)	202(57.4))
Vitamin D supplementation	Yes	34(18.0)	44(27.0)	78(22.2)
	No	155(82.0)	119(73.0)	274(77.8)

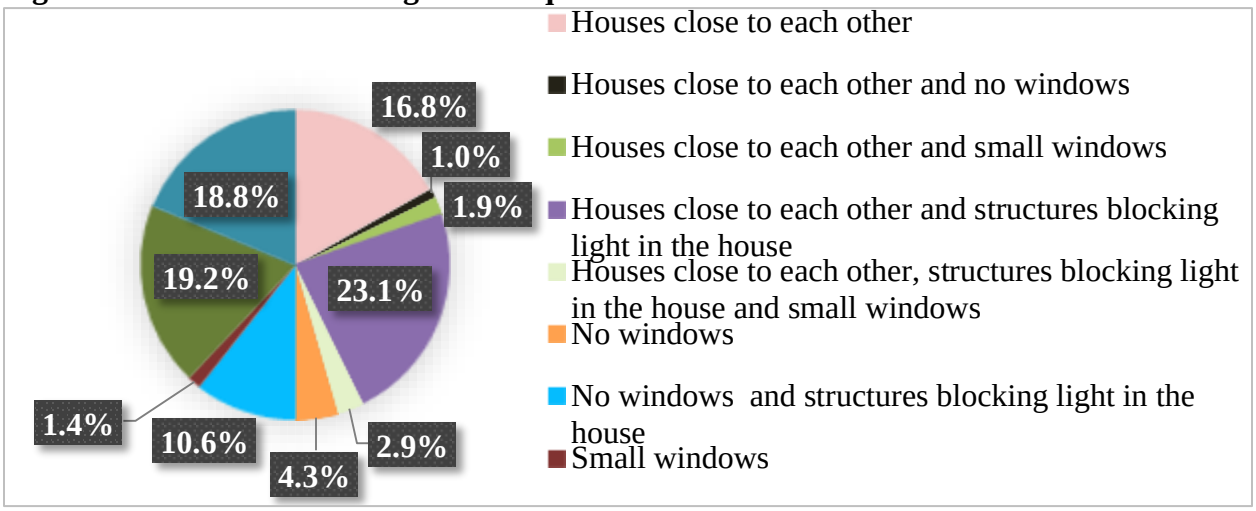
Out of a total of 352 respondents, 40.9% reported having adequate sunlight penetration in their houses as presented in table 2. The explanation given for this was that the houses they resided in had large windows, others had windows that were not painted which allowed sunshine penetration and, there were no structures blocking sunlight penetration in the houses. Figure 6 presents the combination of responses given. The key reason given by 43.1% of the caregivers was that there were no structures blocking sunlight penetration in their houses.

Figure 6: Factors contributing to adequate sunshine in the house



Inadequate sunlight in the houses was reported by 59.1% of the respondents. This was attributed to house designs and environmental factors as shown in figure 7. Majority of the respondents (23.1%) cited congestion of houses and having structures blocking sunlight from the houses as the main reason for not having sunshine penetration in their houses. Other reasons given were: the houses having small (1.4%) and no windows (4.3%). Small or no windows is a common structural characteristic of houses in informal settlements where most of the respondents resided.

Figure 7: Factors contributing to inadequate sunshine in the house



Majority (93.8%) of the children were exposed to direct sunlight either in or outside the house. However, the hours and proportion of the body exposed varied as summarized in table 3. Out of a

total of 330 respondents who reported to be exposing the index children to direct sunlight either inside or outside the house, 24.8% exposed their children to sunlight for at least one hour daily with or without clothes covering both hands and legs and only 6.6% exposed their children to direct sunlight for at least one hour daily without clothes covering the hands and legs.

Table 3: Distribution of study children by daily hours of sunlight exposure

Daily sunlight exposure	Clothes covering hands and legs	No clothes covering hands and legs	Grand Total
Less than 1hr	68.8%	6.4%	75.2%
At least 1hr	18.2%	6.6%	24.8%
Grand Total	**87.0%**	**13.0%**	**100.0%**

The reasons for exposing children to direct sunlight varied across the 330 caregivers. Half (50.0%) cited vitamin D as the sole reason for exposing their children to sunlight. Other reasons given were: for prevention of rickets, for strong bones, for the child to gain strength or energy and for calcium.

Figure 8: Reasons for exposing children to sunlight

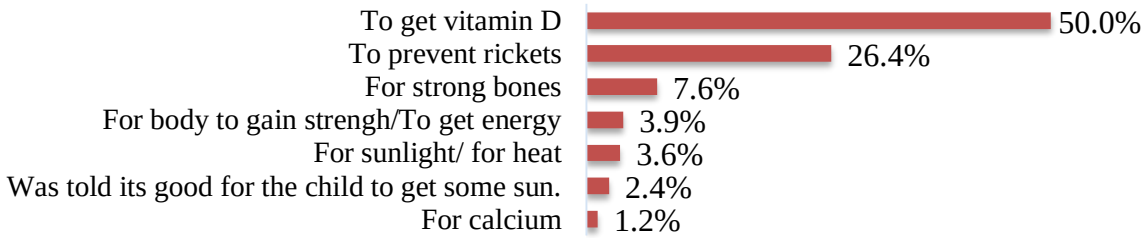
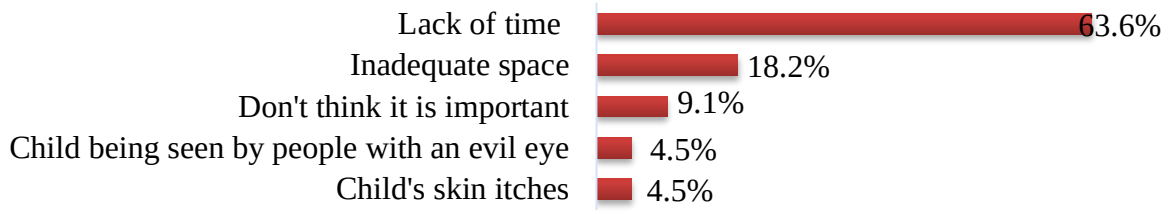


Figure 9 below summarizes the reasons given by 22 respondents who formed 6.3% of the total respondents for not exposing their children to direct sunlight. Majority (63.6%) of the caregivers reported they did not have time to bask in the sun with their children as they were busy with work or fending for the family. Lack of space to sit outside due to congestion in the places of residence was also cited by 18.2% of the respondents. Cultural barrier of the child being seen by people with a bad eye was also reported by 4.5% of the respondents. Other barriers to sunlight exposure were

from the FGDs were religion: *"I cannot go against religion and put my child outside without covering them. I also do not dress down when going out."*

Figure 9: Barriers to sunlight exposure



4.3.2.2. Children with a positive rickets test result

More than half (53.7%) of the sampled children tested positive for rickets, 60.3% of who were male. These were both newly diagnosed and t cases of rickets under medication and on follow up as presented in table 2 above. The mean age was 14.7 months. The rates of severe and moderate acute malnutrition among this category of children were 47.1% and 52.9% respectively. Further, 34.9% and 69.3% of the children were stunted and underweight respectively. Majority (87.3%) of the rickets cases were in the 6 to 23 months age bracket.

Majority (77.8%) of the rickets cases were born at a normal weight and gestational length. Cumulatively, 22.2% were born either underweight or premature while 10.6% were born both premature and underweight. Recall was the main source of child data at 52.4%. Majority of the children were still attending GMP sessions, were fully immunized and had received vitamin A supplementation in the past 6 months at 92.6%, 97.4% and 95.8% respectively. All the children (6) who had not been fully immunized in this study tested positive for rickets.

Previous diagnosed and treated cases of acute malnutrition were at 32.8%, with 43.4% being on nutrition treatment and rehabilitation at the time of the interview. All the children (42.9%) who

had a previous rickets test had tested positive for rickets. Clinical signs and symptoms of rickets were visible in 58.2% of the children with a positive rickets test result.

Optimal infant young feeding practices of exclusive breastfeeding for the first six months of life and timely introduction of complementary feeding were at 59.8% and 73.5% respectively. Further, 78.8% of the rickets cases were still breastfeeding at the time of data collection. Mothers formed 94.7% of the main care takers of the children during the day with 75.7% residing in non storey houses in informal settlements in Nairobi.

4.2.3. Maternal knowledge on nutritional rickets

Maternal knowledge on vitamin D, calcium and rickets was assessed through both FGDs and one on one interviews with the primary caregivers. From the interviews conducted, 85.2% of the caregivers had heard of the term vitamin D, 80.7% had heard about calcium while 94.3% had heard about rickets. In the FGDs, knowledge levels were higher in the children who tested positive for rickets compared to the ones who did not.

Table 4: Knowledge on vitamin D, calcium and rickets

Variable	Categories	Rickets cases N=189	All children N=352
Ever heard of the term vitamin D	Yes	155(82.0)	300(85.2)
	No	34(18.0)	52(14.8)
Ever heard of the term calcium	Yes	157(83.1)	284(80.7)
	No	32(16.9)	68(19.3)
Ever heard of the term rickets	Yes	17(94.7)	332(94.3)
	No	10(5.3)	20(5.7)

The main functions of vitamin D and calcium in the body as reported by the caregivers in the questionnaires were: for formation of bones and for strong bones as outlined in table five below. Caregivers who had heard of either calcium or vitamin D but did not know their functions in the body were 18.7% and 14.8% respectively. Other functions given were immunity, strengthening of

teeth, aiding in absorption on calcium-for vitamin D and aiding absorption of vitamin D-for calcium.

Table 5: Functions of calcium and Vitamin D in the body

Functions in the body	Vitamin D N=300	Calcium N=284
Formation of bones, for strong bones	129(43.0)	98(34.5)
Don't know	56(18.7)	42(14.8)
For strong bones	33(11.0)	31(10.9)
Formation of bones	16(5.3)	17(6.0)
Formation of bones, for strong teeth	10(3.3)	18(6.3)
Formation of bones, for strong bones, immunity	9(3.0)	13(4.6)
Immunity	9(3.0)	14(4.9)
For strong bones, Immunity	8(2.7)	7(2.5)
Formation of bones, for strong bones, for strong teeth	6(2.0)	37(13.0)
Formation of bones, Immunity	6(2.0)	2(0.7)
For calcium absorption	6(2.0)	0(0.0)
Formation of bones, for strong bones, absorption of calcium	4(1.3)	0(0.0)
Immunity, Helps in the absorption of calcium	4(1.3)	0(0.0)
Helps in the absorption of calcium, for formation of bones	2(0.7)	0(0.0)
Immunity, helps in the absorption of calcium, for strong bones	2(0.7)	0(0.0)
For strong teeth	0(0.0)	1(0.4)
Immunity, for vitamin D absorption, for strong bones	0(0.0)	2(0.7)
For vitamin D absorption, formation of bones, for strong bones	0(0.0)	2(0.7)

Majority (80.3%) of the respondents who had heard about vitamin D could list at least one food source of vitamin D while 19.7% did know of any food or other source of vitamin D. Similarly, majority (82.3%) of the caregivers could also list at least one food source of calcium. Flesh foods and dairy products were listed as the main sources of both calcium and vitamin D. Cumulatively only five people listed fortified foods as a source of vitamin D (1.0%) and calcium (1.8%) in combination with other sources. The other source of vitamin D cited was sunshine.

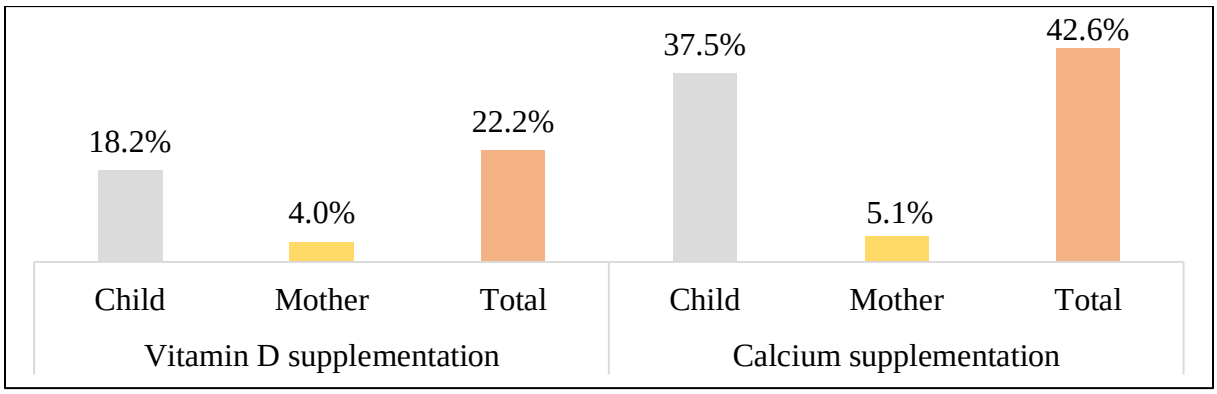
In the FGDs, the sources of calcium and vitamin D listed were sun rays, eggs, milk and green leafy vegetables. "*I know from when I was a child that we bask out in the sun for vitamin D and also to get strength.*" "*Calcium is mainly from eggs and milk but I am not sure if it is fresh or fermented milk.*" "*Vegetables like mrenda also have vitamin D and calcium that is why my bones are strong.*"

Table 6: Food sources of vitamin D and calcium

Food sources	Vitamin D N=300	Calcium N=284
Don't know	59(19.7)	50(17.6)
Dairy products and Flesh foods	59(19.7)	34(12.0)
Flesh foods, fruits &vegetables, legumes and nuts	31(10.3)	7(2.5)
Dairy products, Eggs, Flesh foods	18(6.0)	17(6.0)
Dairy products, Flesh foods, Fruits and vegetables	17(5.7)	10(3.5)
Dairy products and, Legumes and nuts	16(5.3)	9(3.2)
Flesh foods and, Fruits and vegetables	14(4.7)	1(0.4)
Fruits and vegetables	13(4.3)	3(1.1)
Dairy products, Flesh foods, Legumes and nuts	12(4.0)	68(23.9)
Flesh foods, Fruits & vegetables, Dairy products, legumes & nuts	2(0.7)	11(3.9)
Dairy products, Eggs, Flesh food and Legumes, nuts	5(1.7)	15(5.3)
Dairy products	3(1.0)	9(3.2)
Dairy products, Grains, roots and tubers	2(0.7)	5(1.8)
Fruits & vegetables, Grains, roots, tubers and, Legumes & nuts	4(1.3)	1(0.4)
Legumes and nuts, Grains, roots and tubers	4(1.3)	0(0.0)
Fruits and vegetables Legumes and nuts	0(0.0)	5(1.8)
Grains, roots and tubers Eggs Fruits and vegetables	0(0.0)	5(1.8)
Dairy products, Fortified foods	0(0.0)	5(1.8)
Supplements, Flesh foods, Dairy products & Legumes & nuts	0(0.0)	4(1.4)
Dairy products, Fruits and vegetables and Legumes and nuts	4(1.3)	0(0.0)
Fruits and vegetables, Eggs, Legumes and nuts, Flesh foods	4(1.3)	1(0.4)
Flesh foods and Grains, roots and tubers	3(1.0)	0(0.0)
Dairy products and Fortified foods	3(1.0)	0(0.0)
Legumes and nuts	3(1.0)	0(0.0)

While supplements were not listed as a main source of either vitamin D or calcium, 22.2% and 42.6% of the children and respondents had been supplemented with vitamin D and calcium respectively as presented in figure ten below. The caregivers had received vitamin D supplements when they were breastfeeding the index child. The reason for supplementation was listed as prescription from a doctor for the children and mothers.

Figure 10: Children and caregivers supplemented with Vitamin D and calcium



The two main sources of information on calcium, rickets and vitamin D were health workers and books. While majority of the respondents could remember where they had obtained information on both micronutrients, 10.7% and 8.5% of the respondents could not remember the sources of information on vitamin D and calcium respectively as illustrated in table 6. Social media, mainstream media and community health workers ranked low as sources of information. From the questionnaires and FGDs, health workers (nurses and doctors) were reported as the main sources of information on both vitamin D and calcium. "*I heard about vitamin D from the nurse when I had taken my child for immunization.*" "I *was told to be giving my child milk for calcium by the nurse when my child was unwell."* "*I heard about vitamin D when they were advertising blue band on the radio.*" "I *heard about it in our village women group when the community health worker was explaining to us how to feed our children." "Calcium is from fish and omena. You can also add ground omena to porridge flour".*

Further, the signs and symptoms of rickets listed by the caregivers whose children had tested positive for rickets were: "*A child with bowed legs has rickets." "Weak bones like my child – she cannot stand on her own yet she is more than two years old." "A child with knock knees and "My child's legs also broke and I was told it was because he had low calcium*".

Table 7: Sources of information on vitamin D, calcium and rickets

Source of information	Vitamin D (N=300)	Calcium (N=284)	Rickets (N=332)
Health workers	206(68.7)	206(72.5)	254(77.0)
Books	40(13.3)	30(10.6)	51(15.5)
Don't know	32(10.7)	24(8.5)	0(0.0)
Books, Health workers	8(2.7)	8(2.8)	6(1.8)
Peers	8(2.7)	4(1.4)	12(3.6)
Health workers, Peers	4(1.3)	2(0.7)	2(0.6)
Health workers, Community health workers	2(0.7)	0(0.0)	0(0.0)
Social Media	0(0.0)	4(1.4)	1(0.3)
Books, Peers	0(0.0)	2(0.7)	2(0.6)
Community health workers	0(0.0)	2(0.7)	2(0.6)
Broadcast media (Radio, TV)	0(0.0)	2(0.7)	2(0.6)

Lack of adequate sunlight exposure, calcium and vitamin D deficiency and; suboptimal complementary feeding was listed as the main causes of rickets in both the FGDs and questionnaires. From the questionnaires, 12.7% of the respondents could not list any causes of rickets. The combination of responses given by the caregivers is as in table 8. From the FGDs, all the caregivers understood the importance of exposing their children to direct sunlight to prevent rickets but did not know how long they should expose their children to sunlight. Other risk factors of rickets were: "*The child not eating a balanced diet*", "*Not eating a proper meal like ugali, vegetables, meat and milk*" "*Not eating proper meals for bones like omena*5, fish*3, milk*3, eggs, vegetables e.g., mrenda and wimbi porridge*", "*Not giving children foods rich in calcium-I know calcium deficiency mainly affects small children*" "*I was told that vitamin D deficiency is caused by not exposing children of sunshine when they are young and this causes rickets*." "*My child was given calcium tablets to take and she is still taking them and eating calcium rich foods*", "*Mine has finished the calcium tablets prescribed and we are here today to test again. I also gave the child milk, fish and omena after the first test.*"-Caregivers FGDs. Further, some misconceptions were also reported where a caregiver highlighted that "*I was informed not to give my child milk until they get to 1 year that it is not good for the child.*" Other factors listed in the KIIs were: "The

major cause or rickets here is lack of knowledge on calcium and binding agents by the caregivers and poor feeding practices: cooking and mixing porridge flour."-Nutrition worker KII.

Table 8: Risk factors for rickets

Risk factor	N=332
Lack of adequate sunshine exposure, Vitamin D deficiency	90(27.1)
Calcium deficiency, Lack of adequate sunshine exposure	73(22.0)
Lack of adequate sunshine exposure	71(21.4)
Don't know	42(12.7)
Vitamin D deficiency	19(5.7)
Calcium deficiency	13(3.9)
Lack of adequate sunshine exposure, Vitamin D and calcium deficiency	10(3.0)
Suboptimal complementary feeding	8(2.4)
Calcium deficiency, Vitamin D deficiency	4(1.2)
Calcium deficiency, Suboptimal complementary feeding	2(0.6)
Total	**332**

Majority (77.7%) of the respondents who had heard about rickets could list at least one way in which they thought rickets is treated while 22.3% did not know. The main treatment methods listed were: exposure to direct sunshine, calcium and vitamin D supplementation. Table 8 summarizes the responses given from the questionnaires. The treatment options given in the FGDs were: *"My child was given calcium tablets to take and she is still taking" "My child was also given calcium tablets and I was asked to be sitting outside with him as treatment", "Taking calcium tablets like the ones given to my child and also physiotherapy which is done on a weekly basis here".*

Table 9: Treatment for rickets

Treatment options	N=332
Staying outside in the sun, Calcium supplementation	84(25.3)
Don't know	74(22.3)
Staying outside in the sun	70(21.1)
Staying outside in the sun, Supplementation with vitamin D	70(21.1)
Staying outside in the sun, Supplementation with calcium, Supplementation with vitamin D	20(6.0)
Supplementation with calcium	10(3.0)
Supplementation with calcium, Supplementation with vitamin D	4(1.2)

4.2.2. Dietary assessment

Table 10 presents results of the food frequency interview. Consumption of dairy products and amaranth was reportedly high over the seven days preceding the interview at 62.2% and 57.4% daily consumption respectively. Consumption of infant formula, fortified soy milk and cod liver oil was low among all the children over the last seven days. All children were reported to having not consumed infant formula in the week preceding the interview while 99.1% and 91.8% had not taken fortified soy milk and cod liver oil respectively. Consumption of calcium and vitamin D fortified foods was also low at 64.8%. All the children who tested positive for rickets had not consumed infant formula and fortified soy milk over the past seven days preceding the interview.

Table 10: Food consumption frequency in the past 7 days

Food item	Consumption in the past 7 days					
	All children(N=352)					Rickets cases (N=189)
	Never	At least once	2 to 4 days	5 to 6 days	Daily	At least once
Cod liver oil	323(91.8)	0(0.0)	0(0.0)	0(0.0)	29(8.2)	15(7.9)
Dagaa Fish	189(53.7)	119(33.8)	34(9.7)	0(0.0)	10(2.8)	82(43.4)
Amaranth	79(22.4)	16(4.5)	51(14.5)	4(1.1)	202(57.4)	151(79.9)
Blue band/margarine	259(73.6)	8(2.3)	8(2.3)	0(0.0)	77(21.9)	63(33.3)
Eggs	165(46.9)	96(27.3)	80(22.7)	2(0.6)	9(2.6)	102(54.0)
Calcium/vitamin D fortified foods	228(64.8)	10(2.8)	56(15.9)	16(4.5)	42(11.9)	89(47.1)
Infant formula	352(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Fortified soy milk	349(99.1)	2(0.6)	0(0.0)	0(0.0)	1(0.3)	0(0.0)
Dairy products	107(30.4)	5(1.4)	16(4.5)	5(1.4)	219(62.2)	151(79.9)

4.3.3. Health care factors

In Mbagathi hospital, provision of nutrition services in the facility was guided by global and Kenya Ministry of health (MoH) guidelines. Anthropometric assessments were taken in the paediatric outpatient department on a daily basis. Routine growth monitoring was conducted from Monday

to Friday in the MCH department. Malnourished cases from both departments were referred to the nutrition clinic. IMAM services were also offered every day in the nutrition department. The POPD, MCH and nutrition clinics were located at different locations in the clinic and some of the referred cases did not go to the nutrition department due to the queues in the different clinics among other factors. Medical assessment was not mandatory before enrolment into the IMAM programme as there was no clinician based in the nutrition clinic. Medical assessments and treatment were only conducted in the POPD where registration fees of Ksh. 200 and 100 were levied for new and return cases respectively.

Nutrition and health education sessions were routinely conducted at the MCH department, one on one nutrition counselling within the nutrition clinic and nutrition education in wards. This was guided by maternal infant and young child (MIYCN) guideline, the infant young child feeding (IYCF) counselling cards and key message booklets (Cards & Workers, n.d.) (Community et al., 2013). In both guidelines, there was no mention of nutritional rickets, calcium and or vitamin D. The IYCF counselling cards had twenty-four topics on exclusive breastfeeding and complementary feeding. From the KIIs with the health workers, the topics are combined during health education sessions. "*Vitamin D and calcium lessons are not very common. We do not cover health messages on rickets unless in health education sessions on mixing of flours in porridge preparation. The other time this is addressed is when cases have already been identified. We do not have guidelines for treatment and screening for rickets in the nutrition clinic*."-Nutrition Staff KII. This is one of the key sources of information on calcium, vitamin D and rickets as reported by some caregivers. "*I heard about vitamin D from the nurse when I had taken my child for immunization*", "I *was told to be giving my child milk for calcium by the nurse when my child was unwell."* Provision of integrated management of acute malnutrition services was guided by the National IMAM guideline

which did not include assessment of vitamin D or calcium deficiency and/ or nutritional rickets. However, medical assessment before admission in the IMAM programme was not adhered to.

The registration fee levied was a key barrier in clinical assessments as was reported by both the caregivers and health workers: "*The challenge is that the caregivers have to pay a registration fee of Ksh. 200 before having their children assessed.*" "*There are a lot of missed opportunities due to lack of medical assessments. Clinical/ physical signs and symptoms can be deceiving."*- Nutrition staff KII "*For you to be seen by a doctor here or in other hospitals, you have to pay registration fee which ranges between Ksh. 30 and 200. Like for me, I bring this child here weekly. I cannot afford to pay for consultation weekly so I just get Plumpy nut and leave.*" "*The money we get is not enough for rent and other uses in the family. So, I end up giving the child what is available.*" – Caregiver FGD.

The recommendations given from the KIIS were:

- All malnourished cases from the nutrition clinic should be given waivers to get comprehensive care.
- We should have a clinician in the nutrition department to take samples, run tests and give results. It will also make it easier to track progress by linking nutrition cases to one clinician.
- Routine health discussions in FGDs for rickets, calcium and vitamin D deficiency. We should have outreaches in the community. Referrals are only done when there are campaigns (polio, malezi bora and self-referrals by the CHVs) or when severe cases are referred.
- Vitamin D supplements are also quite expensive and not available in the hospitals. 2 years ago, the supplements were available but now they are not.

4.4. Bivariable analysis

Table 11 below gives a summary of the bivariable analysis for maternal and child predictor variables with a significant relationship with nutritional rickets.

4.4.1. Maternal factors

Among the maternal factors assessed, a significant relationship was only established between knowledge of vitamin D (P=0.07, OR=0.6), main breadwinner (P=0.00, OR=2.4) and main caretaker of the child during the day (P=0.02, OR=0.4) and; nutritional rickets. There was no significant relationship established between caregivers' age, marital status, level of education, occupation, average household monthly income, number of children, and knowledge of either calcium or rickets and nutritional rickets.

4.4.2. Child characteristics

There was no statistically significant relationship established between nutritional rickets and chronic malnutrition: stunting and underweight. However, there was a statistically significant relationship established between nutritional rickets and categories of acute malnutrition (P= 0.05, OR=1.5).

Majority (58.2%) of the children who had clinical signs and symptoms of rickets tested positive for rickets. Further, a significant relationship was established between presence of clinical signs and symptoms of rickets and nutritional rickets (P=0.00, OR=4.0). However, having had a previous rickets test had no significant relationship with nutritional rickets.

There was a significant relationship established between sex (P=0.05, OR=1.5), birth weight (P=0.03, OR=0.5), and a combination of gestational length and weight (P=0.02, OR=0.5) and; nutritional rickets. However, there was no relationship established between gestational length and

rickets. While majority (87.3%) of the rickets cases were among infants and young children 6 to 23 months, there was no significant relationship established between child's age and rickets.

The relationship between nutritional rickets and child care practices, living environment and feeding practices varied. There was no significant relationship established between having been exclusively breastfed and nutritional rickets. However, there was a significant relationship established between continued breastfeeding and nutritional rickets (P=0.06, OR=0.6).

In this study, timely initiation of complementary feeding, vitamin A and D supplementation and consumption of dairy products, eggs, amaranth, dagaa fish and cod liver oil in the past seven days had no significant relationship with nutritional rickets. Consumption of infant formula regardless of duration (P=0.06, OR=0.7), calcium/vitamin D fortified foods and (P=0.01, OR=0.4) blue band/margarine (P=0.00, OR=0.4) in the past 7 days had a significant relationship with nutritional rickets. Further, calcium supplementation (P=0.06, OR=0.7) also had a significant relationship with nutritional rickets.

Sunlight exposure (P=0.09, OR=2.1) and average daily hours of sunlight exposure (P=0.02, OR=1.8) had a significant relationship with nutritional rickets. County and type of house the children resided in had no significant relationship with nutritional rickets.

Table 11: Bivariable analysis

Variable	Category	Frequency (N)	Odds ratio (OR)	90% confidence interval		Significance
				Lower	Upper	
Sex	Male	114	1.5	1.1	2.4	$\chi2 = 3.998$, df=1, p value=0.046
	Female	75				
Acute malnutrition	SAM	89	1.5	1.1	2.2	$\chi2 = 3.789$, df=1, p value=0.052
	MAM	100				
Birth weight	At least 2500gm	155	0.5	0.3	0.8	$\chi2 = 4.798$, df=1, p value=0.028

	Below 2500gm	34				
Continued breastfeeding	Yes	149	0.6	0.4	0.9	$\chi 2$ =3.667, df=1, p value=0.055
	No	40				
Consumption of infant formula	Yes	24	0.4	0.2	0.7	$\chi 2$ =6.427, df=1, p value=0.011
	No	165				
Main caretaker	Mother	179	0.4	0.2	0.8	$\chi 2$ =5.468, df=1, p value=0.019
	Non-mother	10				
Main breadwinner	Mother	167	0.4	0.3	0.7	$\chi 2$ =9.222, df=1, p value=0.002
	Non-mother	22				
Calcium supplementation	Yes	89	0.7	0.5	1.0	$\chi 2$ =3.344, df=1, p value=0.067
	No	100				
Knowledge on Vitamin D	Yes	155	0.6	0.3	0.9	$\chi 2$ =3.354, df=1, p value=0.067
	No	34				
Sunlight exposure	Yes	181	2.1	1.0	4.5	$\chi 2$ = 2.834, df=1, p value=0.092
	No	8				
Clinical signs of rickets	Yes	110	4.0	2.7	5.9	$\chi 2$ = 37.525, df=1, p value=0.000
	No	79				
Consumption of calcium/vitamin D fortified foods in the past 7 days	Yes	89	0.6	0.4	0.8	$\chi 2$ = 6.450, df=1, p value=0.011
	No	100				
Consumption of blue band/ margarine in the previous 7 days	Yes	63	0.4	0.2	0.7	$\chi 2$ = 10.033, df=1, p value=0.002
	No	126				
Normal birth weight and age	Yes	42	0.5	0.3	0.8	$\chi 2$ = 5.974, df=1, p value=0.015
	No	147				
Average daily hours of sunlight exposure	Less than 1 hour	136	1.8	1.2	2.8	$\chi 2$ = 5.147, df=1, p value=0.023
	At least one hour	53				

4.5. Multivariable analysis

Multivariable analysis was conducted for predictor variables that had a significant relationship with nutritional rickets in the bivariable analysis using multivariable logistics regression. This was based on the odds ratio (OR) and level of significance of 0.1 and 90% confidence interval for the bivariable results. In the first step of multivariable analysis, some predictor variables were removed from the model as the relationship between the variables and nutritional rickets was non-significant. These included: categories of acute malnutrition, birth weight, consumption of infant formula, and calcium/vitamin D fortified foods in the past seven days. The results for the second level of the multivariable multivariate logistics analysis are as presented in table 12.

Table 12: Multivariable analysis

Variable	Category	B	Sig.	Exp(B)	90% C.I. for EXP(B)	
					Lower	Upper
Sex of the child	Female	-.479	.039	.619	.423	.907
Continued breastfeeding	Yes	-.510	.055	.600	.388	.930
Consumption of infant formula	Yes	-1.427	.004	.240	.107	.539
Main breadwinner	Mother	.465	.094	.586	.990	.347
Main caretaker	Mother	1.416	.002	4.122	1.918	8.860
Ever heard of the term vitamin D	No	.645	.062	1.906	1.080	3.363
Calcium supplementation	No	.498	.040	1.645	1.104	2.451
Daily hours of sunlight exposure	Less than one hour	.643	.024	1.901	1.189	3.040
Consumption of blue band/margarine in the past 7 days	Yes	-.836	.003	.434	.274	.685
Constant		2.799	.000	16.434		

The relationship between the predictor variables and nutritional rickets is as summarized in the equation:

Figure 11: Regression formula

Odds of testing positive for rickets *= 16.434 + 0.6 female + 0.6 continued breastfeeding + 0.2 consumption of infant formula + 0.6 maternal breadwinner + 4.1 non-mother main caretaker + 1.9 never heard of vitamin D + 1.6 no calcium supplementation + 1.9 less than one-hour daily sunlight exposure + 0.4 consumption of blue band/margarine in the past 7 days*

The figures in the equation represent the odds of testing positive for nutritional rickets for all the predictor variables holding all other factors constant. In summary, the odds of testing positive for nutritional rickets reduced if the sex of the child was female at 0.6 times holding all the predictor variables constant. There was a similar relationship for continued breastfeeding, consumption of infant formula and consumption of blue band/margarine in the past 7 days at 0.6, 0.2 and 0.4 times respectively.

The odds of testing positive for nutritional rickets increased 4.1, 1.9, 1.6 and 1.9 times each if the child was mainly taken care of another person who was not the mother, the mother had not heard about vitamin D, the child was not supplemented with calcium or the child was exposed to less than one hours daily respectively each holding all other predictor variables constant.

CHAPTER 5: DISCUSSION

5.1. Introduction

This chapter discusses the study's results in relation to the objectives as well as relevant comparisons made with findings from different studies in literature. While there has been a number of studies investigating rickets and malnutrition in Kenya, this is the first study assessing the proportion of nutritional rickets (NR) among acute malnourished children in a referral hospital. Conclusions and recommendations are summarized and areas for future research proposed.

Nutritional rickets can be classified as a form of malnutrition as it mainly results from vitamin D deficiency which affects the absorption of calcium and phosphorus (*JCRPE ic sayfalar 2010-4linkli _ Enhanced Reader.pdf*, n.d.).

5.2. Undernutrition

The proportion of SAM cases in this study was high at 42.0% and at a ratio of 0.7 to MAM cases. This could be attributed to Mbagathi hospital being a referral hospital where children with acute malnutrition are referred to for further investigations. There are profound changes in physiology, metabolism and immunological status associated with severe acute malnutrition which leads to complications or treatment outcomes that require specialized medical treatment that is not available in level 2 and 3 facilities hence high referral rates. The rates of underweight and chronic malnutrition were 72.2% and 32.7% respectively. This was above the 26% and 11% national levels as reported in the 2014 Kenya Demographic and Health Survey (GAM) rate of 6% (Of, 2009) (National Bureau of Statistics-Kenya and ICF International, 2015) and 9.6% and 24% rates in Nairobi respectively (*NAIROBI COUNTY SMART SURVEY REPORT*, 2020). The high rates could

be attributed to the target population being acutely malnourished which contributes to both stunting and underweight (Nutrition & All, n.d.). Additionally, the causal factors for undernutrition are similar hence, the four forms may occur together.

There was a significant relationship established between categories of acute malnutrition and NR in the bivariable analysis. However, this relationship was not significant in the multivariable analysis. This meant that the relationship between categories of acute malnutrition and NR was as a result of other predictor variables. There was no significant relationship established between underweight and stunting and nutritional rickets in both models. The results of this study are contradictory to two similar studies carried out among SAM cases in the same county which highlighted there was an association between both SAM and stunting with nutritional rickets (K. D. J. Jones et al., 2018). However, despite this relationship not being significant, the more than 50% of NR cases in this target group highlights a need to assess NR which is as a result of micronutrient deficiency, a category of undernutrition, as part of management of acute malnutrition.

The lack of association between stunting and NR, and the low stunting rates compared to the other categories of malnutrition in the study could be attributed to NR being associated with increased linear growth among children hence reducing the rates of stunting (Ngari et al., 2018) (Crowe et al., 2021). Despite underweight not being associated with NR, 69.3% of the nutritional rickets cases were underweight. This was in line with a study carried out in Saudi Arabia where children with rickets were reported to have lower body mass index (BMI) compared to children without NR (Abdulbari Bener & Hoffmann, 2010).

Around a third of the children who tested positive for rickets had been admitted and discharged from a nutrition supplementation program prior to the current acute malnutrition episode. While the discharge outcomes were not explored, this indicates that rickets is a common condition in this group of children. Treatment proxy coverage was lower than the sphere standards of 50% for urban centers for all the categories (Principles et al., n.d.). The caregivers whose children were not enrolled in feeding programmes cited not knowing their children were having malnutrition and stock outs leading to reduced morale to take children to the clinics as the main reasons why their children were not enrolled in any programme. Stock outs as a barrier to nutrition seeking behavior was also echoed by the health workers. Further, SAM and MAM treatment regime requires that the children be taken to the clinic on a weekly and biweekly basis respectively and due to the low economic status and non-formal employment among the caregivers, this affected the clinic attendance.

5.3. Risk factors for nutritional rickets

5.3.1. Child characteristics

5.3.1.1. Sex

Majority (60.3%) of the nutritional rickets cases were male. Further, in this study, there was a significant relationship established between sex of the child and rickets with the odds of testing positive for rickets being 0.6 times that of boys. This was in line with a study carried out in a specialized SAM pediatric center in Yemen assessing prevalence of nutritional rickets among symptomatic children and associated risk factors, where high rates of nutritional rickets were reported in males as compared to females (Mohanna, 2015). In similar studies assessing nutritional rickets in Turkey, Nigeria, Catalonia in Spain, Erzurum, Tehran and Sydney the proportions of males with NR were 71%, 75%, 55%, 60%, 63%, 64% respectively. The study also recommended

that gender should be a key consideration when assessing the causes of rickets. While the relationship between sex and NR has been attributed to oestrogen's inhibitory effect on resorption of calcium in bones(Bicakci, 2005), other studies highlight that there is no biological factors of being male or female that predispose children to NR attributing the relationship to composition of the study groups and distribution of other predisposing factors for example genetics factors (Elidrissy et al., 2012). In this study, there were more boys than girls with a difference of almost 10.0%.

5.3.1.2. Age

The 6-23 months age category had more cases of nutritional rickets at 87.3% compared to 24-59 months. The mean ages of rickets and non-rickets cases were both below two years of age at 14.7 and 16.1 months respectively. There was no significant relationship established between age and NR in this study. The findings in this study are in line with other studies assessing nutritional rickets, where the less than two years age category was found to be the peak for development of rickets with others scaling down the category to between three and 18 months; and 6 to 24 months (Sahay & Sahay, 2013)(Carol L. Wagner & Greer, 2008)(Aidah & Mohanna, 2016)(Mahmoud et al., 2016)(Kumar, 2010) (WHO, 2019a). Based on studies conducted in North Africa and Nigeria the occurrence of rickets in children under 18 months is attributed to vitamin D deficiency while in children over 24 months is attributed to calcium deficiency (Thacher et al., 2006). Further, the 6-23 months age category forms part of the first 1000 days of life, a period in which young children and infants experience rapid growth and high demands of phosphate and calcium in their bodies to develop and strengthen bones (Chanchlani et al., 2020).

5.3.1.3. Preterm birth and low birth weight

The relationship between preterm and low birth weight (LBW) with nutritional rickets in this study varied. Combined, there was a significant relationship between both prematurity and LBW and nutritional rickets in the bivariable analysis. There was also a significant relationship between birth weight and NR. Being born normal and at a normal gestational weight reduced the odds of testing positive for nutrition rickets by 50% each. However, holding all other factors constant in the multivariable analysis, the relationship was not significant. Prematurity did not have a significant relationship with NR both in the bivariable and multivariable analysis. There was also a significant relationship established between birth weight and gestational length making them confounding variables with infants born premature having higher chances of being underweight.

The relationship between birthweight and NR was in line with a systematic review by WHO where low birth weight infants had a 55.0% prevalence of rickets (WHO, 2019a). While there has been a study in KNH reporting a prevalence of up to 60.0% of rickets in premature infants (John & Nairobi, 2009 n.d.), there was no such relationship established in this study. Preterm and low birth weight children have been reported to have higher probability of developing rickets. This is because they do not get to benefit fully from the bone minerals accretion process which normally occurs in the third trimester of pregnancy (Embleton & Wood, 2014).

5.3.1.4. Child care and feeding practices

The rate of exclusive breastfeeding (EBF) was lowest among children who did not test positive for rickets at 67.5% compared to all sampled children and rickets cases which was at 70.7% and 73.5% respectively. This was higher than the national average EBF rate of 61.4% but below the national target of 80.0% (*Factors affecting WHO breastfeeding recommendations in Kenya _ Elsevier*

Enhanced Reader.pdf, n.d.).This could be attributed to the high advocacy by the government and other stakeholders on importance of exclusive breastfeeding for the first 6 months of life. While this is a positive IYCF practices indicator, human milk has been reported to be an insufficient source of vitamin D because of poor penetrance of vitamin D and 25-hydroxyvitamin D [25(OH)D] in milk (Hollis et al., 2015) (Pehlivan et al., 2003). Studies have indicated that breast milk cannot be depended upon as the main source of vitamin D with recommendations being made on supplementation for children less than 6 months (Bishop et al., 2018) (Balasubramanian & Ganesh, 2008) (WHO, 2019a) ((Rajakumar & Thomas, 2005). However, the relationship between EBF and NR in this study was not significant. This relationship could be attributed to the target age for this study where all the children had already been introduced to complementary feeding and exposed to other factors for example sunlight exposure.

Sub optimal complementary feeding practices is a major cause of both acute and chronic malnutrition among children 6-59 months. Initiation of solid, liquid and semi solid foods should be done at 6 months of age as breastmilk is no longer adequate to meet the nutritional requirements of the infant (Rajakumar & Thomas, 2005). Timely introduction of complementary feeding was at 57.7% while 13.8% of the children with rickets had late introduction of complementary feeding at 7 months and beyond. Late introduction of complementary feeding is a risk factor for all forms of malnutrition and nutritional rickets as it deprives the child of nutrients needed for growth and development at that specific age. In this study however, there was no such relationship established. This could be attributed to timely initiation being one component of optimal complementary feeding whose effectiveness is dependent on quantity, variety, hygiene among other factors.

Continued breastfeeding for two years and beyond is an indicator for optimal complementary feeding. However, it has also been reported to be associated with VDD especially when there is

continued breastfeeding and no vitamin D supplementation. The relationship is mainly based on breastmilk not being a good source of vitamin D and low transferability of vitamin D in breastmilk (Darmawikarta et al., 2016)(Mohanna, 2015). In this study, the relationship between continued breastfeeding and NR was significant with the odds being 0.6 compared to children who had stopped breastfeeding. This indicates that the odds of having a positive rickets test result was lower for the children who were still breastfeeding. This could be attributed to the positive effect of continued breastfeeding on the nutritional status of children 6 to 24 months.

The odds of having nutritional rickets was lower for children who had consumed infant formula regardless of the duration at 0.2 times that of children who had not consumed formula. Infant formula is considered superior to exclusive breastfeeding in terms of vitamin D composition. However, exclusive breastfeeding with vitamin D supplementation is considered a better option as the child gets to benefit from the diverse advantages of exclusive breastfeeding while also not being predisposed to Vitamin D deficiency. Further, the average monthly income for majority of the caregivers in this study was below Ksh.10,000 which is an indicator of low economic status where exclusive breastfeeding should be protected, promoted and safeguarded as infant formula is an expensive option and predisposes children to diarrhea due to poor hygiene practices.

The consumption of calcium and vitamin D rich foods was higher in NR cases than in non-rickets cases. There was also no relationship established between knowledge of nutritional rickets and calcium and testing positive for rickets. Further, vitamin D and calcium supplementation status was higher in the non-rickets that rickets cases. This could be attributed to the cured and prevalent rickets cases that were already on treatment having better feeding habits as part of the treatment regimen. This was evident in the FGDs where caregivers reported to have changed their children's' diets and increased uptake of calcium rich milk including milk after they were diagnosed with

nutritional rickets. Further, 47.1%, 79.9% and 43.4% of the rickets cases had consumed calcium and/or vitamin D rich foods, dairy products and dagaa fish at least once in the 7 days preceding the interview. Consumption of calcium and vitamin D rich and fortified foods have been shown to positively correlate with prevention of nutritional rickets among children (WHO, 2019a). However, absorption of calcium is sometimes inhibited by competing dietary factors such as phytates due to mixing up of flours during porridge preparation (Thacher et al., 2006) (Prentice, 2013). Some of the caregivers of children with nutritional rickets also understood the effects of mixing up flours while preparing porridge for the child as was evident in the FGDs where they highlighted that they initially thought it was a good practice but through health education sessions with medical staff and peers they stopped. This was also echoed by the nutrition staff who cited the binding agents in flours as a major cause of rickets at the facility. Consumption of margarine which is rich in vitamin D over the seven days preceding the interview had a significant relationship with NR.

5.3.1.5. Sunlight exposure

Due to scarcity of vitamin D fortified foods and their high cost, the main source of vitamin D in informal set ups is sunshine exposure (Mithal et al., 2020). Exposing children to sunshine is a care practice that helps in preventing nutritional rickets. This study assessed different aspects of sunlight exposure which included the skin colour, type of house the caregiver/child lived in, amount of sunshine accessible in houses, proportion of the body typically exposed to sunlight and estimated daily hours of sunlight exposure. All the children in this study were of African origin with dark skin colour. Although more than two thirds of study children with rickets lived in non-storey buildings which were mainly temporary houses with small windows or none, there was no significant relationship established between housing (storey or non storey) and nutritional rickets.

This could be attributed to the fact that even the children living in storey houses did not get adequate sunshine with only 35.6% of the children with rickets living in houses with adequate sunlight exposure. While more than 95% of the rickets cases were children who were exposed to sunlight, the hours of sunlight exposure were probably not adequate due to the proportion of the body covered when children were out in the sun. Furthermore, only 6.6% of the rickets cases were exposed to direct sunlight in or outside the house for at least one hour daily without clothes covering legs and arms. The main reason for this was structures that were barring sunlight from getting into the house.

There was a significant relationship established between average daily hours of sunlight exposure and NR with children having less than 1 hour of daily sunlight exposure having 1.8 odds of developing NR compared to those exposed to sunlight for at least one hour daily. The required minimum exposure time of infants to sunshine varies depending on what percentage of the body is exposed. If only the face is exposed, then a minimum of two hours is required weekly. If both the lower and upper extremities are exposed, then one hour per day is adequate (Balasubramanian & Ganesh, 2008). Despite religion not having a significant relationship with nutrition rickets, it was also highlighted as an influencer to sunlight exposure with some caregivers reporting that they can't go against their religion and expose children to sunlight with no covering.

The findings in this study are in line with studies carried out that have highlighted children get less exposure to sunshine as a result of: high-rise buildings and shanties that bar sun rays and do not have adequate sunshine penetration, confinement in the houses during the day due to caregiver's workload, customs and religious practices and use of clothing that cover the whole or almost the whole body while outside (Balasubramanian & Ganesh, 2008) (T. Ahmed et al., 2012) (Mahmoud et al., 2016) (Edwards, Thiongó, Van den Bergh, et al., 2014).

5.3.1.5. Growth monitoring and promotion and vaccination

Routine growth monitoring and promotion (GMP), vitamin A supplementation and immunization status did not vary much between the rickets and non-rickets cases all at above 90% for both rickets and non-rickets cases. Although the three variables are not risk factors for nutritional rickets, they are key indicators of infant young feeding practices and important interventions for the first 1000 days of life (Operational & Health, 2013). Vitamin A supplementation and routine vaccination boost the immunity of the children reducing the risk of childhood morbidity and mortality. Monthly growth monitoring and promotion provides an avenue for children's nutritional status to be followed up from birth to five years of life through monthly anthropometric measurements. Through this, challenges in feeding and the health of the child is identified early enough, mothers also get to benefit regular from health education sessions.

Majority (92.6%) of the rickets cases were attending GMP sessions in various facilities, however, 56.6% of the rickets cases malnourished and not in a nutrition programme. This highlights a gap in identification of both malnutrition and rickets cases due to probably lack of knowledge or omission by the health workers in the respective clinics. From observation in the Mbagathi nutrition clinic, triaging was provided by nutrition interns as part of their professional training. Most of them had not worked in a nutrition clinic before and some of these things might have been missed out. The high rates of vitamin A supplementation could be attributed to the active supplementation campaigns held regularly by the ministry of health in the communities.

5.3.2. Maternal factors

Maternal factors assessed in this study were socio demographic, knowledge, attitude and practices. In the multivariable analysis, the maternal factors that had a significant relationship with NR were: knowledge on vitamin D, main household breadwinner and main caregiver during the day.

Maternal education assessed could be categorized into two: formal education and non-formal education from health and nutrition campaigns and messaging. Maternal education is a key factor in influencing behavior and practice. All caregivers of rickets cases had at least primary level education with 67.2% having post primary education. There was no significant relationship established between level of education and nutritional rickets. Therefore, unlike in other studies where education was associated with occurrence of nutritional rickets (Thacher et al., 2016) (Pehlivan et al., 2003), that was not evident in this study. However, this was in line with a study conducted in Almadinah Almunawwarah, Saudi Arabia to assess NR, where maternal education status was reported to have no significant influence on nutritional rickets with prevalence of 25%, 44%, 12.5% and 15.4% reported for children with mother's whose levels of education were classified as higher education, graduates of secondary or intermediate schools, able to read and illiterate respectively (Elidrissy et al., 2012).

Maternal knowledge on rickets and calcium had no significant relationship with nutritional rickets in this study. There was also no significant difference in knowledge levels between caregivers of NR and non-NR cases. This could be attributed to the disconnect between knowledge and practice where whereas caregivers would be having knowledge, there are barriers in attitude and practices (Shrestha, n.d.). Some of the barriers listed in this study were caregivers not having time to expose children to sunlight, living in houses that do not have adequate sunlight exposure, lack of knowledge on food sources that are rich in calcium and vitamin D and low average household

monthly income which affects the food purchasing power. There was however a significant relationship established between awareness of vitamin D and NR with 1.9 odds of developing NR if the caregivers had no awareness of vitamin D. However, there was no significant difference between level of vitamin D awareness between the two categories at 89.0% and 82.0% for rickets and NR cases respectively. The main caretaker of children during the day ranked highest in influencing the odds of developing NR at 4.1 times for children who were not mainly taken care by their mothers. Further, the odds of developing NR were lower (0.6) for children residing in households with mothers as the main breadwinners compared to others. The findings are in line with other studies where significant relationships have been reported between maternal engagement in employment and empowerment with malnutrition in children under five years of age (Ferdous et al., 2016)(Ramakrishnan et al., 2020). While maternal employment increases the level of household income and ultimately the household food choices, it also affects other child care practices where mothers are not actively involved in raising children due to the number of hours they are involved in work. Further, house helps have a high workload and have no time to bask in the sun.

Majority of the children in this study resided in informal settlements. Although there was no relationship established between average monthly income, discussions with the caregivers highlighted that they do not get to access fortified foods and a variety of calcium and vitamin D rich foods because of their economic status. Some caregivers mentioned that the money they earn is just enough for rent and general upkeep and do not have enough to get a variety of foods. This also affected the quality of health and nutrition services the malnourished children get as reported by the caregivers of OTP children who highlighted that they went to the clinic on a weekly basis and could not afford to pay registration fee every week. This is in line with studies carried out in

Turkey where nutritional rickets was labelled as a disease of the underprivileged with a strong correlation with poor social background (Adbulbari Bener et al., 2008) and Lebanon where children from high socio-economic families were more likely to consume calcium and vitamin D fortified foods (Cesur et al., 2008).

Health workers were the main sources of information on vitamin D, calcium and nutritional rickets through individual or health education sessions. Community health workers who are key factor in community mobilization component of IMAM (Kimani & Sharif, 2009) ranked low as a source of knowledge on rickets, with only two (0.6%) of the caregivers reporting to have heard about rickets from community health workers. Broadcast media ranked lowest as a source of information which was affected by availability due to the income levels.

5.4. Health system factors

Health systems are complex and comprise of six building blocks: health service delivery, health work force, health information systems, access to essential medicines, financing and leadership/ governance (WHO, 2010). In nutrition, the factors that interact, influence and impact on one another and on nutrition outcomes are further summarized into: financing and markets, policies and governance, information and communication, infrastructure, resources and supplies, service delivery and production and; socio cultural environment (*Systems Thinking and Action for Nutrition _ SPRING*, n.d.). This study sought to assess two factors; policies and governance and information and communications further broken down into: Incorporation of nutrition rickets screening during acute malnutrition triaging and diagnosis, guiding policies and guidelines on IMAM and inclusion of nutritional rickets in counselling guidelines used.

In Mbagathi hospital, nutrition and health education was conducted at the MCH department, one on one nutrition counselling in the nutrition clinic and nutrition education in wards in line with the MoH guidelines. The IYCF lessons schedule used at the MCH clinic covered different topics focusing on the first 1,000 days of life. From the KIIs conducted, the health workers outlined that sometimes they have the twenty-four topics being collapsed into one session to save up on time. This presented a gap in comprehensive coverage of topics covered. Further, while these cards do highlight the importance of optimal complementary feeding: Frequency, amount, thickness, variety, responsive feeding and hygiene, specific nutrients other than vitamin A, and their functions in the body are not covered. The nutrition staff further outlined that vitamin D and calcium lessons were not very common and that they did not cover health messages on rickets unless in health education sessions on mixing of flours in porridge preparation and/or when rickets cases have already been identified with no guidelines for treatment and/or screening for rickets available in the nutrition clinic.

Clinical assessments as part of triage before admission into the nutrition programme was not a common practice in Mbagathi hospital nutrition department. Children referred from the POPC however had an advantage as a medical assessment was conducted prior to referral. This was because of the Ksh. 200 levied as a registration fee before a child would be attended to by a clinician. In most cases, caregivers would be referred for medical assessment but due to the economic status, they would not afford the registration fee. However, waivers were given on a case-to-case basis through the social support office. Further, there was no clinician based in the nutrition clinic to take the vital signs and conduct the basic tests.

There is no mention of rickets in the 2009 Kenya IMAM guideline (Of, 2009), Counselling Cards for Community Workers (Cards & Workers, n.d.) and the Community Infant and Young Child Feeding Counselling Package July 2013 (Community et al., 2013).

5.5. Conclusions

This study sought to answer the following research questions:

1. What proportion of acutely malnourished children 6-59 months receiving services at Mbagathi hospital have nutritional rickets?
2. What maternal, infant and young child factors are associated with nutritional rickets in acute malnourished children?
3. What is the level of awareness of risk factors of nutritional rickets among caregivers of acute malnourished children in Mbagathi hospital?
4. What health care factors affect provision of services for acute malnourished children 6-59 months with nutritional rickets at Mbagathi hospital?

According to this study, nutritional rickets is common in acutely malnourished children. More than half (53.7% of the acute malnourished children enrolled in this study had a positive rickets test result. However, the cases are missed out on admission as clinical assessment is not done at admission and follow up due to lack of a clinician based at the nutrition clinic; and the registration fees required before receiving services at the Pediatric outpatient clinic. This gap was also identified in health messaging and sensitization where messages on nutritional rickets are rarely disseminated unless in identified cases. This could be partly attributed to not having nutritional rickets and other growth disorders captured in the IMAM guideline. Therefore, there needs to be

more deliberate effort to address vitamin D deficiency and nutritional rickets in children. Sex of the child, continued breastfeeding, consumption of infant formula, consumption of blue band/ margarine in the 7 days preceding the interview, daily hours of sunlight exposure, calcium supplementation, knowledge on vitamin D, main household breadwinner and main caregiver during the day were found to be associated with nutritional rickets. Increasing population in Nairobi County has led to congestion of both storey and non storey houses due to limited space. This has in turn led to low penetration of sunshine in houses. Further, high cost of living has led to caregivers being required to work all day to fend for the family which affects child care practices for instance not having time to sit out with their children and dietary diversity among others.

5.6. Policy and Practice Recommendations

1. Clinical assessment of acute malnourished cases to be made mandatory in Mbagathi hospital for all cases of acute malnutrition as per the Kenyan IMAM guideline. This could be achieved through for example medical fee wavering system for acute malnourished children.
2. Inclusion of nutritional rickets screening and other growth disorders in IMAM guidelines to ensure wholistic treatment for acute malnourished cases by the Ministry of Health.
3. There is need for active prevention of nutritional rickets through messaging and active case finding targeting all caretakers of children by the county governments in urban centres and health extension workers.

5.7. Public Health Implications

In the wake of increasing prevalence of nutritional rickets around the globe, and in Kenya, concerted effort is needed to convince nutrition implementers, educators and policy makers that despite Nairobi having a temperate subtropical climate, children do not get adequate sunshine

exposure which is critical in calcium and phosphate absorption and in formation and strengthening of bones. This has led to reemergence of rickets in urban centers and in malnourished children.

5.8. Recommendations for Future Research

This was a cross-sectional study aimed at assessing the proportion of nutritional rickets and its risk factors among acute malnourished children in an urban referral hospital. These findings cannot be generalized for all acute malnourished children in rural and camp settings. Further, the study did not assess the effects of nutritional rickets on nutrition treatment outcomes. Therefore, longitudinal and/or controlled studies to determine the effects of nutritional rickets on treatment outcomes is recommended and the causes of nutritional rickets in this target population.

CHAPTER 5: REFERENCE

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APPENDICES

Appendix 1: Consent form

English

PARTICIPANT INFORMATION AND CONSENT FORM

TITLE OF STUDY: Assessment of nutritional rickets among acute malnourished children 6-59 months in Mbagathi hospital, Nairobi, Kenya.

PRINCIPAL INVESTIGATOR\AND INSTITUTIONAL AFFILIATION:

Juliet Wangeci,
Department of Public and Global Health, University of Nairobi

ACADEMIC SUPERVISORS AND INSTITUTIONAL AFFILIATION:

Name: Dr. Faith M. Thuita, Senior Lecturer, Department of Public and Global Health, University of Nairobi.

Phone number: +254 722639719

Email: fthuita@uonbi.ac.ke

Name: Dr. Rose Opiyo, Department of Public and Global Health, University of Nairobi.

Phone number: +254 72247312217

Email: roseopiyo@uonbi.ac.ke

INTRODUCTION:

I would like to talk to you about the aforementioned study being conducted by the above listed researchers in this facility. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may

decide to be in the study or not. This process is called 'informed consent'. Once you understand and agree that you and your child be in the study, I will request you to sign your name on these forms. You should understand the general principles which apply to all participants in a medical research: i) Your decision to participate is entirely voluntary ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal iii) Refusal to participate in the research will not affect the services you are entitled to in this health facility or other facilities. We will give you a copy of this form for your records. The researchers listed above are interviewing caregivers of children aged 6-59 months with acute malnutrition in this facility and also screen the children for nutritional rickets. The purpose of the interview is to find out the number of acute malnourished children with rickets and also assess the main risk factors. Caregivers of enrolled children will be asked questions about socio demographic characteristics, child characteristics, maternal characteristics when pregnant with index child, and child care practices.

There will be approximately 360 participants in this study randomly chosen. We are asking for your consent to consider you and your child participating in this study.

WHAT WILL HAPPEN IF YOU DECIDE TO BE IN THIS RESEARCH STUDY?

If you agree to participate in this study, the following things will happen:

1. You will be interviewed by a trained interviewer in a private area where you feel comfortable answering questions. The interview will last approximately ten minutes.
2. After the interview is done your child will be assessed by a clinician to confirm whether they need to be screened for rickets at the laboratory which we will facilitate.

We will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will only be used by individuals working in this study and at no point

will it be shared beyond that. The reason why we may need to contact you is to give you your child's results in case you don't want to wait.

ARE THERE ANY RISKS, HARMS DISCOMFORTS ASSOCIATED WITH THIS STUDY?

Medical research has the potential to introduce psychological, social, emotional and physical risks. Effort should always be put in place to minimize the risks. One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify you in a password-protected computer database and will keep all of our paper records in a locked file cabinet. However, no system of protecting your confidentiality can be absolutely secure, so it is still possible that someone could find out you were in this study and could find out information about you.

Also, answering questions in the interview may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

We will do everything we can to ensure that this is done in private. Furthermore, all study staff and interviewers are professionals with special training in these examinations/interviews. The examination for rickets may involve either drawing of blood (10ml) which may be stressful and uncomfortable.; or depending on the clinician's recommendations, a wrist X ray. The wrist X-ray will be safe and painless and will use a small amount of radiation to make an image of your child's wrist by sending a beam of radiation through the wrist and an image will be recorded on special X-ray film or a computer screen. The film will be given to you.

ARE THERE ANY BENEFITS BEING IN THIS STUDY?

The only benefit you can accrue from this study is getting to know if your child has nutritional rickets which will result into better quality of IMAM services being given to him/her. We will refer you to a hospital for care and support where necessary. Also, the information you provide will help us in knowing the caseload of rickets in acute malnourished children. This information is a contribution to public health science and may be useful in developing health policies that pertains management of acute malnutrition.

WILL BEING IN THIS STUDY COST YOU ANYTHING?

There are no financial costs in this study. We only need your time.

WHAT IF YOU HAVE QUESTIONS IN FUTURE?

If you have further questions or concerns about participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300-9 Ext. 44355 email uonknh_erc@uonbi.ac.ke.

WHAT ARE YOUR OTHER CHOICES?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without injustice or loss of any benefits.

CONSENT FORM (STATEMENT OF CONSENT)

Participant's statement

I have read this consent form or had the information read to me. I have had the chance to discuss this research study with a study counselor. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation

in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study.

I understand that all efforts will be made to keep information regarding my personal identity confidential.

By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: Yes No

I agree to provide contact information for follow-up: Yes No

Participant printed name: _____

Participant's signature_____ Date _____

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Principal investigator

Juliet Wangeci

Email: julietwangeci245@gmail.com

Telephone number: +254 722 454 455

Swahili

FOMU YA IDHINI

KICHWA CHA UTAFITI: Tathmini ya mifuko ya lishe miongoni mwa watoto walio na utapiamlo wapapo hapo

MTAFITI MKUU: Juliet Wangeci,
Shule ya afya ya umma, Chuo Kikuu cha Nairobi

WACHUNGUZI WA USHIRIKIANO:
Jina: Dr. Faith M. Thuita, Shule ya afya ya umma, Chuo Kikuu cha Nairobi
Nambari ya simu: +254 722639719
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Jina: Dr. Rose Opiyo, Shule ya afya ya umma, Chuo Kikuu cha Nairobi
Nambari ya simu: +254 722473122
Barua pepe: roseopiyo@uonbi.ac.ke

UTANGULIZI:

Ningependa kukujuza kuhusu utafiti utakaofanywa na watafiti waliotajwa. Madhumuni ya fomu hii ya idhini ni kukupa taarifa unayohitaji ili kukusaidia katika kufanya uamuzi kama urashiriki katika utafiti huu. Jisikie huru kuuliza maswali yoyote kuhusu madhumuni ya utafiti, hatari na faida zake, haki zakoza kujitolea au kuhusu hjambo lolote lile pindi tu yanapotokea katika hatua yoyote ya utafiti huu. Utakapohisi kwamba tumeyajibu maswali yako yote kwa kuridhika kwako, unaweza kuamua kuhusika katika utafiti huu au la. Utaratibu huu unaitwa 'kibali cha habari'. Mara unapoelewa na kukubali kuwa katika utafiti, naomba usaini jina lako kwenye fomu hii. Unapaswa kuelewa kanuni za jumla ambazo zinatumika kwa washiriki wote katika utafiti wa matibabu: i) Uamuzi wako wa kushiriki ni kikamilifu kwa hiari ii) Unaweza kujiondoa kwenye utafiti wakati wowote bila ya kutoa sababu ya uondoaji wako iii) Kukataa kushiriki katika utafiti hauathiri huduma unazostahili kupokea kwenye kituo hiki cha afya au vituo vingine. Tutakupa nakala ya fomu hii kwa rekodi zako. Watafiti waliotajwa hapo juu watahoji walezi wa watoto walio na

utapia mlo wa papo hapo. Kusudi la mahojiano ni kujua kiwango cha rickets katika watoto walio na utapia mlo.Washiriki katika utafiti huu ambao ni walezi wa watoto waliochaguliwa wataulizwa maswali kuhusu tabia za kijamii, sifa za mtoto, sifa za uzazi wakati wajawazito na mtoto wa kumbukumbu, na utunzaji wa watoto. Watoto watafanyiwa utafiti wa rickets katika maabara. Kutakuwa na washiriki karibu **360** katika utafiti huu watakaochaguliwa kwa nasibu. Tunaomba ridhaa yako kufikiria kushiriki katika utafiti huu.

NINI KITAKACHOFANYIKA UTAKAPOAMUA KUHUSIKA KWENYA UTAFITI HUU?

Ikiwa utakubali kushiriki katika utfiti huu, mambo yafuatayo yatatokea:

1. Utashughulikiwa na mhojaji mwenye ujuzi katika eneo la kibinafsi ambako utajibu maswali. Mahojiano itaendelea kwa takriban dakika tano.
2. Baada ya mahojiano kumaliza uchunguzi wa rickets utafanyika.

Tutaomba namba ya simu ambapo tunaweza kuwasiliana na wewe itakapobidi. Ikiwa unakubaliana kutoa maelezo yako ya mawasiliano, itatumiwa tu na watu wanaofanya kazi kwa ajili ya utafiti huu na kamwe hawatashirikiwa na wengine. Sababu ambazo tunaweza kuwasiliana nayo ni pamoja na kukupa matokeo ya utafitiwa rickets utakao fanyika kwenye maabara japo hutangoja.

JE, KUNA WASIWASI WOWOTE AU HATARI ITAKAYOTOKANA NA KUHUSIKA KWENYE UTAFITI HUU?

Utafiti wa matibabu una uwezo wa kuanzisha hatari za kisaikolojia, kijamii, kihisia na kimwili. Jitihada zinapaswa kuwekwa daima ili kupunguza hatari. Hatari moja ya kuwa katika utafiti ni kupoteza faragha. Tutaweka kila kitu unachotuambia kama siri iwezekanavyo. Tutatumia nambari ili kukutambua kwenye databana la kompyuta iliyohifadhiwa na nenosiri na kuhifadhi

kumbukumbu zote za karatasi kwenye kabati lililofungwa. Hata hivyo, hakuna mfumo wa kulinda siri yako unaweza kuwa salama kabisa, kwa hivyo bado inawezekana kwamba mtu anaweza kujua wewe ulikuwa katika utafiti huu na anaweza kupata habari kukuhusu. Pia, kujibu maswali katika mahojiano inaweza kuwa na wasiwasi kwako. Ikiwa kuna maswali yoyote unayoona huwezi kujibu, unaweza kuruka. Una haki ya kukataa mahojiano au maswali yoyote yaliyoulizwa wakati wa mahojiano. Tutafanya kila kitu tunaweza kuhakikisha kuwa hii imefanywa kwa faragha. Zaidi ya hayo, wafanyakazi wote wa utafiti na wahojiwa ni wataalamu wenye mafunzo maalum katika mahojiano haya.

Uchunguzi wa rickets unaweza kuhusisha kuchora damu (10ml) ambayo inaweza kuwa ya kusumbua na isiyofurahi .; au kulingana na mapendekezo ya daktari, X ray ya mkono. X-ray ya mkono itakuwa salama na haina maumivu na itatumia kiwango kidogo cha mionzi kutengeneza picha ya mkono wa mtoto wako kwa kutuma boriti ya mionzi kupitia mkono na picha itarekodiwa kwenye filamu maalum ya X-ray au kompyuta skrini. Filamu utapewa.

JE, KUNA FAIDA YOYOTE KUWA KATIKA UTAFITI HUU?

Kwa kushiriki katika utafiti huu, mwanao atafaidika na kupokea uchunguzi wa rickets bila kulipa kwa ada ya kushauriana. Panapohitajika, utatumwa kwenye kituo cha afya kwa ajili ya huduma na msaada. Pia, mwanao ataweza kupata huduma bora za utibabu wa utapia mlo. Habari hii ni mchango kwa sayansi ya afya ya umma na inaweza kuwa muhimu katika kuunda sera za afya zinazohusu usimamizi wa utapiamlo mkali.

NINI UTAPOTEZA KWA KUSHIRIKI KATIKA UTAFITI HUU?

Utafiti huu hautakugharimu chochote.

UTAFANYAJE IKIWA UTAKUWA NA MASWALI KUHUSU UTAFITI HII BAADAYE?

Ikiwa una maswali zaidi au wasiwasi juu ya kushiriki katika utafiti huu, tafadhali piga simu au tuma ujumbe wa maandishi kwa watafiti kwa namabari ya mawasiliano iliyotolewa chini ya ukurasa huu. Kwa habari zaidi juu ya haki zako kama mshiriki wa utafiti unaweza kuwasiliana na katibu / Mwenyekiti, kamati ya maadili na utafiti, hospitali ya Kenyatta-Chuo Kikuu cha Nairobi, Namba 2726300-9 Ext. 44355 barua pepe uonknh_erc@uonbi.ac.ke.

UAMUZI KUHUSU KUSHIRIKI KWENYE UTAFITI AU LA

Uamuzi wako wa kushiriki katika utafiti ni wa hiari. Wewe una uhuru wa kushiriki katika utafiti na unaweza kujiondoa kwenye utafiti wakati wowote bila udhalimu au kupoteza faida yoyote.

TAARIFA YA MSHIRIKI KUTOA RUHUSA

Nimeisoma fomu hii ya idhini. Nimekuwa na fursa ya kujadili utafiti huu na mshauri wa utafiti. Maswali niliyokuwa nayo nimeyauliza na nikajibiwa kikamilifu kwa lugha ambayo ninaielewa. Hatari na faida zimeelezewa kwangu. Ninaelewa kuwa ushiriki wangu katika utafiti huu ni hiari na kwamba nipate kuchagua kutohusika wakati wowote. Ninakubali kwa hiari kushiriki katika utafiti huu. Ninaelewa kuwa jitihada zote zitafanywa ili kuweka habari kuhusu siri ya utambulisho wangu binafsi. Kwa kutia saini fomu hii ya kibali, sijaacha haki yoyote ya kisheria ya kushiriki kwenye utafiti

Nakubali kushiriki katika utafiti huu wa utafiti: Ndio Hapana

Nakubaliana kutoa maelezo ya mawasiliano kwa kufuatilia: Ndio Hapana

Jina la mshiriki: _____

Saini ya mshiriki _____ Tarehe _____

TAARIFA YA MTAFITI

Mimi, Juliet Wangeci, nimeelezea kikamilifu maelezo muhimu ya utafiti huu wa utafiti kwa mshiriki aliyechaguliwa hapo juu na kuamini kwamba mshiriki ameelewa na ametoa kibali chake kwa hiari.

Saini ya mtafiti _____Tarehe_____

Mtafiti mkuu: Juliet Wangeci

Barua pepe: julietwangeci245@gmail.com

Nambari ya simu: +254 722 454455

Appendix 2: Caregiver Questionnaire (created using kobo toolbox)

Assessment of nutritional rickets among acute malnourished children 6-59 months in Mbagathi hospital, Nairobi, Kenya.

1. Date yyyy-mm-dd
2. Interviewer code

- ○ S
- ○ D
- ○ C
- ○ J

3. Child code (*Start with your data collection code, must be in the format (A-001))*
4. Sex of the child

- ○ Male
- ○ Female

Maternal characteristics

5. Sex of the caregiver

- ○ Male
- ○ Female

6. Caregiver's age (yrs)
7. Marital status

- ○ Single
- ○ Divorced
- ○ Married
- ○ Other

8. Caregiver's highest level of education

- ○ Primary
- ○ Tertiary
- ○ Secondary
- ○ None

9. How many children have you/the mother of this child had before this child *(Dead and alive before the index child)*

10. Religion of the caregiver and the child

- ○ Christian
- ○ Hindu
- ○ None
- ○ Muslim
- ○ Traditionalist
- ○ Other

11. Who is the main breadwinner of the family?

- ○ Father
- ○ Brother
- ○ Uncle
- ○ Mother
- ○ Sister
- ○ Aunt

- ○ Grandfather
- ○ Relative
- ○ Grandmother
- ○ Other

12. What is the occupation of the breadwinner?

- ○ Employed
- ○ Casual worker
- ○ Self employed
- ○ Other

13. What is the family's/household's average monthly income? (In Kshs)

- ○ < 5,000
- ○ 21,000-30,000
- ○ >100,000
- ○ 5,000-10,000
- ○ 30,000-50,000
- ○ 11,000-20,000
- ○ 50,000-100,000

Maternal knowledge

14a. Have you ever heard of the term vitamin D

- ○ Yes
- ○ No

14b. If yes, what are the functions in the body

- ☐ Immunity
- ☐ Helps in the absorption of calcium
- ☐ Helps in absorption of phosphorus
- ☐ For strong teeth
- ☐ For formation of bones
- ☐ For strong bones
- ☐ Don't know

14c. If yes, what are the food sources of vitamin D (Tick all that apply)

- ☐ Grains, roots and tubers
- ☐ Legumes and nuts
- ☐ Dairy products (milk, yogurt, cheese)
- ☐ Flesh foods (meat, fish, poultry and liver/organ meats)
- ☐ Eggs
- ☐ Fruits and vegetables
- ☐ Supplements
- ☐ Fortified foods
- ☐ Don't know

14d. If yes, what was the source of information (Tick all that apply)

- [ ] Media (Radio, TV)
- [ ] Health workers
- [ ] Books
- [ ] Peers
- [ ] Community health workers
- [ ] Posters
- [ ] Social Media
- [ ] Don't know

15a. Have you ever heard of the term calcium?

○ Yes ○ No

15b. If yes, what are the functions of calcium in the body

- [ ] Immunity
- [ ] Helps in the absorption of Vitamin D
- [ ] Helps in absorption of phosphorus
- [ ] For strong teeth
- [ ] For formation of bones
- [ ] For strong bones
- [ ] Don't know

15c. If yes, what are the food sources of calcium

- [ ] Grains, roots and tubers
- [ ] Legumes and nuts
- [ ] Dairy products (milk, yogurt, cheese)
- [ ] Flesh foods (meat, fish, poultry and liver/organ meats)
- [ ] Eggs
- [ ] Fruits and vegetables
- [ ] Supplements
- [ ] Fortified foods
- [ ] Don't know

15d. If yes, what was the source of information (Tick all that apply)

- [ ] Media (Radio, TV)
- [ ] Health workers
- [ ] Books
- [ ] Peers
- [ ] Community health workers
- [ ] Posters
- [ ] Social Media
- [ ] Don't know

16a. Have you or your child been supplemented with calcium

○ Yes ○ No

16b. If yes, when were you or your child been supplemented with calcium

- ☐ Yes, for me when I was pregnant with this child
- ☐ Yes, when I was breastfeeding this child
- ☐ Yes, but not while pregnant/breastfeeding this child
- ☐ Yes, the child was supplemented
- ☐ Don't know

16c. Were you pregnant or breastfeeding then?

○ Yes ○ No

16d. Why were you or your child supplemented with calcium?

○ Prescription from a doctor ○ Voluntary supplementation

17a. Have you or your child been supplemented with Vitamin D

○ Yes ○ No

17b. If yes, when were you or your child supplemented with vitamin D

- ☐ Yes, for me when I was pregnant with this child
- ☐ Yes, when I was breastfeeding this child
- ☐ Yes, but not while pregnant/breastfeeding this child
- ☐ Yes, the child was supplemented
- ☐ Don't know

17c. Were you pregnant or breastfeeding then?

○ Yes ○ No

17d. Why were you or your child supplemented with vitamin D

○ Prescription from a doctor ○ Voluntary supplementation

18a. Have you ever heard of the term rickets?

○ Yes ○ No

18b. If yes, what was the source of information (Tick all that apply)

- ☐ Media (Radio, TV)
- ☐ Health workers
- ☐ Books
- ☐ Peers
- ☐ Community health workers
- ☐ Posters
- ☐ Social Media
- ☐ Don't know

18c. If yes, what are the causes of rickets

- [ ] Lack of adequate sunshine exposure
- [ ] Vitamin D deficiency
- [ ] Calcium deficiency
- [ ] Phosphorous deficiency
- [ ] Genetic
- [ ] Prolonged breastfeeding
- [ ] Exclusive breastfeeding
- [ ] Suboptimal complementary feeding
- [ ] Don't know

18d. If yes, what is the treatment for rickets

- [ ] Staying outside in the sun
- [ ] Supplementation with calcium
- [ ] Supplementation with vitamin D
- [ ] Don't know

Child sociodemographic and child care factors

19. What is the skin color of the child?

Black-African, Brown-of Asian origin, White-Caucasian, Pther-If child has albinism or any other skin defect

- ○ Black
- ○ Brown
- ○ White
- ○ other

20a. Age in months (of the child)

20b.Source of age data

Select all that apply

- [ ] MCH booklet
- [ ] Recall
- [ ] Other

21a.Birth weight of index child

○ Below 2500 grams ○ >= 2500grams

21b. Source of data (Select all that apply)

○ MCH booklet ○ Recall ○ Other

22a.At how many weeks did you deliver this child (gestational length of index child)

○ < 37 weeks ○ >= 37 weeks

22b. Source of data (Select all that apply)

○ MCH booklet ○ Recall ○ Other

23a. Has the child been in a nutrition supplementation/feeding programme and discharged before?

○ Yes ○ No

23b. Is the child in a nutrition supplementation/feeding programme currently?

○ Yes ○ No

24a. Is this child taken to routine growth monitoring?

◯ Yes, I am still taking him/her

◯ I stopped at 1 year

◯ I stopped at 2 years

◯ Has never been taken for routine growth monitoring

24b. Has the child received all routine immunizations as per the age

○ Yes ○ No

24c. Has the child been supplemented with routine vitamin A in the last six months?

○ Yes ○ No

25a. County of residence

25b. Area of residence of the child (Village and town)

26a. Type of house the child lives in

- ◯ Storey house
- ◯ Shanties (wooden or iron sheet constructed)
- ◯ Bungalow
- ◯ Stand-alone single rooms
- ◯ Flats with only ground floor (The houses are in an array but there are no top floors)
- ◯ Other

26b. Specify

26c. Floor level

◯ Ground floor	◯ Level 3	◯ Level 6
◯ Level 1	◯ Level 4	◯ Level 7
◯ Level 2	◯ Level 5	

26d. For how long has the child been living in that house or a similar house?

◯ < 1 year	◯ 1-2 years	◯ 2-5 years

27a. Is there adequate sunshine in the house (Probe for congestion and around what time of the day the house has adequate sunshine)

◯ Yes	◯ No

27b. Explain the response on adequate sunshine in the house (Do not read out the responses) Tick as the caregiver responds

- ☐ Big windows
- ☐ No structures blocking light in the house
- ☐ Glass windows which are not painted/tinted
- ☐ Many windows

27c. If no, what are the reasons

- ☐ No windows
- ☐ Houses close to each other
- ☐ Structures blocking light in the house
- ☐ Small windows

28a. Do you expose the child to direct sunlight either in the house or outside the house?

◯ Yes	◯ No

28b. If yes, how many hours per day

◯ <1hrs	◯ 1-3hrs	◯ >3hrs

28c. If yes, why

28d. If yes, do you expose the child to sunlight with or without clothes covering both hands and legs

○ Yes ○ No

28e. If no, why

29a. Who mainly takes care of the child during the day?

○ Mother ○ Daycare ○ Other

○ House help ○ Relative but in my house

29b. Is the adequate light in the rooms

○ Yes ○ No

29c. Specify

Child anthropometric measurements (Child should be acute malnourished)

30a. Bilateral pitting oedema

○ No ○ + ○ ++

30b. Weight(kgs)

30c. Height(cm)

30d. Weight for Height z score

○ <-3 ○ >=-3 to <-2 ○ >=-2

30e. MUAC (cm)

31a. Did the child have clinical signs and/or symptoms of rickets?

○ Yes ○ No

31b. If yes, what were the symptoms

Do not read out the responses. Tick all the responses the caregiver gives.

○ Delayed teething ○ Craniotabes ○ Wide fontanel

○ Carious teeth ○ Chest deformities ○ Hypocalcaemia convulsions

○ Bowed legs for infants ○ Greenstick fractures ○ Extremity pain

○ Frontal blossing ○ Caput quadratum

Infant and young child feeding practices

32. Was the child exclusively breastfed?

Exclusive breastfeeding means that the infant receives only breast milk. No other liquids or solids are given – not even water – with the exception of oral rehydration solution, or drops/syrups of vitamins, minerals or medicines.

- ◯ Yes
- ◯ No
- ◯ Don't know

33. Is the child still breastfeeding?

◯ Yes ◯ No

34. At what age was the child fed on other foods other than breastmilk (liquids, solid and semi solid foods including any supplements)?

◯ Before the child reached six months
◯ At 6 months
◯ At 7 months
◯ At 8 or more months

35a. Was the child fed on infant formula?

◯ Yes ◯ No

35b. If yes, for how long?

Less than 1 month
1 to 2 months
3 to 4 months
>4months

» Dietary assessment

36a. Has the child consumed cod liver oil in the last 7 days

◯ Yes ◯ No

36b. If yes, how often?

◯ Once per week
◯ 2-4 times per week
◯ 5-6 times per week
◯ Once a day
◯ 2-3 times per day

37a. Has the child consumed dagaa fish in the last 7 days

◯ Yes ◯ No

37b. If yes, how often?

◯ Once per week
◯ 2-4 times per week
◯ 5-6 times per week
◯ Once a day
◯ 2-3 times per day

38a. Has the child consumed Amaranth in the last 7 days

○ Yes ○ No

38b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

39a. Has the child consumed blue band/margarine in the last 7 days

○ Yes ○ No

39b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

40a. Has the child consumed eggs in the last 7 days

○ Yes ○ No

40b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

41a. Has the child consumed Calcium/vitamin D fortified foods in the last 7 days

○ Yes ○ No

41b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

42a. Has the child consumed infant formula in the last 7 days

○ Yes ○ No

42b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

43a. Has the child consumed Fortified soy milk in the last 7 days

○ Yes ○ No

43b. If yes how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

44a. Has the child consumed dairy products in the last 7 days

○ Yes ○ No

44b. If yes, how often?

○ Once per week ○ 5-6 times per week ○ 2-3 times per day

○ 2-4 times per week ○ Once a day

45. What foods has the child consumed for the last 24 hours (Liquids, solid and semi solid including any supplements)?

This is from yesterday from such a time. Kindly ensure that you capture everything consumed in whatever form. Probe for quantity, contents of for example porridge and fortification.

46. Any other information

47. Caregiver's phone number

48. Signed consent form

Kindly take a pic of the last signed page of the consent form and upload

Click here to upload file. (< 5MB)

» » Rickets test results

49a. Has this child tested for rickets before

○ Yes ○ No

49b. If yes what were the results

○ Positive ○ Negative

50. Did the child test positive for rickets today?

○ Yes ○ No

51a. X ray done?

○ Yes ○ No

51b. If yes, what were the results

○ Positive ○ Negative

Appendix 3: Health worker's KII guide

Assessment of Nutritional rickets in children 6-59 months in Mbagathi hospital.

Health worker questionnaire

1. Enter a date: yyyy-mm-dd _____
2. Interviewer code: N001 N002 N003
3. Cadre_____Department_____
4. Number of years worked in current position?
5. How do you get acute malnutrition cases in the facility?
6. Is rickets a common condition among children 6-59 months in this hospital *(Both malnourished and healthy children)*
    - Around how many rickets cases referrals do you get in a week in the nutrition program?
    - What do you think are the main causes of rickets among those children?
7. Is rickets screening part of the triaging before children are admitted to the nutrition program *(If yes, probe for where it is done and by who and what treatment is offered. If no, Probe for whether he/she thinks it is important to have it incorporated into the triaging?)*
8. What guidelines do you normally use for health education and treatment *(probe for inclusion of rickets messaging and treatment in the guidelines)*
9. What is your experience treating children with rickets in this clinic *(probe for challenges ranging from the health system and maternal factors)?*
10. Any other comments_____

Appendix 4: Focus Group Discussion Guide

Assessment of nutritional rickets among acute malnourished children 6-59 months in Mbagathi hospital, Nairobi, Kenya.

The FGD guide is meant to assess the child care and feeding practices among caregivers in relation to nutritional rickets. Obtain informed consent from the caregivers before commencement.

Location of FGD_____
Number of participants (disaggregate based on sex, if possible) _____

1. On the paper, Indicate the age of the mother, age of the child, sex of the child)
2. Have you ever heard about rickets?

(*If yes, probe for* a) who are mostly affected b) causes of rickets c) impacts of rickets on the child d) how to identify a child with rickets e) prevent of rickets f) treatment of rickets g) source of information)

3. Have you ever heard about vitamin D? (*If yes, probe for* a) who are mostly affected b) Sources of vitamin D c) Effects of vitamin D deficiency d) source of information)
4. Have you ever heard about calcium? (*If yes, probe for* a) who are mostly affected b) Sources of calcium c) effects of calcium deficiency in the body c) source of information)
5. Do you expose your child to direct sunlight (For those who answer yes, probe for how long, why and the percentage of body coverage? For that answer no, probe for why)
6. What type of houses do you live in (for every type of house, probe if there are windows and/or sunlight in the house)
7. Probe for whether they think nutritional rickets is a common condition among acute malnourished children

Appendix 5: Standardization test results

Parameter		Number of subjects	Outcome		From Supervisor
Weight	Supervisor	10	TEM good	R value good	Bias good
	Enumerator 1	10	TEM good	R value good	Bias acceptable
	Enumerator 2	10	TEM good	R value good	Bias acceptable
	Enum inter 1st	2x10	TEM acceptable	R value good	
	Enum inter 2nd	2x10	TEM acceptable	R value good	
	Inter Enum + sup	3x10	TEM acceptable	R value good	
	Total intra+inter	2x10	TEM acceptable	R value good	
	Total+ sup	**3x10**	**TEM acceptable**	**R value good**	
Height	Supervisor	10	TEM good	R value good	Bias good
	Enumerator 1	10	TEM good	R value good	Bias good
	Enumerator 2	10	TEM good	R value good	Bias good
	Enum inter 1st	2x10	TEM good	R value good	
	Enum inter 2nd	2x10	TEM good	R value good	
	Inter Enum + sup	3x10	TEM good	R value good	
	Total intra+inter	2x10	TEM good	R value good	
	Total+ sup	**3x10**	**TEM good**	**R value good**	
MUAC	Supervisor	10	TEM good	R value good	Bias good
	Enumerator 1	10	TEM good	R value good	Bias good
	Enumerator 2	10	TEM good	R value good	Bias good
	Enum inter 1st	2x10	TEM good	R value acceptable	
	Enum inter 2nd	2x10	TEM good	R value acceptable	
	Inter Enum + sup	3x10	TEM good	R value acceptable	
	Total intra+inter	2x10	TEM good	R value acceptable	
	Total+ sup	**3x10**	**TEM good**	**R value acceptable**	

Appendix 6: KNH-ERC Letter

UNIVERSITY OF NAIROBI

COLLEGE OF HEALTH SCIENCES
P O BOX 19676 code 00202
Telegrams: varsity

Tel 54-020 2726300
Ext 44355
Ref: KNH-ERC/A/68

KNH-UON ERC

Email: uonknh_erc@uonbi.ac.ke

Website: http:l/YNN.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: https:11twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL

P O BOX 20723 Code 00202

Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

25th February 2021

Juliet Wanjiru Wangeci
Reg. No.H57/87550/2016
School of Public Health
College of Health Sciences
University of Nairobi

Dear Juliet

RESEARCH PROPOSAL - ASSESSMENT OF NUTRITIONAL RICKETS AMONG ACUTE MALNOURISHED CHILDREN 6-59 MONTHS IN MBAGATHI HOSPITAL, NAIROBI, KENYA P359/07/2020

This is to inform you that the KNH- (JON Ethics & Research Committee (KNH- I-JON ERC) has reviewed and approved your above research proposal. The approval period is 25th February 2021 — 24th February 2022.
This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life-threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- (JON ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (Attach a comprehensive progress report to support the renewal).

g. Submission of an executive summary report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website:http://www.erc.uonbi.ac.ke

Yours sincerely

PROF. M.L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information Dept, KNH
The Director, School of Public Health, UoN
Supervisors: Faith Thuita, School of Public Health, UoN, UoN
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