Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.5, 2016

Assessment of Malnuorished Children under Plumpy Nut Clinical Trial

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Abstract
The work assessed malnutrition cases and the effectiveness of plumpy nuts on the malnourished children within the Kassena- Nankana district in the Upper East Region of Ghana.Malnourished children under five years of age were followed for sixteen weeks during the period of years 2010 – 2014 in which the ready - to – use therapeutic food (RUTFs) "plumpy" nuts which contains calories and essential nutrients that restore, maintain body weight and health in severely malnourished were administered to the children depending on their admission weight until the target weight is obtained. The work resort to determine the effectiveness of plumpy nuts on the malnourished children and to come out with the best model to estimate the mean weight of malnuorised children under the influence of censored observations. The study revealed that, malnutrition rate among children in the Region has decreased for the last year of the selected period of study. This shows that the ready – to –use- therapeutic food (RUTFs) plumpy nuts was effective. It also revealed that, even though malnutrition cases were 20% higher in male children than female children, this shows that sex has an influence on the number of malnutrition cases. In this work Kaplan and Meier estimator was the appropriate model for estimating mean weight of the malnourished children
Keywords: Malnutrition, plumpy nuts, RUTFs, malnourished, weight.

1.INTRODUCTION

Malnutrition (literally, bad nutrition) is a condition that results from eating a diet in which nutrients are not enough or are too much such that it causes health problems. The nutrients involved include: calories, protein, carbohydrates, vitamins or minerals. It is a category of diseases that includes under nutrition and over nutrition. Over nutrition can result in obesity and overweight (UNICEF, 2010).

It is often used specifically to refer to undernutrition where there are not enough calories, protein or micronutrients; however, it also includes over nutrition. If under nutrition occurs during either pregnancy or before the age of two years of age it may result in permanent problems with physical and mental development Extreme undernourishment, known as starvation, may have symptoms that include: a short height, thin body, very poor energy levels, and swollen legs and abdomen. People also often get infections and are frequently cold. The symptoms of micronutrient deficiencies depend on the micronutrient that is lacking (UNICEF, 2010).

Undernourishment is most often due to not enough high quality food available to eat. This is often related to high food prices and poverty. A lack of breast feeding may contribute, as may a number of infectious diseases such as: gastroenteritis, pneumonia, malaria and measles which increase nutrient requirements (Arora and Justin, 2007). There are two main types of under nutrition, protein-energy malnutrition (PEM) and dietary deficiencies. Protein-energy malnutrition has two severe forms: marasmus (a lack of protein and calories) and kwashiorkor (lack of just protein). Common micronutrient deficiencies include: a lack of iron, iodine and vitamin A. During pregnancy, due to increased demand, deficiencies become more common. In some developing countries. over nutrition in the form of obesity is beginning to present within the same communities as under nutrition. Other causes of malnutrition include anorexia nervosa and bariatric surgery. In the elderly malnutrition becomes more common due to physical, psychological and social factors (Ronnie *et al.,* 2011).

Under nutrition encompasses stunted growth, wasting, and deficiencies of essential vitamins and minerals (collectively referred to as micronutrients). The term hunger, which describes a feeling of discomfort from not eating, has been used to describe under nutrition, especially in reference to food insecurity (Black *et al.,* 2008).

The term "severe malnutrition" or "severe under nutrition" is often used to refer specifically to protein-energy malnutrition (PEM). PEM is often associated with micronutrient deficiency. Two forms of PEM are kwashiorkor and marasmus, and they commonly coexist (Katsilambros, 2011).

Kwashiorkor ('displaced child') is mainly caused by inadequate protein intake resulting in a low concentration of amino acids. The main symptoms are edema, wasting, liver enlargement, hypoalbuminaemia, steatosis, and possibly depigmentation of skin and hair. Kwashiorkor is identified by swelling of the extremities and belly, which is deceiving of actual nutritional status (Stevenson, 2011).

Marasmus ('to waste away') is caused by an inadequate intake of protein and energy. The main

symptoms are severe wasting, leaving little or no edema, minimal subcutaneous fat, severe muscle wasting, and non-normal serum albumin levels. Marasmus can result from a sustained diet of inadequate energy and protein, and the metabolism adapts to prolong survival. It is traditionally seen in famine, significant food restriction, or more severe cases of anorexia (Katsilambros, 2011). Conditions are characterized by extreme wasting of the muscles and a gaunt expression (Stevenson, 2011).

Overnutrition caused by overeating is also a form of malnutrition. In the United States, more than half of all adults are now overweight a condition that, like hunger, increases susceptibility to disease and disability, reduces worker productivity, and lowers life expectancy (Gardner *et al.,* 2000) Overeating is much more common in the United States, where for the majority of people, access to food is not an issue. Many parts of the world have access to a surplus of non-nutritious food, in addition to increased sedentary lifestyles. Yale psychologist Kelly Brownell calls this a "toxic food environment" (Gardner *et al.,* 2000). where fat and sugar laden foods have taken precedent over healthy nutritious foods. Not only does obesity occur in developed countries, problems are also occurring in developing countries in areas where income is on the rise. The issue in these developed countries is choosing the right kind of food. More fast food is consumed per capita in the United States than in any other country. The reason for this mass consumption of fast food is its affordability and accessibility. Often fast food, low in cost and nutrition, is high in calories and heavily promoted. When these eating habits are combined with increasingly urbanized, automated, and more sedentary lifestyles, it becomes clear why weight gain is difficult to avoid (Gardner *et al.,* 2000). However, overeating is also a problem in countries where hunger and poverty persist. In China, consumption of high-fat foods has increased while consumption of rice and other goods has decreased. Overeating leads to many diseases, such as heart disease and diabetes, that may result in death (Gardner *et al.,* 2000).

2 CAUSES OF MALNUTRITION

Major causes of malnutrition include poverty and increase in food prices, dietary practices and agricultural productivity, with many individual cases being a mixture of several factors. Clinical malnutrition, such as in cachexia, is a major burden also in developed countries. Various scales of analysis also have to be considered in order to determine the sociopolitical causes of malnutrition. For example, the population of a community may be at risk if the area lacks health-related services, but on a smaller scale certain households or individuals may be at even higher risk due to differences in income levels, access to land, or levels of education (Fotso, 2005).

3 EFFECTS OF MALNUTRITION

Malnutrition increases the risk of infection and infectious disease, and moderate malnutrition weakens every part of the immune system. For example, it is a major risk factor in the onset of active tuberculosis (Schaible, 2007). Protein and energy malnutrition and deficiencies of specific micronutrients (including iron, zinc, and vitamins) increase susceptibility to infection. Malnutrition affects HIV transmission by increasing the risk of transmission from mother to child and also increasing replication of the virus (Stillwaggon, 2008). In communities or areas that lack access to safe drinking water, these additional health risks present a critical problem. Lower energy and impaired function of the brain also represent the downward spiral of malnutrition as victims are less able to perform the tasks they need to in order to acquire food, earn an income, or gain an education. Vitamin-deficiency-related diseases (such as scurvy and rickets).

Hypoglycemia (low blood sugar) can result from a child not eating for 4 to 6 hours. Hypoglycemia should be considered if there is lethargy, limpness, convulsion, or loss of consciousness. If blood sugar can be measured immediately and quickly, perform a finger or heel stick.

4 PLUMPY NUT

Plumpy'Nut is a peanut-based paste in a plastic wrapper for treatment of severe acute malnutrition manufactured by a French company, Nutriset. Removing the need for hospitalization, the 92 gram packets of this paste can be administered at home and allow larger numbers to be treated. Plumpy'Nut may be referred to in scientific literature as a Ready-to-Use Therapeutic Food (RUTF) alongside other RUTFs such as F-100, a solid form of therapeutic milk (Andrew, 2010).

The United Nations has recognized this utility, stating in 2007 that "new evidence suggests... that large numbers of children with severe acute malnutrition can be treated in their communities without being admitted to a health facility or a therapeutic feeding centre." Plumpy'nut conforms to the UN definition of a Ready-to-Use Therapeutic Food (RUTF) (WHO, 2007). Peanut allergies have not been found to be a problem in usage due to a lack of allergic reactions in the target populations (Klonick, 2006).

Plumpy'Nut is used as a treatment for emergency malnutrition cases. It supports rapid weight gain derived from broad nutrient intake which can alleviate a starving child from impending illness or death. The product is easy for children to eat because it dispenses readily from a durable, tear-open package. The fortified peanut butter-like paste contains fats, dietary fiber, carbohydrates, proteins (as essential macronutrients), vitamins

and minerals (as essential micronutrients). Peanut butter is also an excellent source of vitamin E and B vitamins (USDA, 2014).

5. OVERVIEW

Ghana is a small coastal country of West Africa well-endowed with natural resources. The population is young and a high proportion is urban. Agriculture, which is still predominantly traditional, plays an important role in the country's economy and remains the main sector of employment. Over the last years, Ghana has registered robust economic growth. While poverty still has a firm grip on the North, there has been a substantial decline in poverty at national level and the country is on track to achieve the first Millennium Development Goal if the current economic growth rate is sustained (FAO, 2010).

With regard to health indicators, infant and under-five mortality rates are stagnating. Low access to health services and to safe water and sanitation, high incidence of malaria and malnutrition as an underlying factor are among the main causes of mortality (FAO, 2010).

Recent analyses based on state-of-the-art epidemiological evidence show that in Ghana, 40% of all deaths that occur before the age of five are due directly and indirectly to under nutrition, making it the single most important cause of child mortality. A recent study suggested that the high prevalence of under nutrition coupled with inadequate maternal and child care behavior (e.g. low rate of iron supplementation among pregnant women, early or late initiation of complementary feeding among children), might be reasons for the stagnated child mortality levels in Ghana. While there was a steady improvement of the nutritional situation in recent years, the prevalence of undernutrition is still unacceptably high (GHS, 2011). Protein and energy under nutrition is the major problem, and the micronutrient deficiencies are of public health significance. A national survey in 2003 show that 77 percent of children aged 6-59 months and 47 percent of women aged 15-49 are anemic. According to a study in the early 90s, one third of districts in Ghana are reported to have severe iodine deficiency disorder problems (GHS, 2011).

The prevalence of stunting in Ghana varies widely by residential and socio-economic factors. Disaggregation of the national average shows that the prevalence of stunting is significantly higher among children from rural areas, from poorer households, and whose mothers were less educated. Regional variation was also considerable with children from the Northern Region being almost three times more likely to be stunted than those from the Greater Accra region. As expected, older children were substantially more likely to be stunted, given the historicity of the problem (GHS, 2011). The UN therefore called for food security and nutrition to be put high on the development agenda by key stakeholders including the Government of Ghana. This call by the UN to place nutrition high on the development agenda comes in the wake of a looming concern.

Data released recently in the 2013 Lancet Series on maternal and child nutrition found that globally, malnutrition is responsible for nearly half the deaths of children under age 5 years. This underscores an urgent need to invest resources and ensure continued political will to eliminate Malnutrition in Ghana.

Malnutrition starts as early as pregnancy. Children can be born too small or too short because their mother did not consume the right kind and amount of food. Children who do not get the right nutrition during critical growth stages are at risk of compromised physical and cognitive development. Children who are chronically malnourished can end up too short for their age.

This is called 'stunted'. Being stunted means not only that a child has not reached his or her potential height, but that because the child has not consumed a healthy diet over a long period of time that child is also at risk of not performing as well at school, is more prone to illness and even death (UNDP, 2013). In addition to stunting, many children also suffer from being too thin and more recently some are becoming overweight, which is also a sign of malnutrition. Every other pregnant woman and every other child in Ghana experience unacceptable levels of iron deficiency anemia, iodine deficiency and/or Vitamin A deficiency. Close to one out of 4 children suffer from chronic malnutrition. Chronic malnutrition does not only stunt the physical and mental development of children, it reduces their potential, undermining their adult earnings by up to 10 percent and in some countries reduces the size of the economy by up to 11 percent as a result (UNDP, 2013).

6 PLUMPY NUTS AS A TREATMENT FOR MALNUTRITION

Plumpy Nut has a two-year shelf-life and requires no water, preparation, or refrigeration. Its ease of use has made mass treatment of malnutrition in famine situations more efficient than in the past. Severe acute malnutrition has traditionally been treated with therapeutic milk and required hospitalization. Unlike milk, Plumpy Nut can be administered at home and without medical supervision. It also provides calories and essential nutrients that restore and maintain body weight and health in severely malnourished children more effectively than F100 (Diop *et al.,* 2003).

WFP does its part by providing food through programs which supplement the food households already have with nutritious products such as fortified Blended Foods or Ready-to-Use Foods (Plumpy nut). By treating moderate malnutrition, WFP tries to prevent children from slipping into severe malnutrition. In many emergency

settings, for every child suffering from severe acute malnutrition, there are eight or ten suffering from moderate malnutrition.

In recent years, new ready-to-use therapeutic foods (RUTFs) for severely malnourished children have been developed. The progress in foods for severe malnutrition has worked as a catalyst for the development of special foods for other forms of malnutrition. The WFP nutrition toolbox already includes fortified staples, fortified condiments and fortified blended foods. Among the fortified blended foods is corn soya blend (CSB) and plumpy nut, which WFP has used for decades. WFP is working on ways of improving the composition of these foods to better meet the nutritional needs of specific groups (young children, pregnant and lactating women, the chronically ill) (WFP, 2014).

7 NEW STRATEGIES

The WFP toolbox also includes new strategies such as home-fortification with multi-micronutrient powder (MNP, also known as 'sprinkles'). Home fortification means that beneficiaries themselves sprinkle the powder onto food after they have cooked it. It is a viable option when households already have some food but the food they have lacks important micronutrients. Other new strategies include ready-to-use supplementary foods (RUSFs), for treating children with moderate acute malnutrition, and complementary food supplements, to complement the diet of young children (6-24 months) with the highest nutritional needs.

8 RESEARCHES ON MALNUTRITION

Many researches have been made on malnutrition in children under five years of age, but most have rarely used the plumpy nut as a weight determination for the effects of malnutrition.

(Rodriguez *et al.,* 2005) used the multiple linear regression to evaluate the effect of a moderate dose of vitamin A as an adjunct to standard antimicrobial treatment on the duration of respiratory signs in children with pneumonia in underweight and normal-weight children.

The enrolled 287 children, 145 received vitamin A and 142 received placebo. No overall differences were observed between the 2 groups in the duration of signs of pneumonia. Multiple linear regression showed a significant interaction between basal serum retinol concentration and vitamin A group for the time (in h) to remission of respiratory signs ($\beta = 3.57$, SE=1.09, P =0.001). Duration of clinical signs was less in children with basal serum retinol concentrations $>200\mu g/L$ who received vitamin A supplements than in children with similar concentrations who received placebo (69.9$\pm$49.9 h compared with 131.3$\pm$143.9 h; P=0.049). In Conclusion they found no effect of a moderate dose of vitamin A supplementation on the duration of uncomplicated pneumonia in underweight or normal-weight children aged $<$5 years. However, a beneficial effect was seen in children with high basal serum retinol concentrations.

Next, (Dibari *et al.,* 2010) used qualitative methods such as focused group discussion, key informative interviews and direct observations to do an investigation of adherence to nutritional therapy in malnourished adult AIDS patients to understand factors affecting the compliance of malnourished, HIV-positive adults with a nutritional protocol using ready-to-use therapeutic food (RUTF; Plumpy nut) in KENYA.

Thirty-four out of forty-six patients were receiving RUTF (8360 kJ/d) at the time of the study and nineteen of them were wasted (BMI, 17 kg/m2). Six of the thirteen wasted out-patients came to the clinic without a caregiver and were unable to carry their monthly provision (12 kg) of RUTF home because of physical frailty. Despite the patients' enthusiasm about their weight gain and rapid resumption of labour activities, the taste of the product, diet monotony and clinical conditions associated with HIV made it impossible for half of them to consume the daily prescription. Sharing the RUTF with other household members and mixing with other foods were common. Staff training did not include therapeutic dietetic counselling. In conclusion the level of reported compliance with the prescribed dose of RUTF was low. An improved approach to treating malnourished HIV-positive adults in limited resource contexts is needed and must consider strategies to support patients without a caregiver, development of therapeutic foods more suited to adult taste, specific dietetic training for health staff and the provision of liquid therapeutic foods for severely ill patients.

Furthermore, (Menezes *et al.,* 2011) used the Kaplan-Meier survival curve, the chi-squared test of association and the multiple logistic regression to assess the effect of malnutrition as an independent risk factor affecting outcome in critically ill children in Brazil.

In a prospective cohort study, 385 children admitted to the ICU of a teaching hospital over a 2 years period were assessed for nutritional status at admission and clinical outcome. The outcome variables were 30 day mortality, length of ICU stay, and length of mechanical ventilation. Potential exposure variables were gender, age, diagnosis (clinical versus surgical), septic shock, malnutrition, and scores on the Pediatric Index of Mortality and Pediatric Logistic Organ Dysfunction. Nutritional status was determined using z scores of weight for age, height for age, and body mass index, based on the World Health Organization child growth standards. Patients with z score $<$ -2 of anthropometric indexes were considered malnourished. Results: 175 patients (45.5%) were malnourished on admission. Sixteen patients of the malnourished group (9.14%) and 25 patients (11.9%) of the

non-malnourished group died. Malnutrition was associated with greater length of mechanical ventilation and length of ICU stay, but not with mortality on univariate analysis. Malnutrition was associated with greater length of ventilation on the multiple logistic regression model (OR 1.76, 95%; CI 1.08-2.88; P = 0.024).They concluded that, Malnutrition was common among children admitted to an ICU. This factor was not a predictor of mortality but showed independent association with length of mechanical ventilation.

9. METHODOLOGY

Information was gathered from the Navrongo Health Centre in the upper East Region of Ghana, data on malnourished children who attended the Navrongo Health Centre between the period of years 2010-2014 and were followed for sixteen weeks each year were obtained for the study and analysis.

The data for the work was purely secondary obtained from the Navrongo Health Centre. Some of the informations for the study were obtained through an interview with some key informants to ascertain the causes of malnutrition and the effectiveness of the plumpy nuts on the malnourished children in the municipality.

10. KAPLAN MEIER ESTIMATOR METHOD OF ESTIMATING MISSING DATA

The Kaplan Meier estimator is named after Edward L. Kaplan and Paul Meier (Kaplan and Meier, 1958). The Kaplan–Meier estimator, also known as the product limit estimator, is an estimator for estimating the survival function from lifetime data. In medical research, it is often used to measure the fraction of patients living for a certain amount of time after treatment.

A plot of the Kaplan–Meier estimate of the survival function is a series of horizontal steps of declining magnitude which, when a large enough sample is taken, approaches the true survival function for that population. The value of the survival function between successive distinct sampled observations is assumed to be constant.

An important advantage of the Kaplan–Meier curve is that the method can take into account some types of censored data, particularly right-censoring, which occurs if a patient withdraws from a study. On the plot, small vertical tick-marks indicate losses, where a patient's survival time has been right-censored. When no truncation or censoring occurs, the Kaplan–Meier curve is the complement of the empirical distribution function.

For human subjects, to compare efficacy and safety, controlled experiments are conducted which are called as clinical trials. In clinical or community trials, the effect of an intervention is assessed by measuring the number of subjects survived or saved after that intervention over a period of time. Sometimes it is interesting to compare the survival of subjects in two or more interventions. In situations where survival is the issue then the variable of interest would be the length of time that elapses before some event to occur.

11. FORMULATION

Let $S(t)$ be the probability that a member from a given population will have a lifetime exceeding time, t. For a sample of size N from this population, let the observed times until death of the N sample members be

$$t_1 \leq t_2 \leq t_3 \ldots t_N$$

Corresponding to each t_i is n_i, the number "at risk" just prior to time, t_i and d_i the number of deaths at time t_i. The Kaplan–Meier estimator is the nonparametric maximum likelihood estimate of $S(t)$. It is a product of the form

$$\hat{S}(t) = \prod_{t_i<t} \frac{n_i - d_i}{n_i},$$

When there is no censoring, n_i is just the number of survivors just prior to time t_i. With censoring, n_i is the number of survivors minus the number of losses (censored cases). It is only those surviving cases that are still being observed (have not yet been censored) that are "at risk" of an (observed) death. There is an alternative definition that is sometimes used, namely

$$\hat{S}(t) = \prod_{t_i\leq t} \frac{n_i - d_i}{n_i},$$

The two definitions differ only at the observed event times. The latter definition is right-continuous whereas the former definition is left-continuous.

Let T be the random variable that measures the time of failure and let $F(t)$ be its cumulative distribution function. Note that

$$S(t) = P[T > t] = P[T \leq t] = 1 - F(t)$$

Consequently, the right-continuous definition of $\widehat{S}(t)$ may be preferred in order to make the estimate compatible with a right-continuous estimate of $F(t)$.

To conclude, Kaplan-Meier method is a clever method of statistical treatment of survival times which not only makes proper allowances for those observations that are censored, but also makes use of the information from these subjects up to the time when they are censored. Such situations are common in Ayurveda research when two interventions are used and outcome assessed as survival of patients. So Kaplan-Meier method is a useful method that may play a significant role in generating evidence-based information on survival time.

12 MEAN SUBSTITUTION METHOD

The theory is that, in the absence of any other information, the mean is the best single estimate of any participant's score. In the case where an observed is unreported, the group or overall sample mean is substituted for each individual with missing data. The flaw in this theory is that if 20% of a sample is missing, even at random, substituting the identical score for a large portion of the sample artificially reduces the variance of the variable, and as the percentage of missing data increases, the effects of missing data become more profound. These effects have been known for many decades now (Cole, 2008; Haitovsky, 1968), yet many researchers still view mean substitution as a viable, or even progressive, method of dealing with missing data.

13. Zero substitution:

In this case, in the absence of any information, zeroes are substituted for the missing data (censored observations). However, the substitution of zeroes reduces the mean making it too small but enlarging the variance. Zero substitution is also known as zero imputation. This is the opposite extreme of setting the censored observations to the RL. The consequences of setting all censored observations to zero is a bias to a low mean/median because the sum is that of the quantified observations but the divisor includes the number of zero values.

14. CENSORING

Censoring is a form of missing data problem which is common in survival analysis. A subject is said to be censored if they are loss to follow up during the period of study.

In biomedical applications, especially in clinical trials, two important issues arise when studying time to event" data (we will assume the event to be death". It can be any event of interest):

1. Some individuals are still alive at the end of the study or analysis so the event of interest,
Namely death, has not occurred. Therefore we have right censored data.
2. Length of follow-up varies due to staggered entry. So we cannot observe the event for
individuals with insufficient follow-up time.

Left censoring occurs when we know that the event occurs at a time before a left bound, but we do not known when the event happens for example, when we know the date of a medical examination that revealed a disease, but we do not know when the patient has been infected.

Left censoring is when the event of interest has already occurred before the enrolment. If a subject lifetime is known to be less than a certain duration then it is said to be left censored.

15. PRELIMINARY ANALYSIS

In presenting the results, attention was focused on the statistical results of data collected from the Navrongo Health Centre. Malnourished children were followed for sixteen(16) weeks each year during which the ready-to-use therapeutic foods (RUTFs) '' plumpy nuts'' which contains calories and essential nutrients that restore and maintain body weight and health in severely malnourished children more effectively were given to the children in order to restore nutrients and to enable them achieve their target weight.

From Table 4.1, it was revealed that out of fifty(50) cases of malnutrition recorded from the period of 2010-2014, thirteen (13) cases were recorded in 2010 with a percentage of 26% of the total percentage for the period, nine(9)) cases were recorded in 2011 with a percentage of 18% for the period, eleven(11)) cases were recorded in 2012with a percentage of 22% of the total percentage for the period, ten(10)) cases were recorded in 2013 with a percentage of 20% of the total percentage for the period, seven(7)) cases were recorded in 2014 with a percentage of 14% of the total percentage for the period.

Also, each year recorded number of uncensored observations and censored observations as a result of factors such as; failure of the malnourished child to eat the plumpy nut to enable their weights to be restored, the study was terminated as a result of parents of children travelling or refusal of parents to bring the child for review, target weight of child not being achieved after the study. The study recorded fifteen(15) censored observations and thirty-five(35) uncensored observations.

16. DISTRIBUTIONS OF MALNUTRITION CASES FOR THE PERIOD OF STUDY

During the study some malnourished children were lost to follow due to reasons such as withdrawal from the study, refusal of children to eat the plumpy nut food, while some were still on the food at the end of the study. These observations were considered as censored observations and were marked with pluses and distributed in the table

below as shown on Table 4.2.

From the survey conducted, Table 4.3 shows the distribution of children's mean weight for malnutrition cases with plumpy nuts. The mean weight data was categorized into six, those between mean weight 1.0-2.9 which had only one(1) number of case with a percentage of 2%, those between 3.0-4.9 which had one number of case with a percentage of 2%, those between 5.0-6.9 which represented twenty-eight (28) cases with 56%, 7.0-8.9 which also represented 15 number of cases with 30%, 9.0-10.9 represented four(4) number of cases with 8% and between 13.0-14.9 which had one number of case with 2%.

The pattern indicates children's mean weight for malnutrition cases with plumpy nuts as seen in fiqure A. The graph shows the mean weight of children between 5.0-6.9 recording the highest percentage of 56%, followed by mean weight between 7.0-8.9 recording a percentage of 30% , mean weight between the range 9.0-10.9 also recording a percentage of 8%. Children's with mean weights between 1.0-2.9,3.0-4.9 and 13.0-14.9 recording a percentage of 2%.

From the survey conducted, the number of malnutrition cases recorded during the period of study stood at fifty(50) cases which out of this thirty(30) cases were recorded for males making sixty percent(60%) and twenty(20) cases were recorded for females making forty percent(40%).

Fiqure B indicates the pattern of sex distribution of malnutrition cases throughout the period of study. From the graph, the malnourished male children recorded a percentage of 60% of the total percentage due to high metabolic rate in male children which makes them prone to malnutrition than females. The malnourished female children also recorded a percentage of 40% of the total percentage.

17. PRODUCTS-LIMIT ESTIMATES OF $P_{(t)}$

Kaplan and Meier (1958) introduced the product –limit estimate $\hat{P}_t$ or $\hat{S}_t$ of $\hat{P}_t$ (the probability that an individual survives beyond time t) in a life such that

$t_{(1)}<t_{(2)}<,\ldots..,t_{(i)}$. then $n_{(i)}$ is the number of patients still under observation at time $t_{(i)}$, including the one that died at time $t_{(i)}$.

$$\hat{P}_t = \prod_{j=1}^{i}\left(\frac{n_j-1}{n_j}\right)$$

Considering a clinical trial in which fifty (50) patients are observed to have the following average weights in sixteen (16)
weeks;
$2.9, 4.8^{+}, 5.0, 5.0^{+}, 5.1^{+}, 5.2^{+}, 5.3, 5.4, 5.5, 5.5^{+}, 5.5^{+}, 5.6, 5.7, 5.8, 5.8^{+}, 5.9, 5.9^{+} 6.0, 6.1^{+}, 6.1, 6.1^{+}, 6.2, 6.3^{+} 6.3$
$6.4, 6.4^{+}, 6.5, 6.6, 6.8, 6.9, 7.0, 7.1, 7.2, 7.4, 7.6, 7.7, 8.1, 8.1^{+}, 8.2^{+}, 8.2, 8.3, 8.4, 8.6, 8.9^{+}, 8.9, 9.0, 9.1, 9.3, 10.2, 13.7$
(Those with the plus sign on top were lost to follow up during the sixteen (16) weeks.)

$$\hat{P}_t = \prod_{j=1}^{i}\left(\frac{n_j-1}{n_j}\right)$$

(i) $\hat{P}_{(2.9)}=\left(\frac{50-1}{50}\right)=0.980$

(ii) $\hat{P}_{(5.0)} = 0.980 * \left(\frac{48-1}{48}\right) = 0.960$

(iii) $\hat{P}_{(5.3)} = 0.960 * \left(\frac{44-1}{44}\right) = 0.938$

(iv) $\hat{P}_{(5.4)} = 0.938 * \left(\frac{43-1}{43}\right) = 0.916$

(v) $\hat{P}_{(5.5)} = 0.916 * \left(\frac{42-1}{42}\right) = 0.894$

(vi) $\hat{P}_{(5.6)} = 0.894 * \left(\frac{39-1}{39}\right) = 0.871$

(vii) $\hat{P}_{(5.7)} = 0.871 * \left(\frac{38-1}{38}\right) = 0.848$

(viii) $\hat{P}_{(5.8)} = 0.848 * \left(\frac{37-1}{37}\right) = 0.825$

(ix) $\hat{P}_{(5,9)} = 0.825 * \left(\frac{35-1}{35}\right) = 0.801$

(x) $\hat{P}_{(6.0)} = 0.801 * \left(\frac{33-1}{33}\right) = 0.777$

(xi) $\hat{P}_{(6.1)} = 0.777 * \left(\frac{31-1}{31}\right) = 0.752$

(xii) $\hat{P}_{(6.2)} = 0.752 * \left(\frac{29-1}{29}\right) = 0.726$

(xiii) $\hat{P}_{(6.3)} = 0.726 * \left(\frac{27-1}{27}\right) = 0.699$

(xiv) $\hat{P}_{(6.4)} = 0.699 * \left(\frac{26-1}{26}\right) = 0.672$

(xv) $\hat{P}_{(6.5)} = 0.672 * \left(\frac{24-1}{24}\right) = 0.644$

(xvi) $\hat{P}_{(6.6)} = 0.644 * \left(\frac{23-1}{23}\right) = 0.616$

(xvii) $\hat{P}_{(6.8)} = 0.616 * \left(\frac{22-1}{22}\right) = 0.588$

(xviii) $\hat{P}_{(6.9)} = 0.588 * \left(\frac{21-1}{21}\right) = 0.560$

(xix) $\hat{P}_{(7.0)} = 0.560 * \left(\frac{20-1}{20}\right) = 0.532$

(xx) $\hat{P}_{(7.1)} = 0.532 * \left(\frac{19-1}{19}\right) = 0.504$

(xxi) $\hat{P}_{(7.2)} = 0.504 * \left(\frac{18-1}{18}\right) = 0.476$

(xxii) $\hat{P}_{(7.4)} = 0.476 * \left(\frac{17-1}{17}\right) = 0.448$

(xxiii) $\hat{P}_{(7.6)} = 0.448 * \left(\frac{16-1}{16}\right) = 0.420$

(xxiv) $\hat{P}_{(7.7)} = 0.420 * \left(\frac{15-1}{15}\right) = 0.392$

(xxv) $\hat{P}_{(8.1)} = 0.392 * \left(\frac{14-1}{14}\right) = 0.364$

(xxvi) $\hat{P}_{(8.2)} = 0.364 * \left(\frac{11-1}{11}\right) = 0.331$

(xxvii) $\hat{P}_{(8.3)} = 0.331 * \left(\frac{10-1}{10}\right) = 0.298$

(xxviii) $\hat{P}_{(8.4)} = 0.298 * \left(\frac{9-1}{9}\right) = 0.265$

(xxix) $\hat{P}_{(8.6)} = 0.265 * \left(\frac{8-1}{8}\right) = 0.221$

(xxx) $\hat{P}_{(8.9)} = 0.221 * \left(\frac{6-1}{6}\right) = 0.184$

(xxxi) $\hat{P}_{(9.0)} = 0.184 * \left(\frac{5-1}{5}\right) = 0.147$

(xxxii) $\hat{P}_{(9.1)} = 0.147 * \left(\frac{4-1}{4}\right) = 0.110$

(xxxiii) $\hat{P}_{(9.3)} = 0.110 * \left(\frac{3-1}{3}\right) = 0.073$

(xxxiv) $\hat{P}_{(10.2)} = 0.073 * \left(\frac{2-1}{2}\right) = 0.037$

(xxxv) $\hat{P}_{(13.7)} = 0.040 * \left(\frac{1-1}{1}\right) = 0.000$

It is shown by Kaplan and Meier that the estimated mean weight is given by;

$\hat{\mu}$ = (1.000)(2.9)+0.980(5.0-2.9)+0.960(5.3-5.0)+0.938(5.4-5.3)+0.916(5.5-5.4)+0.894(5.6-5.5)+0.871(5.7-5.6)+0.848(5.8-5.7)+0.825(5.9-5.8)+0.801(6.0-5.9)+0.777(6.1-6.0)+0.752(6.2-6.1)+0.726(6.3-6.2)+0.699(6.4-6.3)+0.672(6.5-6.4)+0.644(6.6-6.5)+0.616(6.8-6.6)+0.588(6.9-6.8)+0.560(7.0-6.9)+0.532(7.1-7.0)+0.504(7.2-7.1)+0.476(7.4-7.2)+0.448(7.6-7.4)+0.420(7.7-7.6)+0.392(8.1-7.7)+0.364(8.2-8.1)+0.331(8.3-8.2)+0.298(8.4-8.3)+0.265(8.6-8.4)+0.221(8.9-8.6)+0.184(9.0-8.9)+0.147(9.1-9.0)+0.110(9.3-9.1)+0.073(10.2-9.3)+0.037(13.7-10.2)

$$\hat{\mu} = 7.4764$$

VARIANCE

An appropriate estimate of the variance of $\hat{P}_t$ is given as

$\text{Var}\left[\hat{P}_t\right]=\left[\widehat{P_t}\right]^2 \sum_j^i \frac{1}{nj(nj-1)}$

(i) $\text{Var}\left[\hat{P}(2.9)\right]=(0.980)^2\left(\frac{1}{50*49}\right)=0.000392$

(ii) $\text{Var}\left[\hat{P}(5.0)\right]=(0.960)^2\left(\frac{1}{50*49}+\frac{1}{48*47}\right)=0.000784$

(iii) $\text{Var}\left[\hat{P}(5.3)\right]=(0.938)^2\left(\frac{1}{50*49}+\frac{1}{48*47}+\frac{1}{44*43}\right)=0.001214$

(iv) $\text{Var}\left[\hat{P}(5.4)\right]=(0.916)^2\left[0.001379967+\frac{1}{43*42}\right]=0.001622$

(v) $\text{Var}\left[\hat{P}(5.5)\right]=(0.894)^2\left[0.001933677+\frac{1}{42*41}\right]=0.0020096$

(vi) $\text{Var}\left[\hat{P}(5.6)\right]=(0.871)^2\left[0.002514397+\frac{1}{39*38}\right]=0.002419$

(vii) $\text{Var}\left[\hat{P}(5.7)\right]=(0.848)^2\left[0.00318916+\frac{1}{38*37}\right]=0.002808$

(viii) $\text{Var}\left[\hat{P}(5.8)\right]=(0.825)^2\left[0.003900398+\frac{1}{37*36}\right]=0.0031657$

(ix) $\text{Var}\left[\hat{P}(5.9)\right]=(0.801)^2\left[0.004651149+\frac{1}{35*34}\right]=0.003523$

(x) $\text{Var}\left[\hat{P}(6.0)\right]=(0.777)^2\left[0.005491485+\frac{1}{33*32}\right]=0.0038871$

(xi) $\text{Var}\left[\hat{P}(6.1)\right]=(0.752)^2\left[0.006438455+\frac{1}{31*30}\right]=0.004249$

(xii) $\text{Var}\left[\hat{P}(6.2)\right]=(0.726)^2\left[0.00751372+\frac{1}{29*28}\right]=0.004609$

(xiii) $\text{Var}\left[\hat{P}(6.3)\right]=(0.699)^2\left[0.00875247+\frac{1}{27*26}\right]=0.004972$

(xiv) $\text{Var}\left[\hat{P}(6.4)\right]=(0.672)^2\left[0.01017697+\frac{1}{26*25}\right]=0.00529$

(xv) $\text{Var}\left[\hat{P}(6.5)\right]=(0.644)^2\left[0.0117154+\frac{1}{24*23}\right]=0.005610$

(xvi) $\text{Var}\left[\hat{P}(6.6)\right]=(0.616)^2\left[0.013526+\frac{1}{23*22}\right]=0.005882$

(xvii) $\text{Var}\left[\hat{P}(6.8)\right]=(0.588)^2\left[0.01550228+\frac{1}{22*21}\right]=0.006108$

(xviii) $\text{Var}\left[\hat{P}(6.9)\right]=(0.560)^2\left[0.01766678+\frac{1}{21*20}\right]=0.006287$

(xix) $\text{Var}\left[\hat{P}(7.0)\right]=(0.532)^2\left[0.02004773+\frac{1}{20*19}\right]=0.006419$

(xx) $\text{Var}\left[\hat{P}(7.1)\right]=(0.504)^2\left[0.02267931+\frac{1}{19*18}\right]=0.006504$

(xxi) $\text{Var}\left[\hat{P}(7.2)\right]=(0.476)^2\left[0.02560329+\frac{1}{18*17}\right]=0.006542$

(xxii) $\text{Var}\left[\hat{P}(7.4)\right]=(0.448)^2\left[0.02887126+\frac{1}{17*16}\right]=0.006532$

(xxiii) $\text{Var}\left[\hat{P}(7.6)\right]=(0.420)^2\left[0.032548+\frac{1}{16*15}\right]=0.006476$

(xxiv) $\text{Var}\left[\hat{P}(7.7)\right]=(0.392)^2\left[0.03671467+\frac{1}{15*14}\right]=0.006373$

(xxv) $\text{Var}\left[\hat{P}(8.1)\right]=(0.364)^2\left[0.04147657+\frac{1}{14*13}\right]=0.006223$

(xxvi) $\text{Var}\left[\hat{P}(8.2)\right]=(0.331)^2\left[0.04697108+\frac{1}{11*10}\right]=0.006142$

(xxvii) $\text{Var}\left[\hat{P}(8.3)\right]=(0.298)^2\left[0.0560619+\frac{1}{10*9}\right]=0.005965$

(xxviii) $\text{Var}\left[\hat{P}(8.4)\right]=(0.265)^2\left[0.06717301+\frac{1}{9*8}\right]=0.005693$

(xxix) $\text{Var}\left[\hat{P}(8.6)\right]=(0.221)^2\left[0.08106189+\frac{1}{8*7}\right]=0.004831$

(xxx) $\text{Var}\left[\hat{P}(8.9)\right]=(0.184)^2\left[0.0989190+\frac{1}{6*5}\right]=0.005448$

(xxxi) $\text{Var}\left[\hat{P}(9.0)\right]=(0.147)^2\left[0.13225233+\frac{1}{5*4}\right]=0.003938$

(xxxii) $\text{Var}\left[\hat{P}(9.1)\right]=(0.110)^2\left[0.18225233+\frac{1}{4*3}\right]=0.003214$

(xxxiii) $\text{Var}\left[\hat{P}(9.3)\right]=(0.073)^2\left[0.26558566+\frac{1}{3*2}\right]=0.002303$

(xxxiv) $\text{Var}\left[\hat{P}(10.2)\right]=(0.037)^2\left[0.43225233+\frac{1}{2*1}\right]=0.001276$

(xxxv) $\text{Var}\left[\hat{P}(13.7)\right]=(0.000)^2[0.93225233+0.000]=0.000$

$$\hat{\mathbf{V}}(\hat{\mu})=\sum_r \frac{A^2}{(N-r)(N-r+1)}$$

$$\hat{\mathbf{V}}(\hat{\mu})=\sum 0.000392+0.000784+0.001214+0.001622+0.0020096+\cdots+0.000$$

$$\hat{\mathbf{V}}(\hat{\mu})=\mathbf{0.148}$$

SIMULATION OF THE DATA WITH R

Number of subjects at risk

```
----------------------------
 sub.risk
    100
```

Number of events

```
----------------------------
 num.events
       70
```

Proportion of subjects with event

```
----------------------------
 mean.ep.sub
     0.1505
```

Total time of follow-up

```
----------------------------
   foltime
 1302
```

Time of follow-up (median)

```
----------------------------
 med.foltime
   1.015501
```

Density of incidence

```
----------------------------
 dens.incid
0.04237541
```

At n=200

Number of subjects at risk
---
sub.risk
200

Number of events
---
num.events
142

Proportion of subjects with event
---
mean.ep.sub
0.1504

Total time of follow-up
---
foltime
2600.64

Time of follow-up (median)
---
med.foltime
1.194109

Density of incidence
---
dens.incid
0.04746018

Simulation is an attempt to estimate the properties of a process by using a random variable or the natural data to represent that process. It is done as a sensitive analysis for an existing study and also used to assess the performance of theoretical background. The data was simulated to get the true value of the data in conformity with the Kaplan Meier estimator. The data was initially simulated to 100 which represents the subject at risk and it gave the number of event (uncensored cases) as 70 with a proportion of subjects with event giving as 0.1505 (censored cases).The total follow up time was 1302 and the time for follow up median and density of incident were 1.015501 and 0.04237541 respectively.

Also the data was simulated to 200 that is the number of subject at risk and the number of subject with event was 142(uncensored cases). The proportion of event in this case was 0.1504 and the total follow up time was 2600with a follow up median of 1.194109 and density of 0.04746018.

This indicates that the Kaplan Meier estimate of the mean is accurate since it is a true reflection of the original data even when the sample size is increased.

18. MEAN SUBSTITUTION

Mean Weight=$\frac{\text{sum of all children who were not censored}}{\text{total number of children who were not censored}}=\frac{299.3}{35}$

Mean Weight=8.55143

Substituting the mean weight in place of all children who were censored (15 children)

15*8.55143=128.2714

Mean Substitution=$\frac{128.2714+299.3}{50}$=8.5514

The Mean Substitution=8.5514

VARIANCE

Variance=$\frac{1}{n}\sum(x-\overline{x})^2$

$\bar{x}$=8.5514

$n = 50$

$(2.9-8.5514)^2$+$(5.0-8.5514)^2$+$(5.3-8.5514)^2$+$(5.4-8.5514)^2$+$(5.5-8.5514)^2$+$(5.6-8.5514)^2$+$(5.7-8.5514)^2$+$(5.8-8.5514)^2$+$(5.9-8.5514)^2$+$(6.0-8.5514)^2$+$(6.1-8.5514)^2$+$6.2-8.5514)^2$+$(6.3-8.5514)^2$+$(6.4-8.5514)^2$+$(6.5-8.5514)^2$+$(6.6-8.5514)^2$+$(6.8-8.5514)^2$+$(6.9-8.5514)^2$+$(7.0-8.5514)^2$+$(7.1-8.5514)^2$+$(7.2-8.5514)^2$+$(7.4-8.5514)^2$+$(7.6-8.5514)^2$+$(7.7-8.5514)^2$+$(8.1-8.5514)^2$+$(8.2-8.5514)^2$+$(8.3-8.5514)^2$+$(8.4-8.5514)^2$+$(8.6-8.5514)^2$+$(8.9-8.5514)^2$+$(9.0-8.5514)^2$+$(9.1-8.5514)^2$+$(9.3-8.5514)^2$+$(10.2-8.5514)^2$+$(13.7-8.5514)^2$

$\frac{187.2491788}{50} = 3.74498$

Variance of mean substitution=3.74498

19. ZERO SUBSTITUTION

Mean of Zero Substitution=$\frac{\text{Total number of children who were not censored}}{\text{Total number of children}}=\frac{299.3}{50}$

Mean of zero substitution=5.9860

VARIANCE

Variance=$\frac{1}{n}\sum(x-\overline{x})^2$

$\bar{x}$=5.9860

n =50

$(2.9-5.9860)^2$+$(0-5.9860)^2$ + $(5.0-5.9860)^2$+$(0-5.9860)^2$ + $(0-5.9860)^2$ + $(0-5.9860)^2$ + $(5.3-5.9860)^2$+$(5.4-5.9860)^2$+$(5.5-5.9860)^2$+$(0-5.9860)^2$ + $(0-5.9860)^2$ + $(5.6-5.9860)^2$+$(5.7-5.9860)^2$+$(5.8-5.9860)^2$+$(0-5.9860)^2$ + $(5.9-5.9860)^2$+$(0-5.9860)^2$ + $(6.0-5.9860^2$+$(0-5.9860)^2$ + $(6.1-5.9860)^2$+$(0-5.9860)^2$ + $(6.2-5.9860)^2$+$(0-5.9860)^2$ + $(6.3-5.9860)^2$+$(6.4-5.9860)^2$+$(0-5.9860)^2$ + $(6.5-5.9860)^2$+$(6.6-5.9860)^2$+$(6.8-5.9860)^2$+$(6.9-5.9860)^2$+$(7.0-5.9860)^2$+$(7.1-5.9860)^2$+$(7.2-5.9860)^2$+$(7.4-5.9860)^2$+$(7.6-5.9860)^2$+$(7.7-5.9860)^2$+$(8.1-5.9860)^2$+$(0-5.9860)^2$ + $(0-5.9860)^2$ + $(8.2-5.9860)^2$+$(8.3-5.9860)^2$+$(8.4-5.9860)^2$+$(8.6-5.9860)^2$+$(0-5.9860)^2$ + $(8.9-5.9860)^2$+$(9.0-5.9860)^2$+$(9.1-5.9860)^2$+$(9.3-5.9860)^2$+$(10.2-5.9860)^2$+$(13.7-5.9860)^2$

$\frac{705.9594}{50}$=14.11919

Variance of Zero Substitution=14.1192

The Table 4.5 indicates three different models used in the analysis of data. These models are; Kaplan Meier estimator, Mean substitution model and Zero substitution model. Kaplan Meier has a mean weight of 7.4764 with a variance of 0.14871, standard deviation of 0.38563 and a standard error of 0.05454. Mean Substitution has a mean weight of 8.5514 with a variance of 3.74498, standard deviation of 1.93520 and a standard error of 0.27368 and Zero substitution has a mean weight of 5.9860 with a variance of 14.11919, standard deviation of 3.75755and a standard error of 0.53140

The Kaplan Meier mean gave the average mean weight of all the malnourished children throughout the period of study. To test for the variability in the data set, Kaplan Meier model gave the least standard deviation and variance which indicates that there is less variation within the individual mean weights and hence less biasedness in the various weights as compared to the other models.

Mean substitution model also has a largest mean weight since the mean substituted artificially increases the mean as compared to the mean weight of the Zero substitution and Kaplan Meier but has lesser standard deviation and variance compared to that of Zero substitution and hence there is less variation within the individual

weights. Zero substitution has the largest standard deviation and variance with a least mean weight which indicates that there is greater variation within the individual mean weights and hence greater biasedness in the data set.

Also, the standard error which is a measure of dispersion and how accurate and precise the mean weight is also indicated Kaplan Meier estimate with the least standard error of 0.05454 followed by the Mean substitution with a standard error of 0.27368 and Zero substitution recorded the highest standard error of 0.53140. This indicates that the dispersion within the mean weight with regards to Kaplan meier is less which means that the Kaplan Meier mean weight is more accurate and precise as compared to the mean weights of the Mean Substitution and the Zero Substitution.

20. DISCUSSION OF RESULTS

The research work was carried out in the Kasena-Nankana District in the Upper East Region (Navrongo) to be precise. In all fifty (50) cases of malnutrition for the period of years 2010-2014 were studied, to calculate the mean weight of the malnourished children to determine the effectiveness of the plumpy nut food on the malnourished children and to come out with the most model that is appropriate for calculating the mean weight of the malnourished children. It was realized that for the period of years 2010-2014, the year 2010 recorded the highest number of cases with a percentage of 26% of the total number of cases followed by the year 2012 with eleven number of cases with a percentage of 22% and the year 2014 recorded the least number of cases with a percentage of 14%. The research revealed that the year 2010 recorded the highest number of cases due to reasons such as; refusal of the malnourished children to eat the plumpy nut food to enable nutrients to be restored, the study was loss to follow up as a result of parents traveling with children during the period of study and target weight not achieved even at the end of the study.

The study also revealed that the number of malnutrition cases was found more in male children who recorded thirty (30) numbers of cases with a percentage of 60% than female children which is due to high metabolic rate in male children which makes them prone to malnutrition than females.

In terms of mean weight, the research revealed that malnourished children who fell in the range between 5.0-6.9 recorded twenty-eight number of cases which was the highest with a percentage of 56% of the total percentage, followed by the mean weight between the range 7.0-8.9 which also recorded fifteen number of cases making a percentage of 30% and mean weights between the ranges 1.0-2.9,3.0-4.9,13.0-14.9 recorded the least mean weight with one number of cases making a percentage of 2% of the total percentage.

For malnourished children responding to the ready-to-use therapeutic foods (RUTFs) '' plumpy nuts'' which contains calories and essential nutrients that restore and maintain body weight and health in severely malnourished children , the research revealed that thirty-five(35) children responded to the food and fifteen children failed to respond due to reasons such as; refusal of the malnourished child to eat the plumpy nut food to enable nutrients to be restored, the study was loss to follow up as a result of parents traveling with children during the period of study and target weight not achieved even at the end of the study.

From the Kaplan Meier, Mean substitution and Zero substitution results, it was revealed that Kaplan Meier gave the most appropriate model in calculating for the mean weight of the malnourished children since it gave the least standard deviation and variance indicating that there is less variation within the individual mean weights and hence less biasedness in the model used to estimate the data. It also indicated that the dispersion within the mean weight with regards to Kaplan Meier is less which means that the Kaplan Meier mean weight is more accurate and precise as compared to the mean weights of the Mean Substitution and the Zero Substitution.

The research also revealed that the ready-to-use therapeutic foods (RUTFs) '' plumpy nuts'' which contains calories and essential nutrients that restore and maintain body weight and health was effective since the number of cases during the last year of the period of study decreased.

20. CONCLUSION

The study revealed that malnutrition rate among children in the Kassena-Nankana district has decreased for the last year of the selected period of study. This shows that the ready-to-use therapeutic foods (RUTFs) '' plumpy nuts'' which contains calories and essential nutrients that restore and maintain body weight and health in severely malnourished children was effective since majority of the malnourished children were not censored .This reveals that the health management team within the Kassena-Nankana district who extended their outreach programs to the communities to follow the malnourished children for a certain period of time and administered the plumpy nuts to the children to restore their nutrients are to a large extent performing well.

Even though malnutrition cases were 20% higher in male children than female children, this shows that sex has an influence in the number of malnutrition cases and that a child must not be male or female to become malnourished. The study also revealed that the Kaplan –Meier estimator was the best model appropriate for estimating the mean weight of the malnourished children since there is no variation in the individual weights and hence less biased.

21. RECOMMENDATIONS

In the light of this, we seek to put across the following recommendations;

The health management team should educate pregnant and lactating mothers on the causes and effects of malnutrition and also see to it that the ready-to-use therapeutic foods (RUTFs) ' plumpy nuts' which contains calories and essential nutrients that restore and maintain body weight and health in severely malnourished children is given to the children as prescribed to restore their nutrients.

Families need to have access to adequate preventive and curative health care .They also need to access to safe water and hygienic sanitation to prevent infection and diseases.

NGO's and other philanthropist within the Kassena-Nankana district should help equip teenagers and lactating mothers who are not working with some vocational training to enable them generate some money to cater for themselves as well as the babies.

Researchers within the Kassena –Nankana district should look out for other causes of the menace and come out with possible solutions to try and reduce malnutrition cases.

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APPENDIX

Table 4.1 DISTRIBUTIONS OF MALNUTRITION CASES FOR THE PERIOD OF YEARS 2010-2014

YEAR	NUMBER OF CASES	PERCENT%	NUMBER OF CENSORED CASES	PERCENT%	NUMBER OF UNCENSORED CASES	PERCENT%
2010	13	26	3	20	10	28.57
2011	9	18	2	13.33	7	20
2012	11	22	4	26.67	7	20
2013	10	20	4	26.67	6	17.14
2014	7	14	2	13.33	5	14.29
TOTAL	50	100	15	100	35	100

SOURCE: NAVRONGO HEALTH CENTRE

Table 4.2

SERIAL NUMBER	ADMISSION WEIGHT	AVERAGE WEIGHT
1	2.5	2.9
2	5.0	4.8^{+}
3	4.0	5.0
4	6.0	5.0^{+}
5	5.7	5.1^{+}
6	6.0	5.2^{+}
7	4.5	5.3
8	4.7	5.4
9	4.6	5.5
10	7.2	5.5^{+}
11	6.4	5.5^{+}
12	5.3	5.6
13	4.9	5.7
14	5.0	5.8
15	6.3	5.8^{+}
16	4.8	5.9
17	6.1	5.9^{+}
18	5.4	6.0
19	6.5	6.1^{+}
20	5.7	6.1
21	6.4	6.1^{+}
22	5.6	6.2
23	6.5	6.3^{+}
24	5.8	6.3
25	5.6	6.4
26	6.6	6.4^{+}
27	5.9	6.5
28	4.6	6.6
29	5.3	6.8
30	5.4	6.9
31	6.2	7.0
32	5.5	7.1
33	4.7	7.2
34	6.4	7.4
35	4.9	7.6
36	4.8	7.7
37	5.8	8.1
38	8.5	8.1^{+}
39	8.3	8.2^{+}
40	4.9	8.2
41	5.9	8.3
42	5.2	8.4
43	7.3	8.6
44	9.0	8.9^{+}
45	7.7	8.9
46	6.7	9.0
47	8.1	9.1
48	7.7	9.3
49	9.8	10.2
50	10.9	13.7

Table 4.3 DISTRIBUTION FOR CHILDREN'S MEAN WEIGHT FOR MALNUTRITION CASES WITH PLUMPY NUTS

MEAN WEIGHT	NUMBER OF CASES	PERCENT %
1.0-2.9	1	2
3.0-4.9	1	2
5.0-6.9	28	56
7.0-8.9	15	30
9.0-10.9	4	8
13.0-14.9	1	2
TOTAL	50	100

SOURCE: NAVRONGO HEALTH CENTRE

FIGURE A: PATTERN OF CHILDREN'S MEAN WEIGHT FOR MALNUTRITION CASES WITH PLUMPY NUTS

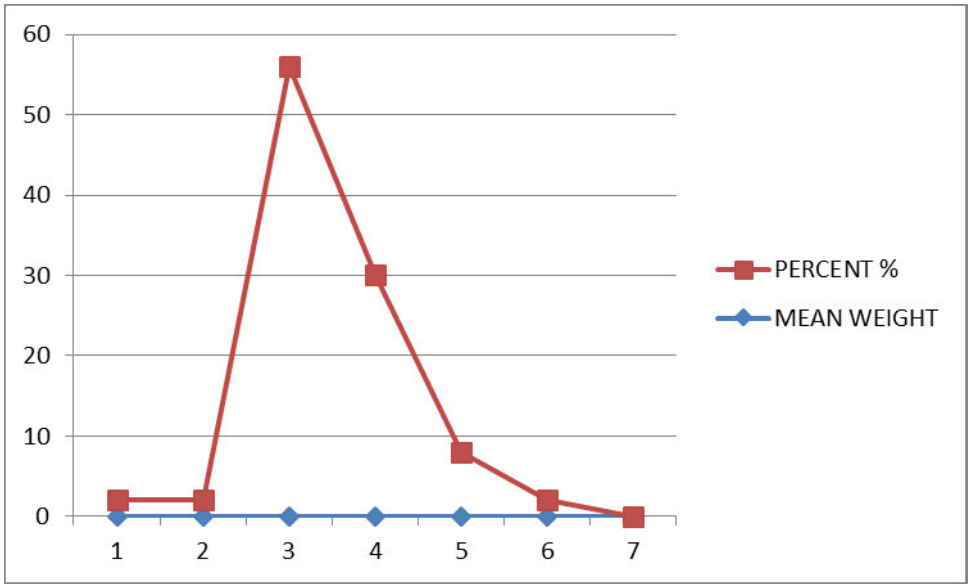

Table 4.4 SEX DISTRIBUTION OF MALNUTRITION CASES WITH PLUMPY NUTS

SEX	NUMBER OF CASES	PERCENT %
MALE	30	60
FEMALE	20	40
TOTAL	50	100

FIGURE B: PATTERN FOR SEX DISTRIBUTION OF MALNUTRITION CASES WITH PLUMPY NUTS

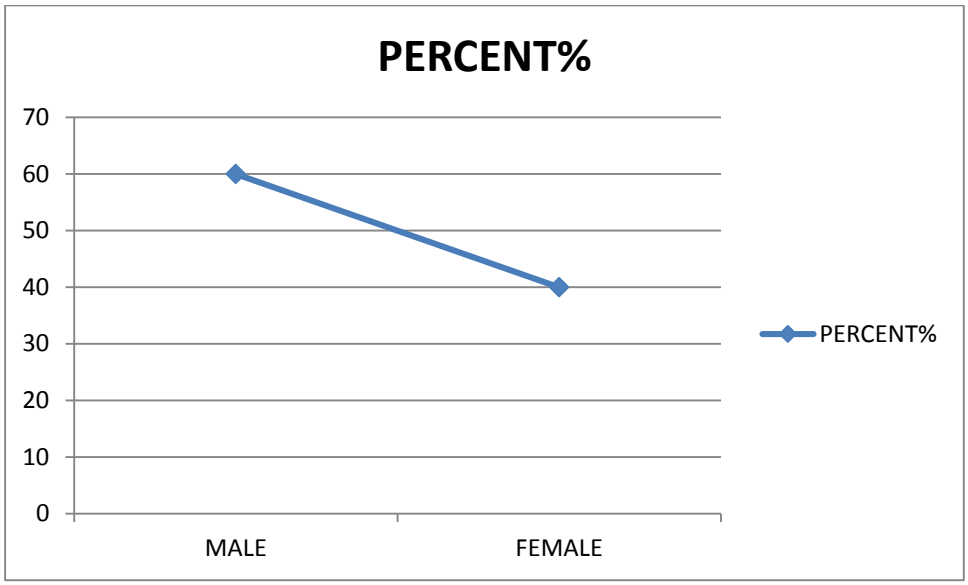

TABLE4.5 INTERPRETATION OF RESULTS

Mean	Variance	Standard deviation	Standard error
7.4764	0.14871	0.38563	0.05454
8.5514	3.74498	1.93520	0.27368
5.9860	14.11919	3.75755	0.53140