KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

THE RELATIONSHIP BETWEEN DIETARY INTAKE OF ANTI-OXIDANT MICRONUTRIENTS AND THE RATE OF RECOVERY IN BURN PATIENTS

BY

MARY ADJEPONG

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THIS DISSERTATION IS PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MPhil. DEGREE IN HUMAN NUTRITION AND DIETETICS

BY

MARY ADJEPONG

AUGUST, 2014

DECLARATION

I declare that I have wholly undertaken the study reported herein under the supervision of Prof. I. Oduro, Prof. Pius Agbernorku and Dr. Patricia Brown and that except portions where references have been duly cited, this dissertation is the outcome of my research.

…………………………….. ……..………………………………..
Date (Signature)
Mary Adjepong

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Date (Signature)
Prof. Ibok Oduro

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Date (Signature)
Prof. Pius Agbernorku

…………………………….. ……..………………………………..
Date (Signature)
Dr. Patricia Brown

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Date (Signature)
Head of Department

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ABSTRACT

Burn injury results in emotional stress affecting dietary intake and anti-oxidant micronutrient intake, which is known to have effects on recovery outcomes.
The study aimed to assess dietary intake of anti-oxidant micronutrients and recovery outcomes of burn patients. Secondary data of 487 patients was taken from the Burns Intensive Care Unit (BICU) at Komfo Anokye Teaching Hospital (KATH) for a period of 4 years (May 1, 2009 – April 30, 2013). Questionnaires were administered to 40 burn patients at KATH from March 1, 2014 – May 30, 2014. The data taken include anthropometric measurements and dietary assessment. Their nutrient intakes were assessed with Nutrient Analysis Template. The average intakes were compared to the Recommended Daily Allowance. Assessment of recovery was based on records of wound healing assessments and infection rates from the health practitioners.
The secondary data indicated that the mean ICU stay and mean Total Burns Surface Area (TBSA) was 8.44 days and 28.79% respectively with 224 (46.0 %) females and 263 (54.0%) males. The mortality rate for the period under review was 20.4%. Cross sectional study for 40 patients revealed an average TBSA of 31.4%; where 70.0%, 35%, 75%, 52.5%, 12.5% and 32.5% patients were deficient in Vitamin A, C, E, Zinc, Copper and Selenium respectively. Patients with adequate amounts of zinc had a lower rate of infection, 26.3% as compared with those with inadequate amounts 33.33%, 25% of patients with adequate amounts of Vitamin A had wound infections as compared to 32% with inadequate amounts. With Vitamin C, 26.9% patients with adequate amounts had infections as compared with 35.7% with inadequate amounts. Also 76.9% of patients with adequate amounts of Vitamin C showed progress in wound healing. The adequacy of anti-oxidants resulted in positive wound healing outcomes. The prevalence of burn injury is high; hence there should be public education to prevent it. Also, most burn patients did not meet their dietary requirements for anti-oxidant micronutrient and this may be due to meals not tailored to suit individual requirements, hence the need for planned and well balanced meals.

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CHAPTER ONE

BACKGROUND

1.1 Introduction

Burns place a great socio- economic burden on individuals, their families and the health services (Balseven-Odabaşı, 2009). Apart from the financial burden to families, communities and the nation, it leads to pain, infection, extensive scarring, wound and scar contractures, amputations and death in some of its victims. World Health Organization (WHO) estimated that 43,000 people die of burns in Africa every year with a rate of 6.1 per 100,000 (Outwater, 2013).

The main causes of mortality in burn patients are associated with infection, delayed wound healing and extensive protein catabolism. Underlying these processes include immunological, endocrine, inflammatory and other metabolic responses (Berger *et al*., 1998). Where the skin is exposed in burn patients, there are several mechanisms that lead to oxidative damage to the cell membranes. This include the peroxidation of polyunsaturated fatty acids residues in membranes that can lead to membrane impairment, in addition to fragmentation of proteins at vulnerable points in the amino acid chain. There is also the irreversible damage to protein sites where metal ions normally bind to functional protein (Webb, 2011).

The main cause of immune suppression in burn patients is as a result of the presence of reactive oxygen species (ROS) and this can lead to a delay in wound healing and increase the patient's susceptibility to infections (Al – Jawad *et al*., 2011). There is an alteration in the mechanism by which free radical are produced and disposed of in burn patients; there also exist a correlation between the free radical cascade and wound healing (Berger *et al*., 2007). Free radicals increase the synthesis of cytokines, whose elevation increases the mortality and morbidity in burns patients in addition to causing severe organ dysfunction (Church *et al*., 2006). In severe burns there is an elevation of hormones especially, the glucocorticoids which lead to an alteration in the production of cytokines such as Interleukin-1 (IL-1) and tumor necrosis factor alpha (Church *et al*., 2006). Generally, many changes in cytokine levels present an alteration in adaptive immunity. In contrast, the influence of anti-oxidants is known to inhibit a dimmer that causes an increase in the production of cytokines (Closa and Folsch-Puy, 2004).

Nutritional therapy is an integral part of burns care (Machado, 2011; Rousseau, 2013) and it involves nutritional assessment and nutritional support. The main goals of nutritional therapy for burn patients involve maintaining body mass, restoring protein losses, managing infection as well as preventing starvation and specific nutrient deficiencies (Prins., 2009). Burn patients have a high rate of metabolism compared to other critically ill patients and this hyper metabolism is designed to support immune function, brain activity, wound healing, preservation of body tissues, maintaining nitrogen balance (Machado *et al*., 2011) hence the need for adequate nutritional support.

Numerous and diversified measures are taken by diet experts to prevent malnutrition and wasting in burn patients. These include high protein and high calorie diet among others. There are also other immune enhancing formulae that are of much use to burn patients (De souza and Green., 1998). Sometimes there are supplementation of vitamins and minerals. Some of these food supplements contain anti-oxidants.

Anti – oxidants play a vital role in scavenging free radicals to render it harmless and this is applied extraordinarily in burns patients to promote wound healing. As reported by Al-Jawad *et al.*, 2011, low levels of anti-oxidants coupled with high levels of free radicals leads to a remarkable delay in wound healing; hence an increase in anti-oxidants and a decrease in free radical can cause a reverse. During burn injury the individual becomes deficient in trace elements and vitamins through its loss in urine and in wound exudates. Kurmis *et al*., 2013 reported that a deficiency in anti – oxidant micronutrients that is very common in burns lead to delayed wound healing, increase in the presence of infection as well as increasing the length of hospital stay. These findings strongly support the use of anti-oxidants in nutrition therapy when burn patients are considered.

A research done by Takyi and Amankwa, 2004 with some Ghanaian students revealed that about 15.3% and 83% of the population had a deficiency of copper and selenium respectively, giving an indication that, at baseline some patients may have trace element deficiencies that can have an adverse effect on the outcome variables in the case of burns. A study by Aryee *et al*., 2011 also reported that all the burn patients in that study had micronutrient deficiencies at baseline. Also Ghana Nutrition Profile, 2011 account for low Zinc and Vitamin A levels in most inhabitants in Ghana especially children.

At baseline, there is suspected deficiency, hence the relevance of adequacy of dietary micronutrient to the burn patient should be considered as it may have a potency on the recovery outcomes.

1.2 Problem Statement

Burns are tragic accidents that are on the rise in Ghana as evidenced by the number of patients in the Burn Intensive Care Units and most Reconstructive and Plastic Surgery wards in the country in the past few years. In children below three years, scalds are on the increase (Agbenorku, 2013). Most patients in this category suffer a lot of emotional stress that affect their dietary intake as well as the possible nutritional deficiencies.

Furthermore, there are reports indicating that there are micronutrient deficiencies in the Ghanaian population that increases a patient’s susceptibility to micronutrient deficiency during burns. The use of antioxidant micronutrient supplements for patients with burn injury is common in nutrition therapy in some other countries (Berger *et al*., 2007) but there is little reported work of the dietary intake of such nutrient. The dietary assessment of anti-oxidant micronutrient of burns patients in Ghana is thus relevant.

There is little emphasis on the intake of micro nutrients as compared to the emphasis made on the intake of macronutrient hence there is a need to assess the effect of the intake of micronutrients in burn patients as micronutrients have very important roles in wound healing as well as the infection rates.

1.3 Research questions

The study seeks to answer the following questions

- Does the dietary intake of some anti-oxidant micronutrient have an effect on the recovery rates in the patients?
- Does dietetic input have an effect on the recovery outcomes of burn patients?

1.4 Hypothesis

The dietary intake of anti –oxidant micronutrients by patients with burns injury improve their recovery outcomes. The micronutrients to be considered are Copper, Zinc, Selenium, Vitamin A, C and E.

1.5 Aim

The aim of this study is to assess the relationship between dietary intake of anti-oxidant micronutrient and recovery outcomes of the burns patients.

1.6 Specific Objectives of the Study

- To assess the dietary intake of some anti-oxidant micronutrient of burn patients before burn injury

- To determine the effect of the dietary intake of anti -oxidant micronutrient on the rate of recovery of patients as determined by wound healing, infection rates and the length of hospital.
- To assess the serum Vitamin A of the patients and its effect on recovery outcomes.
- To evaluate the effect of dietetic input on the recovery outcomes of burn patients.

1.7 Justification

The data obtained from this project will provide information on the importance of the dietary intake of the anti-oxidant micronutrients and their role on the recovery rates of burn patients in the Ghanaian population. This project also seeks to provide evidence – based recommendation for clinical nutritional care in Ghana with regards to burn patients. With these, the nutritional management of burn patients will be optimized.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Burn injury, which is among the most devastating of all injury and a major global public health crisis, is defined as an injury to the skin or other organic tissues primarily caused by heat or due to radiation, electric current, friction or exposure to chemicals (WHO, 2014). It can thence be classified under three main headings depending on the cause of the injury, as chemical burns which is caused by exposure to acids or alkali, thermal burns which caused by hot water, hot oil, open flame; and electrical burns caused as a result to exposure to high voltage current or lightening.

Though it is highly preventable, burn injury is the fourth most common cause of trauma in the world following traffic accidents, falls, and interpersonal violence (WHO,2014). It is reported that women and children, persons living in low and middle income countries are at risk compared with persons living in high income countries. Other risks include occupation that increase people's exposure to open flame, poverty that lead to overcrowding and lack of proper safety measure, alcohol abuse and smoking(Fordjour, 2006).

Statistics show that about 90% of burn injury in developing countries occur in the homes as most homes resort to open flame as the means of preparing meals (Gosselin *et al.*, 2009).Due to its prevalence, most of the victims require medical care and this is highly dependent on it severity. The severity of burns also depend on burn depth and burn size which also depends on the temperature to which the skin is exposed, specific heating agent as well as the duration of exposure.

The aims of managing burns include occlusive dressing, pain relief and early nutritional support (Prelack *et al*., 2007). Nutritional support is the cornerstone of burns management because there are several alterations in nutritional requirements due to loss of protein and micronutrient to wound exudates. Hormonal responses also lead to hyperglycemia. In addition, the pathophysiology reveals hypermetabolism that lead to an increased rate in the utilization of nutrients and hypercatabolism that enhances the breakdown of muscle and fat (Rousseau, 2013).

2.2 Incidence of burn injury

The global incidence of burn injury has declined in the past two decades (Theodorou *et al.*, 2013) and reports from World Health Organization (WHO) states that, there are nearly 11 million victims annually with someone severely burned every 5 seconds. The worldwide incidence is recorded as 1.1 per 100,000 persons, with the highest rate in South Eastern Asia and the United Stated recording the lowest. The incidence of burns varies by geographical location, socio-economic status, ethnic group, age and sex (WHO, 2014).

Burn injury accounts for 265,000 deaths annually and children below 20 years are the most affected. The deaths in low and middle income countries were 11 times higher, though reports show regional variability; the poor countries are in the lead (WHO, 2014)

In the United States, 410, 000 burn injuries occurred with approximately 40, 000 requiring hospitalization in 2008. The risks for residential fires include alcoholism and the absence of resident smoke alarms. The main causes of burns are fire/ flame and scald with majority occurring in the residence with a survival rate is 96.6% with more males affected than females. (Spinks *et al*., 2008)

Majority of burn patients occur in the developing countries. It is reported that, about 90% of the injury occurred in low income countries (Gosselin *et al.,* 2009) with 27% of all global incidences happening to women and girls in South Asia. World Health Organization, 2014 reports that, about 1, 000,000 of Indians are severely or moderately burned yearly. Statistics reveal that, in rural Nepal burn injury account for 5% of disabilities. Similarly, in Bangladesh, Columbia and Egypt 17% of children suffer temporal disability and 18%, permanent disability (WHO, 2014).

In Sub Saharan Africa including Ghana, burn injury is the 19th leading cause of death, with Infants in the region having three times the total number of deaths than infants worldwide. The incidence of burn injury in Ghana is 6.1 per 100000 (Mock *et al*., 2008). More females and children are at risk due to open flame exposure in most homes as well as the role women play in the various households. In a study by Agbenorku *et al.,* 2013, it is reported that there is an increase in the number of pediatric burns in Ghana and this is evidenced by the number of children admitted in the Burns Unit.

2.3 Overview of burn injury

The skin, the largest organ in the human body functions as a neurosensory organ, protects the body from invasion of microbes, regulates body temperature, fluid and electrolyte homeostasis in addition to the synthesis of Vitamin D (Bryd-Bredbrenner *et al.*, 2013). Hence its damage through burn injury impairs its functions especially its ability to fight infections and in homeostasis. The skin functions with two main layers namely the epidermis which is the tough protective layer and the dermis which contains blood vessels, nerve endings and sweat glands.

Burn injuries are of varying degrees depending on the layer of skin that is destroyed and this is a potent measure of the severity of the injury. Superficial burns lead to reddening of the top layer of the skin (epidermis) in a white person and darkening in a black person and it is generally caused by ultra violet rays and very short flame exposure hence it takes three to six days to heal and results in no scarring. Superficial, partial thickness burns or second degree burns produce open wounds with blisters that cause much pain to the victim. It can lead to change in pigment of the skin hence can take eight to twenty days to heal and results in minimal scarring. Deep partial thickness or third degree burns may be caused by flame, hot oil or grease. It is characterized by wet or waxy blisters with a destruction of the dermis and the epidermis and may lead to painless wound due to the destruction of the nerves and nerve endings. It leads to severe scarring and there is the risk of contractures. Full thickness burns destroys all layers of skin and can involve in the destruction of bones and destruction of organs. It appears waxy to leathery gray to charred and black and may never heal unless there is skin grafts (Evers *et al.*, 2010)

2.3.1 Pathophysiology of burns

The functional changes associated with burn injury are independent on the cause of burns. Thermal burns, electric burns and chemical burn leads to local and systemic responses.

The local response involves three zones which cover a three-dimensional area on the site of injury; the zone of coagulation which occurs at the points of maximum damage leads to irreversible tissue loss due to coagulation of constituent proteins. The zone of statis surrounds the zone of coagulation and it is characterized by decreased tissue perfusion that prevents irreversible damage. Infection, oedema and hypotension can lead to complete loss of tissue in this zone. The area that has a higher rate of recovering unless there is severe sepsis or prolonged hyperperfusion is called the zone of hyperemia, and directly surrounds the zone of sepsis (Evers *et al*., 2010).

The systemic response is characterized by circulatory, hormonal, biochemical and various immunological responses:

The circulatory response involves increase in capillary permeability that results in the loss of intravascular proteins and fluids into the interstitial compartment. These changes coupled with a decrease in myocardial contractility results in systemic hypotension and end organ hypotension and the loss of fluid lead to a decrease in oxygen to the tissues (Cakir and Yegen, 2004).

Sequences of hormonal surges up to 50 times occur during burn injury. These include an increase in the production and circulation of catecholamines (epinephrine and nor-epinephrine) that affects the nervous system (fight or flight). It affects the cardiovascular system that contributes to an increase in the heart rate, increase in the consumption of oxygen and carbon dioxide production. The release of these hormones causes an increase in the resting energy expenditure, respiratory rate and body temperature. Glucorcorticoids are also released that lead to an alteration in carbohydrate and protein metabolism. There is also an increase in the glucagon/ insulin ratio that results in hyper catabolism and hyperglycaemia (Williams *et al*., 2009) An increase in endogenous glucose production as a result of gluconeogenesis, proteolysis, glycogenolysis, lipolysis and proteolysis in burn injury.

The interaction of cells with the neuroendocrine system determines the ability of a burns patient to survive infection. The immune responses include lymphocyte and macrophage production that help to fight pathogens. The neuroendocrine system stimulates the nerves to produce a neuropeptide receptor and the macrophage attaches to the receptor and begins the inflammatory reactions. The central cells also produce interleukins and cytokines that are involved in inflammatory responses. The release of inflammatory mediators during the inflammatory responses such as Reactive oxygen species (ROS) promotes oxidative stress leading to a decrease in immunity (Xie *et al*., 2007).

All the above mentioned responses give a hyper metabolic response in the cells of the burn victim. In this case the basal metabolic rate (BMR) of the individual increases up to three times the original state (Williams *et al*, 2009) and this is mainly due to the direct effect of inflammation on the hypothalamus and the release of cytokines. The magnitude of the hyper metabolic response is directly proportional to the extent of burn injury and it can last for at least nine to twelve months. Due to this, the nutritional needs of the individual increase (Prelack *et al*., 2006) and poor nutritional management can lead to malnutrition.

In summary, burn patients are at risk to malnutrition basically because of:

- Hypercatabolism: breakdown of muscle and fat
- Hypermetabolism: Increase utilization of nutrients
- Hyperglycaemia: As a result of hormonal response
- Protein and micronutrient loss in urine and wound exudates

2.3.2 Medical Nutrition Therapy for burns patients

The goals of medical nutrition therapy for burn patients is to maintain body mass, prevent starvation and specific nutrient deficiencies, improve wound healing, manage infection and restore protein losses (Prins 2009). These goals are met through nutritional assessment and various clinical evaluations that present and equip the experts to plan and give interventions tailored to suit individual needs.

The various assessments include anthropometry, relevant biochemical parameters for nutritional status, clinical signs and symptoms, and dietary intakes to determine usual intakes. Prins, 2009 states that patients with TBSA greater than 15% need nutritional support and this involves enteral feeding or parenteral feeding. Total enteral nutrition starting within first 24 hours post burn improves caloric intake, stimulate insulin secretion, enhances utilization of glucose and decreases weight loss throughout hospitalization. In addition enteral feeding prevents the increase secretion of catabolic hormones, maintain gut mucosal integrity, may contribute to less to immunosuppression and have beneficial effect on reduction of enterogenic infection (Chan and Chan, 2009).

In nutrition therapy, macronutrients and micronutrients are considered. The estimation of these are dependent on the weight, height, age, sex and Total Burns Surface Area (TBSA) (A'Beckett *et al*.,2011). The caloric needs are thence calculated accurately as both over estimation and under estimation has repercussions. After the calculations amounts of carbohydrates, protein and fats are given to patients depending on their needs.

2.3.2.1 Macronutrients

The increase of the synthesis of glucose precursors increase maximally in burn injury and this lead to an increase in the release of amino acid and an increase in gluconeogenesis in the liver. This also leads to impaired glucose oxidation, moreover, glucose is much preferred energy substrates for macrophages, leucocytes and fibroblasts (Prins, 2009). Due to these occurrences; there is a need for adequate carbohydrates for compensation Work done by Lee *et al.,* 2011 reveals that, children who were fed with low fat and high carbohydrate diet had shorter ICU stays per % TBSA of burn, and lower incidence of sepsis and survived better than persons who were given a high fat diet. Williams *et al.,*2011 also states in their paper that, carbohydrates is the major source of energy for burn patients because they serve as fuel required for wound healing, provides glucose for metabolic pathways and spares amino acids that are needed for catabolism in the patients. Extra proteins are needed for the burn patient due to the release of stress hormones and cytokine that leads to mobilization of lean body mass. An increase in cortisol levels also stimulates proteolysis, and oxidation of proteins and the rate at which lean body mass is eroded from a burn patient which is proportional to the extent of injury increases the protein needs of the individual. There is also an imbalance of protein degradation and protein synthesis leading to muscle weakness (Prins, 2009). Due to this, adequate amounts of protein in the burn patient of 1.5g/kg body weight are recommended. Williams *et al.,* 2011 reports that, though an increase in protein are known to be beneficial to the burn patients it is known that an increase above 2g/kg body weight leads to increased urea production without improvements in lean body protein.

It has been reported that excessive intake of fats can lead to increase in infection (Lee *et al*., 2011) in burn patients, but adequate amounts are beneficial in diverse ways. Increase in lipolysis with a release in triglycerides and free fatty acids reduce the utilization of fats. It also reports that hyper metabolic and catabolic response to severe burns suppresses lipolysis and limits the extent to which lipids can be utilized for energy, hence limiting fat as a source of energy is beneficial (Williams *et al*., 2011). Works done by

Erridge *et al.*, 2007 states that foods high in fats induces endotoxema which leads to infection, hence fat should be limited in burn patients.

In addition, a systematic review on the intake of macronutrients and the rate of recovery, reported that, high carbohydrate, high protein and low fat feeds reduced incidence of pneumonia as compared to low carbohydrates, high protein and high fat enteral feeds (Masters *et al.*, 2012).

2.3.2.2 Micronutrients

Micronutrient needs are elevated in burn patients due to urine and cutaneous losses and diminished gastro intestinal absorption but there are no specific guidelines for their administration however provision of at least the Required Daily Intakes (RDI) is good for wound healing (A'Bekett *et al.*, 2011). It is reported that, patients with TBSA greater than 30% lose 20 to 40% of copper and 10% of selenium and zinc in the first week post burns. Also in the presence of inhalational injury, there was a decrease in Vitamin E (Prins, 2009).

Supplementation of micronutrient in a burn patient is known to increase rate of wound healing and reduce infections (Berger, 2007). There are reports indicating that, some of these doses are higher than the RDIs and there are reports to show the efficacy of such high doses (Berger *et al.*, 1998, Berger *et al.*, 2007).

2.4 Systematic review on the anti-oxidant micronutrients on the rate of recovery of burns patients

Numerous studies have been done to examine the efficacies of the different micronutrients on thermally injured patients (Berger *et al.*, 2006). Several reviews and commentaries as well as journal publications exist but it is important to note that despite the numerous studies and journal publications in this area, little published data exist for anti – oxidant micronutrients and there are no published work was found for Africa.

Various electronic databases such as Pubmed, Google scholar, Biomed, Embase, Cochrane library were searched using the appropriate keywords. Some of the key words include recovery rate of burns patients, micronutrient and burns patients, dietary intake, supplementation, Vitamin A, Vitamin C, Vitamin E, Ascorbic acid, tocopherol, carotenoids, copper, zinc, infection, sepsis, wound healing , protein catabolism, protein turn over etc. Majority of the outcomes of the searches revealed works done in various developed countries with little emphasis in the developing world.

Exposures for this review are Vitamin A, Vitamin E, Vitamin C, Zinc, Copper, Selenium, whilst the main outcome was recovery rate: wound healing time, protein turn over, sepsis, infections, and mortality rate and protein catabolism. The category of subjects included all age groups. Though most of the studies had age restrictions, there were no exclusions to the ages of the patients in the search. The only works that were excluded were those that were not done with human subjects.

2.4.1 Search strategy

A systematic search was done and all published data from 1990 to 2013 to search for all data on the effects of various anti-oxidants micronutrients on the recovery rate of burn patients of all ages. In reality, the gravity of the burns suffered by the various patients was not considered; also the sexes of the patients were of little consideration, giving an indication that studies involving patients of all ages and sexes were included.

The main search engines used include Pubmed, Elsevier, BMC, Embase, Cochrane library, Google scholar and Hinari. The searches were conducted systematically to find the effect of each of the micronutrients on the various outcomes: wound healing time, infection rate, length of hospital stay, protein turn over and catabolism.

2.4.2 Inclusion and exclusion criteria

Below was the inclusion criterion

- Population: Human population of all ages
- Study designs: Experimental and Observational Studies
- Outcomes: Outcomes measured include rate of recovery, length of hospital stay, infection, sepsis, wound healing time, protein turn over, protein catabolism and mortality rate.

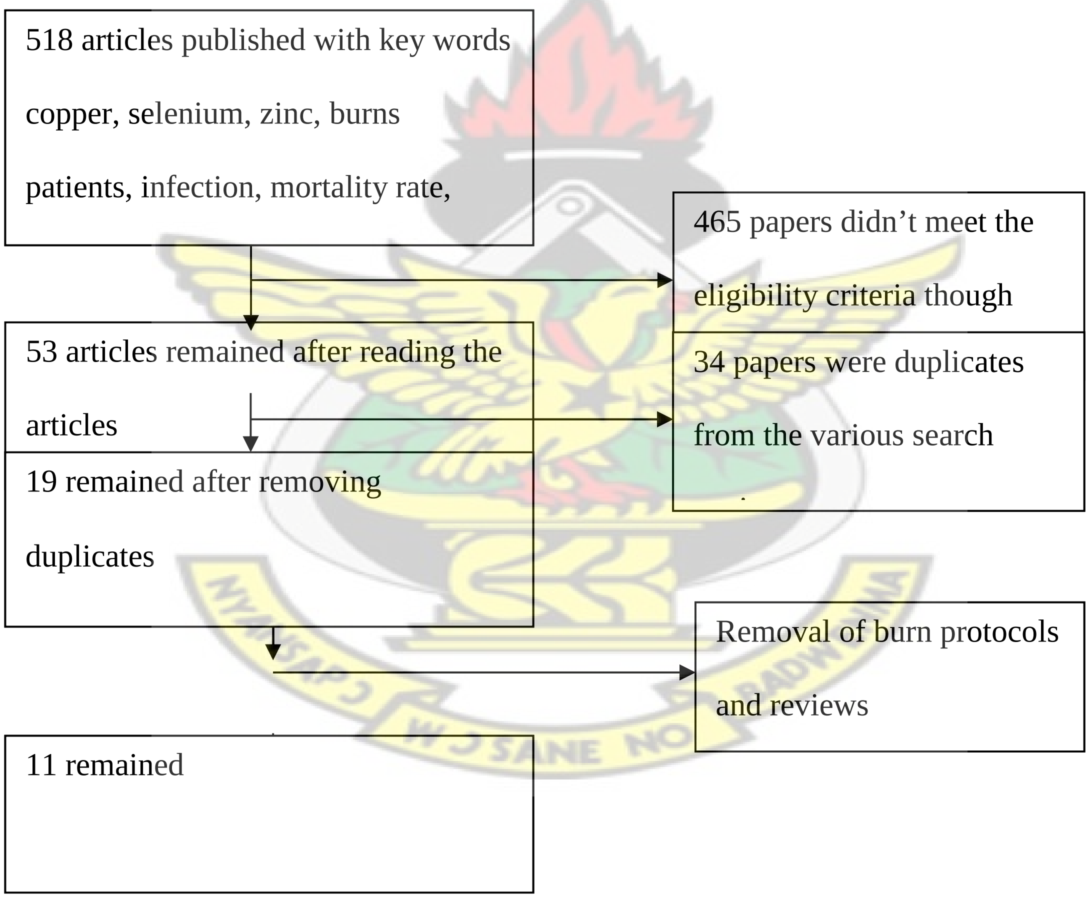
The following search results were excluded

- Reviews
- Reports on various protocols used for managing burns patients were excluded
- Studies that were done with non human subjects.
- Various case studies that did not meet the inclusion criteria

2.4.3 Search results

A total number of over 500 journal articles were obtained from the various search engines. When the repeated articles were removed, articles that did not meet the criteria such as reviews and burns protocol were also excluded.

Unfortunately some of the full texts of the articles could not be accessed. At the end of the systematic search, only **11** remained.


518 articles published with key words copper, selenium, zinc, burns patients, infection, mortality rate,
465 papers didn't meet the eligibility criteria though
53 articles remained after reading the articles
34 papers were duplicates from the various search
19 remained after removing duplicates
Removal of burn protocols and reviews
11 remained

2.4.4 The findings on the studies involving effect of antioxidant micronutrient on the rate of recovery

Based on the results obtained from the various searches, a summary of the results have been done.

2.4.4.1 Study Designs

The prevailing study designs used in the various studies were clinical trials where the micronutrients were administered to the patients intravenously, orally or through enteral feeding and various outcomes were measured after the intervention.

2.4.4.2 Study Population, Setting and Country

The populations of the various studies were similar. The subjects were healthy male and female children and adults mostly between the ages of 6 years and 60 years. The exclusion criteria were mainly patients who suffered from other chronic diseases such as renal complications in addition to the burn injury. The total burns surface area (TBSA) of the patients used in all these study ranged from 10% to 93%.

The country that dominated the results obtained was Switzerland (Berger *et al.,* 2007) with other studies in Iraq. There was a study each in USA, Canada and Brazil. There was no study done in Africa.

2.4.4.3 Anti – oxidant micronutrients considered in the study

The anti – oxidant micronutrients considered are Vitamin A, C, E, Copper, Zinc and Selenium. In one study the efficacy of various antioxidants were compared among various groups with respect to the Total Burns Surface Area (TBSA) (Sahib *et al*., 2010)

Apart from the micronutrients that were used N- acetyl cysteine was the other most efficient anti-oxidant used (Sahib *et al*.,2010; Al Jawad *et al*., 2011)

2.4.4.4 Main findings

One remarkable measure of the rate of recovery is the reduced wound healing time as reported by most of the journals (Berger *et al.*, 2007:Al – Jawad *et al.*, 2011: Sahib *et al.*, 2010) . Apart from that, there was a decrease in mortality rate that was evidenced by a decrease in hospitalization period and reduced incidence of infection (Sahib *et al.*, 2010: Al-Jawad *et al.*, 2011). In addition decreases in protein catabolism as well as an increase in the concentration of trace elements in serum and skin tissues of the patients after the clinical interventions were also discovered in the findings (Berger *et al.*, 2007).

There was a significant outcome from the studies as reported by Berger *et al.*, 1998 and Berger *et al.*, 2007 that revealed that the administration of trace elements caused a reduction in nosocomial infections such as broncho- pneumonial infections.

Moreover, a normalized anti-oxidant status of patients who received the interventions as evidenced by an increase in glutathione (GSH) concentration in the plasma is a good indication of the positive effect of trace element supplementation in burn patients.

The efficacy of anti-oxidant micronutrient on the recovery rate of burns patients can thence be ascertained with these positive results and indications.

2.4.5 Research gaps

From the results, it is important to note that, no published work exist for Africa and this creates a research gap because people in Africa are known to have micro nutrient deficiencies (Takyi and Amankwa,2004) due to poverty and poor socio economic conditions, hence the need for micronutrient studies especially on burn patients. The effect of supplementation of micronutrients is a major area that needs to be researched.

It was noted that children were omitted from most of the studies which introduces a research bias. This is because children need micro nutrient for their growth, cognitive function and development (Byrd Bredbenner *et al.*, 2013), hence under trauma the effect of these micronutrients supplementation on them is relevant. Moreover the results obtained for the anti-oxidant vitamins were not substantial hence more work needs to be done.

It is evident that little work has been done with burn patients and some of the papers have stated clearly that because of this there is no uniformity in the treatment of burns across the globe, hence burns management as a whole is an area worth studying.

Table2.1: Summary of the main findings of the research

AUTHOR AND COUNTRY	STUDY DESIGNS	MICRONUTRIENTS INVOLVED	SEVERITY OF BURNS (TBSA)	AGE OF PATIENTS	OUTCOMES
Berger *et al.*,2007 (a), Swtizerland	Randomized controlled trials (Clinical	Copper Zinc Selenium	Greater or equal to 10%: greater than	16 to 65 years	• Higher circulation of plasma and skin tissue

	trials)		20%		contents of selenium and zinc • Decreased pulmonary infection • Better wound healing
Berger *et al*., 2007 (b), Swtizerland	Randomized controlled trials (Clinical trials)	Copper Zinc Selenium	Greater or equal to 10%: greater than 20%	16 to 65 years	• Increase skin tissue concentration of Selenium and Zinc • Decrease protein catabolism
Berger et al., 2006, Swtizerland	Randomized controlled trials (Clinical trials)	Copper Zinc Selenium	Greater than 20%	16 to 65 years	• Reduced pulmonary infectious • Normalized plasma GSHPx activity, Increased tissue selenium and zinc concentrations • An improved wound healing, • A reduction length of stay.
Berger et	Randomize	Copper	Greater than	21 to 60	• Decrease

al., 1998 Switzerland	d controlled trials (Clinical trials)	Zinc Selenium	30%	years	broncho pneumonial infections • Decrease hospital stay
Al-Kaisy et al., 2006 Iraq	Randomized controlled trials (Clinical trials)	Zinc	15% to 70%	6 to 67 years	• Increase in anti-oxidant status as evidence by increase in GSH concentration • Decrease healing time
Sahib *et al*., 2010 Iraq	Randomized controlled trials (Clinical trials)	Vitamin E, C, Zinc Sulphate, allopurinol, Melatonin, N, Acetylcysteine	15% to 40%	Not stated	• Reduced incidence of infection • Reduced wound healing time and decrease in mortality rate.
Al – Jawad *et al*., 2011 Iraq	Randomized controlled trials (Clinical trials)	N- Acetylcysteine	15%-40%	20 to 40 years	• Decrease time of hospital stay • Decreased healing time
Calds-Courtis *et al*., 2012 Canada	Prospective Cross sectional	Zinc Vitamin C	10% to 93%	17 to 80 years	• Zinc concentration returned to normal values

					after three weeks. • Zinc supplementation didn't have adverse effect on serum copper concentration • Supplementation didn't lead to gastrointestinal side effects.
Barbosa *et al.*, 2009 Brazil	Randomized controlled trials (Clinical trials	Ascorbic acid Vitamin E Zinc	Not stated in abstract	Not stated in abstract	• Decrease in wound healing time
Rock *et al.*, 1997 USA	Prospective randomized trials	Careteniods	Greater than 20%	Not stated in abstract	• Increase in plasma concentration of beta carotene
Zhang *et al.*, 1992	Not stated in abstract	Vitamin E	Severe burns	Not stated in abstract	• Concentrations of vitamin E increased whilst lipid peroxides decreased

Table 2.2: Study designs, main finding and research gaps

AUTHOR AND COUNTRY	AIM OF STUDY	MAIN FINDINGS	GAPS
Berger *et al.*, 2007(a), Switzerland	To investigate the effect of large intravenous doses of Trace Element supplements on circulatory , on the anti-oxidant status and clinical outcomes after major burns	Trace element supplementation is associated with higher circulatory plasma and skin tissue contents of selenium and zinc, as well as improved anti – oxidants status. Improved clinical outcome: better wound healing.	• Consideration of patients of all ages. • A larger sample size will be beneficial
Berger *et al.*, 2007(b),	To assess the effects of Trace Element	• Decreased rate of pulmonary	• Smaller population size

Switzerland	Supplements on systemic substrate turnover and local protein metabolism during wound healing after major burns	infection. • Trace element supplementation is associated with high skin tissue content of selenium and zinc with a reduction in skin protein catabolism	is a major limitation. • No study in Africa • Much work should be done to increase the doses of the micronutrient level, but not ro get to toxicity level
Berger *et al.*, 2006, Switzerland	To determine the effect of trace element supplementation on nosocomial or Intensive Care Unit acquired Pneumonia	• Reduced pulmonary infectious • A normalized plasma GSHPx activity, increased tissue selenium and zinc concentrations • Improved wound healing, and a reduction length of stay.	Selenium needs to be probed separately as its is reported in animal models that, pre injury selenium deficiency aggravates the oxidative stresses; hence a study to access the efficacy of the individual micronutrients will be important.
Berger *et al.*, 1998 Switzerland	To determine the effect of trace elements supplementation on burns injury	• Decrease broncho pneumonial infections • Decrease hospital stay	• The effect of trace element supplementation and immunity is a major area to

			be explored.
Al - Kaisy *et al.*, 2006 Iraq	To determine the effect of zinc on recovery rate of burns patients	• Increase in anti-oxidant status as evidence by increase in GSH concentration • Decrease healing time	• Population bias: include children of all ages.
Sahib *et al.*, 2010 Iraq	To know the effects of various antioxidants on the recovery of burns patients	• Reduced incidence of infection • Reduced wound healing time and decrease in mortality rate	• Population bias: exclusion of teenagers
Al – Jawad *et al.*, 2011 Brazil	To explore the variable effect of N-acetyl cysteine on wound healing in burns patients	• Decreased in hospitalization period • Shortened wound healing time	• Population bias, teenagers were exempted.
Barbosa *et al.*, 2009 Brazil	To know the effect of Vit C, E, and Zinc on oxidative stress of burn patients	• Decreased wound healing time	• The study population is smaller hence a bigger sample size is much helpful
Caldis-Courtis *et al.*, 2012 Canada	To know the duration of zinc supplementation and the effects it has on Gastrointestinal side	• Zinc levels returned to normal levels after three weeks of supplementation	• The study population was smaller and the study didn't aim to find out the

	effects	and it didn't have any adverse effect on gastrointestinal health of the burn patients.	measures of recovery with respect to zinc supplementation
Rock *et al*., 1997 U.S.A	To know the effect of the intake of carotenoids	• Plasma beta carotene levels increased when carotenoids were incorporated in oral feeds.	• The study sample was small.
Zhang *et al* ., 1992 China	To know the effect of Vitamin E on lipid peroxidates	• Serum concentration in subjects with Vitamin E supplements and serum lipid peroxides decreased.	• Sample size is small

2.4.6 DISCUSSION

The various results obtained from the studies indicate that, the effect of multiple antioxidants on the rate of recovery of burns patients is notable. In the study by Berger *et al.*, 2006, it is noted that, the multiple micro nutrient used as an intervention had a positive effect on wound healing, infection rate, protein turn over and protein catabolism. Studies by Al -Jawad *et al*., 2011 and Al- Kaisy *et al.*, 2009, where single anti – oxidant nutrients are used there was an improvement in only one outcome variable.

The synergistic role of the various micronutrients in the recovery outcomes was evident hence the role of individual micronutrients on the recovery outcomes can be challenging to know. Hence a study to find out the role of each of the micronutrient will be beneficial as Berger *et al*., 2006 states that, selenium is a major nutrient that can be investigated alone because of the role it plays in oxidative stress as seen in animal models.

The effect of micronutrients and the role it plays in immunity cannot be over emphasized. Some studies that measure infection rate have established that trace elements may have an effect in the neutrophil level in an individual. From this search it is reported by Berger *et al*.,1998, Berger *et al*., 2006, that trace element supplementation reduced infection rates. Bryd-Bredbenner *et al*., 2013 reports that selenium is likely to play a role in immune function hence a major research area.

Zimmerman *et al*., 2003 and Winichagoon *et al*., 2006 reported that supplementation of micronutrients such as Zinc in young people can help in their growth and development and cognitive function. Apart from its effect in oxidative stress, zinc, they play significant roles in bone formation, taste acuity and the stabilization of membranes and also in the formation of connective tissues (Byrd-Bredbenner *et al.*, 2013). A burn child is likely to be deficient in zinc becomes vulnerable to all kinds of infection due to prolonged deficiency due to burn injury.

Most of the anti-oxidant micronutrients were given in doses higher than the Recommended Daily Allowance, hence considered as therapeutic dose. As to whether the quantities of the micronutrients can be obtained in the diets of the patient remains unknown.

Interventional studies dominated the results of this study. There was none done on a cross sectional prospective basis, hence designing a study in that manner can give detailed information about the situation in Ghana.

The study revealed supplementation of micronutrients on the burn patients that resulted in positive recovery outcome, but there was only one work (Rock *et al*., 1997) that was done on the dietary intake of the micronutrients. In view of this, it is essential to assess the micronutrient intake of burns patients on their rate of recovery.

2.5 An overview of anti-oxidant micronutrients and their role in burn patients

Free radicals naturally occur in the body and can cause intense damage to cells, interact with genetic materials and contribute to the development of numerous health problems and disease (Meydani *et al.,* 1995). In injured patients, severe sepsis lead to mitochondrial dysfunction and ischemic reperfusion on the injury that may contribute to increased generation of reactive oxygen species (Agarwal *et al*., 2011). It has also been reported that long-term cumulative oxidative damage caused by free radicals can also lead to many chronic diseases such as cancer and arteriosclerosis (Webb *et al*., 2011). Sequentially, anti – oxidants are known to inactivate the damaging activities of free radical by scavenging them. They act to maintain membrane lipid integrity and functionality. In immune cells they control signal transduction gene expression (Meydani *et al*., 1995).

The up-regulation of the free radicals production contributes to burn mediated immune suppression and anti-oxidants are known to have positive effects on wound infection and its related outcomes. The role of anti – oxidant in scavenging free radicals has an important role in wound healing because the presence of free radicals cause damage to cell membranes, DNA, proteins and lipids. The cytotoxic effect of free radicals in response to burn injury can cause a delay in wound healing and anti – oxidant are known to play a positive role in its removal. (Meydani *et al*., 1995)

Numerous anti-oxidants have been administered both locally and systemically and have proven to have positive effect on the wound healing outcomes. There are also vitamins and minerals that have anti-oxidant properties.

Retinol, which naturally occurs in foods of animal origin such as egg yolks, diary fat, liver, fatty fish, is a potent anti-oxidant. It is also found in breakfast cereals with a Recommended Dietary Allowance (RDA) of 900μg per day for adult men and 700μg per day for adult women. Plant pigment, beta carotene and other carotenoids pigment can be converted to Vitamin A in the human body and these can be found in dark green yellow, orange and red fruits and vegetables (Webb,2012). It has vital roles in gene expression, growth and development, cell differentiation, immune function and in vision.

Ascorbic acid, discovered when scientist found out that sailors died of scurvy because their diets were mainly dried meat and cereals, can be found in fruits and vegetables. The RDA is 90mg and 75mg per day for men and women respectively. It functions in collagen synthesis and iron absorption (Bryd-Bredbenner *et al*.2013). Its role in immunity has been proven because it is transported actively into the leucocytes against concentration gradient during infection (Ottoboni and Ottoboni, 2005). According to Iqbal *et al*., 2004, it functions to neutralize free radicals. Ascorbic acid also acts in scavenging reactive oxygen species and this causes a reduction in cytokine production. Clinical trials have also shown that, patients with low Vitamin C had sepsis; with this effect on sepsis, its role in scavenging free radicals can be proven due to the role free radicals play in sepsis and the proposed role of Vitamin C in immunity.

Alpha – tocopherol is one out of many compounds that is synthesized by plants with Vitamin E. It can also be found in various animal fats and has an RDA of 15mg per day for both men and women. It plays a role in the body's anti-oxidant network helping in the maintenance of the cell membrane integrity by preventing the oxidation of polyunsaturated fatty acid residues in membrane phospholipids. It protects against atherosclerosis by preventing the oxidation of LDL (low density lipoproteins) which could lead to damage of arterial walls and mops up free radicals that could lead to oxidative stress. Nathens *et al*., 2002 states that, alpha tocopherol supplement reduces morbidity and organ dysfunction in critically ill surgical patients.

The use of copper to treat disease can be dated back to 400 BC, its potency as an essential nutrient was not recognized till 1964. It has thence been used in many areas of medical science because of its ability to alternate between two oxidation states (Cu^+ and Cu^{2+}). It is also a major component of some enzymes due to this property. Copper also functions as a component of lysyl oxidase cross-links strands of elastin and collagen to give tensile strength to connective tissues in the lungs, blood vessels, skin, teeth and bones (Agarwil *et al*., 2011) It is also a co-factor in superoxide dismutase involved in the removal of damaging superoxide radical to prevent oxidative cell membrane damage. As an anti-oxidant, copper scavenges or neutralize free radicals and this reduces the damage they cause to cells. It is also important in wound healing and hematopoeisis. Significant amounts of copper can be found in liver, shell fish, nuts, dried fruits, whole grain products and soy products and has an RDA of 900μg (Bryd-Bredbenner *et al*., 2013).

Being noted as an essential nutrient since 1930s, zinc plays diverse roles in the body's anti – oxidant defense systems (as part of the Cu/Zn superoxide dismutase (SOD) enzymes) apart from its role in 300 enzymes. As a component of superoxide dismutase, it protects the body from oxidative stress by interacting with catalase and glutathione peroxidase (Knoell *et al.*, 2010) It also functions in DNA and RNA synthesis, heme synthesis, bone formation, taste acuity, immune function, reproduction, growth and development. Dietary zinc can be found in animal based foods such as lamb, beef and pork. Plant based foods such as nuts, beans, wheat germ, and whole grains also contain appreciable amounts with and RDA of 11mg and 8mg per day for men and women respectively (Bryd-Bredbenner *et al*.2013). It is difficult to name a body process or organ that is not affected directly or indirectly by zinc hence has a good role in burn injury. Its role in innate and specific immunity and also plays a significant role in the stability of membranes. Zinc deficiency damages epidermal cells and may contribute to organ damage and increase in cell death and oxidative stress. Knoell *et al*., 2010 continues to state that, zinc deficiency augment immune responses and oxidant resulting in increase mortality. It is finally recommended that nutritional zinc support would be beneficial.

Discovered in 1979 by Chinese Scientists who observed its role in a cardiac condition, selenium is known to decrease risk of prostate, lung, or other cancers. It is also involved in thyroid metabolism and synthesis of protein. There are significant amounts in grains, sea food and meats and has an RDA of 55μg per day (Bryd-Bredbenner *et al*.2013). It is a component of 25 enzymes and in the anti-oxidant network including glutathione peroxidase, which repairs of damaged cell membranes destroyed lipid peroxidation caused by reactive oxygen species. Low levels of anti-oxidants such as selenium contribute to an increase in the levels of markers of free radial damage. (Mc Arthur and Quansey, 2011).

It is reported by Alhazzani *et al*., 2013 that, there was a reduction in mortality in patients with sepsis who received selenium supplementation that was higher than their daily requirement. It has also been observed that, many enzymes with selenocysteine (amino acid with a selenium component) at their active sites maintain an appreciable oxidative balance. Another observation reveals that patients with low serum selenium had an increase in nocosomal infections (Mc Arthur and Quansey, 2011).The anti-oxidant roles of these micronutrients in scavenging free radicals is evident hence its direct roles in recovery outcomes such as wound healing, length of hospital stay and presence of infection on burns patients are factors worth to note.

2.6 Recovery outcomes of burn patients

The rate of recovery of burn patients is affected the TBSA, the depth of the wound, the dietary intake of the individual as well as medications and some psychological factors. All these factors lead to recovery outcomes such as improvement in wound healing, length of stay in the hospital and the presence of infection. Anti-oxidant micronutrients are known to play a significant role on these recovery outcomes.

2.6.1 Wound healing and closure

The hemostasis phase of wound healing begins immediately the source of damage is removed unless there are other clotting disorders. When an individual gets injured, the outflow of blood and lymphatic fluid activates clotting mechanisms. Platelets seal off the damaged blood vessels as they secrete vasoconstrictive substances to aid the process. Though the main aims of platelets are to form a stable clot to seal the blood vessels, they also aggregate and adhere to the exposed collagen with the aid of Adenosine diphosphate (ADP) that has leaked from the tissues. There is also the secretion of factors that interact with and stimulate the clotting cascade through the production of thrombin, which in turn initiates the formation of fibrin from fibrinogen. There is a hemostatic plug that is formed as the fibrin mesh strengthens the platelet aggregation. The platelets sequentially secrete cytokines such as platelets-derived growth factor (PDGF), which initiates the other steps such as inflammation, collagen degradation and collagenogenesis, myoblastic creation from transformed fibroblasts, growth of new blood cells and re- epitheliailization (Velnar *et al.*, 2009)

Inflammation which is characterized by erythema, swelling and warmth, and is associated with pain lasts up to 4 days after injury. The inflammatory responses cause the blood vessels to become leaky releasing plasma and polymorphonucleocytes (PMN). The neutrophils provide the first line of defense against infection by its phagocytic action on debris and microorganisms, with the help of mast cells. Fibrin is broken down in this process whilst macrophages also have phagocytic action on bacteria thence providing the second line of defense. The macrophages are responsible for the secretion of chemotactic and growth factors such as fibroblast growth factor(FGF), epidermal growth factors (EGF) transforming growth factor beta (TGF - β) and interleukin – 1 (IL-1). The macrophages also orchestrate the multiplication of endothelial cells with the emergence of new blood vessels. The role of macrophages in the wound healing cascade cannot be overemphasized (Velnar *et al.*, 2009).

In acute wounds, granulation starts four days after wounding and lasts until after twenty one days. This is highly dependent on the size of the wound. It involves fibroplasia, matrix deposition, angiogenesis and re-epithilialization. It involves the replacement of the dermal tissues and sometimes sub-dermal tissues in deeper wounds as well as the presence of contractions and this is characterized by the presence of pebbled red tissue in the wound. After the cleanup of the debris, one significant occurrence is when the fibroblasts secrete the collagen framework on which further dermal regeneration occurs. Fibroblasts are also responsible for wound contraction. Angiogenesis occurs when pericytes which regenerates the outer layers of capillaries and the endothelial cells which produce the lining. The keratinocytes, which are cells responsible for epithelialization differentiate as a result of the contractures that occur to form a protective layer (Velnar *et al.,* 2009)

Collagen deposition in normal wound healing reaches the peak by the third week, but during this phase, collagen is degraded and deposited at equilibrium with no increase in the amount of collagen secreted. Remodeling of dermal tissues produces greater tensile strength with the help of the fibroblast and can take two years (Velnar *et al.,* 2009)

2.6.1.1 The wound healing cascade, the role of antioxidant micronutrients.

Healthy wound healing involves a well coordinated immune/inflammatory response and micronutrients are known to be effective in these. The wound healing cascade also consist of numerous cells that play diverse roles in wound closure and anti-oxidant micronutrients play significant roles in the entire process from hemostasis, the initial phase and remodeling, the final phase

There is substantial evidence to prove that vitamin A has a good role in wound healing because it is able to reverse the corticosteroid induced inhibition of cutaneous wound healing; steroids have an anti-inflammatory effect on wound healing. By increasing the presence of monocytes and macrophages at wound site, modulating collagenase activity and supporting collagenase activity, Vitamin A enhances the early inflammatory phase in the wound healing cascade. It also supports epithelial cell differentiation and improves localization and stimulation of the immune response. Vitamin A is also known to elicit immune response contributing to wound healing (Mckay and Miller, 2003).

Vitamin C plays an outstanding role in wound healing especially in its effect in collagen synthesis; the conversion of proline and lysine to form hydroxyproline and hydroxylysine is done with Vitamin C being a co- factor. These compounds formed are important in the stabilization of the triple helix structure of collagen with strong hydrogen bonds and cross links during wound healing (Williams, 1997). It is also reported by Mckay and Miller, 2003 that a deficiency in ascorbic acid leads to abnormal collagen fibers and alters the intracellular matrix, decreased adhesions of endothelium cells and a reduction of tensile strength of fibrous tissue. The paper further reports that when post surgical patients were given vitamin C supplements, there was no further evidence of bleeding supporting the fact that vitamin C has a role to play in the initial phase of wound healing where there is coagulation of blood. The paper continues to give evidence of free radical damage that is caused to injured tissues and its effects it has on the vitamin C concentration on wound sites and effects on wound healing rate. In addition, the rate of wound healing decreases with the presence of infection and an impaired immunity leads to infection. Another study reports that vitamin C supplementation enhanced neutrophils mortility to chemotactic stimulus and stimulation of lymphocyte transformation (McKay and Miller, 2003).

Apart from its use in skin care in the prevention of the formation of scars, Vitamin E functions as a major lipophilic antioxidant contributing to the stability of cell membranes by preventing peroxidation of lipids. It also acts by stabilizing the lysomal membrane. Though Vitamin E is known to hinder wound healing by inhibiting inflammatory response, there is complex way it improves wound healing. Animal studies have given conflicting results as to efficacy of the supplementation of Vitamin E and wound healing. Some of the authors attribute the negative effect of Vitamin E on its lysosomial stabilization properties. Other reports also showed increased breaking strength and collagen content of the wound when a hydrophilic Vitamin E preparation was administered, and here inhibition of lipid peroxidation is speculated. (McKay and Miller, 2004). In addition to all these, Vitamin E is a free radical scavenger which preserves macrophages and polynuclear leukocytes (Rayner *et al.*, 1991).

Copper plays a good role in angiogenesis, the process where new capillaries are formed from existing ones. Vascular endothelial growth factor (VEGF) provides long term effect in the stimulation of angiogenesis and relevant concentrations of copper sulphate induces VEGF expression in primary and transformed human keratinocytes. Copper is also known to stimulate proliferation and immigration of endothelial cells. They also activate factors that mediate migration, mitosis, differentiation of endothelial cells and the re-shaping of matrix proteins into the familiar capillary anatomy (Chianeh and Rao, 2013). The role of copper containing enzymes play on angiogenesis is remarkable. A typical example is ceruloplasmin which has the ability of oxidizing ferrous iron to ferric ion , the form of iron that can help in red blood cell formation and instigates angiogenesis (Lin and Chen, 1992).

Its function in the activities of approximately 300 enzymes; cell division, protein synthesis, DNA synthesis ,stability of cell membranes, cellular replication and collagen formation renders zinc a very good micronutrient for tissue regeneration and repair. Hence its role in proliferative and remodeling phases of wound healing cannot be denied. Studies show that, zinc deficiency led to decrease breaking strength of animal wounds, decrease in collagen synthesis, (Agren and, Franzén) but there needs to be studies to show the effects of supplemental or dietary intake of zinc on wound healing.

Selenium is required for the glutathione system, a major intracellular anti- oxidant to function. This anti-oxidant system is responsible for cell protection in wound healing by managing wound-inflammation-induced oxidative stress. A study by Nelson *et al*., 2010 concludes that, selenium supplementation of macrophages produce endogenous activators that contribute to wound healing.

The considerations and roles of micronutrients inn wound healing makes it an indispensable factor in the recovery outcomes. The role each micronutrient in each stage of wound healing is outlined in Fig 2.2

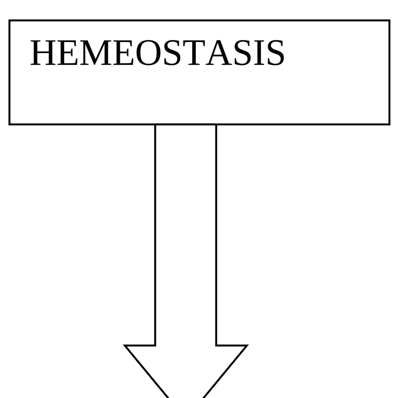


Fig 2.2: The wound healing cascade, the role of anti – oxidant micronutrients

2.4.1.2 Wound healing and infection

Apart from nutrition and supplementation of micronutrients other factors that affect wound healing include wound care, oedema, presence of metabolic disturbances, surgical intervention, infection and medication.

Burn patients are susceptible to infection locally and systemically due to immune defects. There are reports of burn patients with pneumonia and colds which probably is due to lowered immunity (Berger *et al*., 1998). In addition to these, pathogens such as E. Coli and Pseudomonas *sp*. invade wounds and this can cause adverse effect to wound healing. The presence of greater than 100,000 micro organisms in wounds delays epithelialization which delays the other phases, delaying wound healing in general, hence measures to curb this must be put in place and one these is with the use of micronutrients (Australian Wound Management Association Inc, 2011).

Vitamin A improves the function of neutrophils and macrophages (Stephesnson, 2001) and these play a role in clearing up bacteria in the initial stages of wound healing. The presence of ascobate molecules in leucocytes and its rapid expenditure during infection and phagocytosis suggests that, Vitamin C has a role in immunity. A study by Kahmann *et al*, 2008 revealed that zinc supplementation led to the reduction of inflammatory cytokines and restores T cell functions. Copper play a good role in immunity because it produces antibodies an white blood cells (Kumar *et al*., 2011). Selenium may also play various roles in immunity because of its roles in macrophage action hence much work needs to be done to ascertain this.

2.7 Conclusion

The roles of anti-oxidant micronutrients on the recovery outcomes of burn patients cannot be overemphasized. Their roles in wound healing, immunity, scavenging of free radicals and protein catabolism reduced length of stay in the hospital.

It is evident that all the study done so far on nutrition in burns focused on supplementation with no study on dietary intake. In view of this, the study aims to find out how dietary micronutrients help in the progress of wound healing and infection rates.

CHAPTER THREE

METHODOLOGY

3.1 Study Setting

The Komfo Anokye Teaching Hospital is the second largest hospital in Ghana and the main referral hospital for the northern sector of Ghana. It has a bed capacity of over a thousand. There is a Reconstructive Plastic Surgery and Burns Unit under the Directorate of Surgery. Apart from the Burns Intensive Care Unit (BICU) that caters for burn patients who are critically ill, there are other wards that cater for less severe cases of burns.

A prospective cross sectional study was done where data was collected from March to May 2014.

3.2 Subjects

The subjects were burn patients who were admitted to the BICU from January to May 2014 of all ages. Some other cases of interest were also taken from the outpatient department.

3.2.1 Eligibility criteria*:*

Consent of all patients was sort and for participants who are children parental consent was sort.

3.2.2 Exclusion Criteria

- Patients who refused to give consent.
- Any patient with a chronic disease such as diabetes and hypertension.
- Children under 6 months

3.3 Data collection

Pretested questionnaires were administered to forty (40) patients. Demographics, medical history, anthropometry, food frequency and triplicate dietary recalls were done. (Copy of complete questionnaire is at the appendix 1)

3.3.1 Demographic data.

The age, sex, occupation, level of education of subjects, marital status of the subjects as well as their occupation was also sort for.

3.3.2 Anthropometric data.

The weights of the burn patients were measured with a weighing scale (model H89 red) when patients were being bathed to make sure all bandages were off. With Patients having limb burns, their estimated weights were taken from the folders.

Heights of seven (7) patients were measured with tape measure when the patients were laid on their beds, because with the discomfort of the patients, they couldn't stand straight for the measurements to be taken. Patients were made to lie on their bed in a horizontal position (180 degrees, beds were not tilted) with minimal discomfort. A tape measure (butterfly brand) was used to accurately measure their length, from head to toe and recorded accordingly.

Six (6) patients also gave their heights verbally and it was recorded as such. Estimated heights were also recorded for twenty seven (27) of the patients in consultation with the health professionals.

A tape measure was used to measure the mid upper arm circumference of the children in this study.

3.3.3 Biochemical data

Serum retinol analysis was done. Venous blood samples of participants were collected and the samples were sent to the Clinical Analysis laboratory of the KNUST- Dept. of Biochemistry and Biotechnology. The samples were centrifuged and the serum was collected and stored at -8 degrees Celsius for two months before transportation to Noguchi Memorial Institute for Medical research, Accra for analysis.

Serum Vitamin A was determined with the High Performance Liquid chromatography (Shimadzu HPLC equipement, pump – LC – 6A, Recorder Shimadzu C- R5A, Detector Shimadzu- SOD – 6A, Column – Reversed phase ODs, Injector - Rhyhodyne 1745)

One hundred and twenty micrograms of the serum was pipettted into a 2 ml splendorf tube and deproteinized with ethanol. The solution was vortexed for 2 minutes and centrifuged at 100,000 rpm for 2 minutes. An amount of (250microliters) of the supernatant was evaporated under a stream of nitrogen gas. The resultant is reconstituted with 120 micro liters of methanol and 20 micro liters is injected into the HPLC. The retinol concentration was measured at the wavelength of 325nm. (Kim and Quadro , 2010) Persons with retinol concentrations below 20 μg/dl (0.7μmol/l) were considered deficient of Vitamin A. (WHO, 2011).

3.3.4 Dietary assessment

The dietary assessments were done with both food frequency questionnaire and with a 24 hour dietary recall.

The food frequency questionnaire was used to assess the baseline and usual intakes of micronutrients of the subjects before burn injury. The amounts of the nutrients in the food were determined by comparing the amount of nutrients in a 100gram food sample. A food that contained 50% and above of Recommended Daily Allowance (RDA) per 100gram of a particular nutrient was considered to have a high amount of that nutrient hence was and put on scale 3. A food with 10% to 50% of RDA per 100gram of a particular nutrient was considered to have medium amount of that nutrient and was put on scale 2. A food with less than 10% of RDA per 100gram of a particular nutrient was considered to have low amount of that nutrient and was put on scale 1. There were some food with no and trace amounts of the nutrients, hence was put on scale zero(--). On a scale of 1 to 3, the foods were grouped into high content, medium content and low content of the micronutrient of interest (Appendix 4). The intakes of each of the patients were counted. Using bar graphs, the intake of the patients were compared to know the patients with the highest intakes and patients with the lowest intakes.

The 24 hour dietary recall gave a vivid representation of the foods that were taken by the subjects on the ward taking into consideration leftover foods.

The multiple dietary recalls were done for all patients for three days including a day in a weekend. Using handy measures, the weights of all the foods consumed by the subjects were recorded. The nutrient compositions of the foods were analyzed with the Nutrient Analysis Template (University of Ghana, Food Science and Nutrition Department, 2010) and the West African Food Composition table, 2012. The average intakes were calculated, recorded and compared to the Recommended Dietary Allowance (National Academic Press USA, 2011) of the individuals.

3.3.4.1 Calculations of macronutrient requirement

Schofield's equation was used to calculate the energy requirement of the burn patients and the protein requirement was 1.5g/kg body weight (A'beckett *et al.*, 2012). Energy expenditure was calculated for burn children below 14 years based on simplified Schofieds equations reported by ESPGHAN, 2005. (Appendix 2)

3.3.5 Medical history

This was done by taking the information from the folders of the subjects with the guidance of a health professional. The information was filled out onto the questionnaire. The information taken includes the cause of burn, TBSA, the presence of any existing complication. (Copy of complete questionnaire is available at appendix 1)

The assessment of recovery was done on weekly basis, where information about wound healing and infection were recorded from the folders of patients with the guidance of a health professional.

3.4 Data analysis

Data storage and analysis was done by Microsoft excel 5.0. Statistical Package for Social Scientist (SPSS) was used for data analysis. Chi-square was used to find relationships between variables of interest.

3.5 Ethical clearance

Ethical clearance was granted by the Committee of Human Research Publication and Ethics of Komfo Anokye Teaching Hospital/School of Medical Sciences, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

3.6 Retrieved data

Secondary data was retrieved from the BICU about patients who have been admitted to the facility from 2009 to 2012. The data that were available include demographic data, TBSA and the outcome of treatment of the patients.

CHAPTER FOUR

RESULTS

This chapter is in two parts. The first part reports on the data retrieved from Burn Intensive Care Unit (BICU) from 2009 to 2012 while the second part reports on the results obtained in the prospective cross sectional studies.

4.1 Burn injuries in Komfo Anokye Teaching Hospital: A four year analysis.

The results reviewed include demography, medical history, length of stay and state of the patients as they exited the BICU.

4.1.1 Demographic statistics and medical history of the patients

The demographic data of burn patients admitted to the BICU from 2009 to 2012 is represented in Table 4.1. A total of 487 patient records were reviewed. There were 263 (54.0%) males and females 224 (46.0%). The age range was from One month to 84 years with a mean age of 17.18 years. Children less than 10years were the frequently admitted group

(48.68%). The age distribution of the burn victims throughout the period are as follows: 237 (48.68%) patients fell under the age of 0-10, 94 (19.30%) burn patient were from ages 21-30, 53 (10.88%) burn patients fell under 31-40 years respectively.

Scalds were the main cause of burns 225(46.20%) followed by open fire/flame 221(45.38), others included chemical 17(3.49 %), electricity 13(2.67%) and Stephen Johnson's syndrome 11(2.26` %).

Table 4.1: Demographic data and medical history for 4 years.

Characteristics	Number of patients	
	N=487	%
Age		
0 – 10	237	48.7
11-20	49	10.1
21-30	94	19.3
31-40	53	10.9
41-50	30	6.2
Above 51	24	4.9
Sex		
Male	263	54.0
Female	244	46.0
Occupation		
Artisan	101	20.7

Professional	16	3.3
Trader	34	7.0
Unemployed	10	2.1
Child	286	58.7
Unknown*	43	8.8
Medical history(cause of burn)		
Scalds	225	46.2
Open flame/fire	221	45.38
Chemical	17	3.49
Electricity	13	2.67
Stephen Johnson's syndrome	11	2.26

**The occupation of some of the subjects were not recorded*

4.1.2 Characteristics of the burns

A presentation of the characteristics of the burns and length of stay in the BICU is presented in figure 4.1. The mean Total Body Surface Area (TBSA) for the period under review was 28.79%.Yearly analysis showed that, 2012 recorded the highest mean TBSA of 35.07% followed by 2010; 27.98%, 2011; 27.76 % and 2009; 24.74%, respectively.

The mean (Intensive Care Unit) ICU stay was 8.44days for the period under review. The mean number of days spent yearly in the ICU also showed an upward trend with 2011 recording the highest period of stay 9.7 days, followed by 2012; 9.02 days, 2010 8.99 days and 2009, 6.39 days.

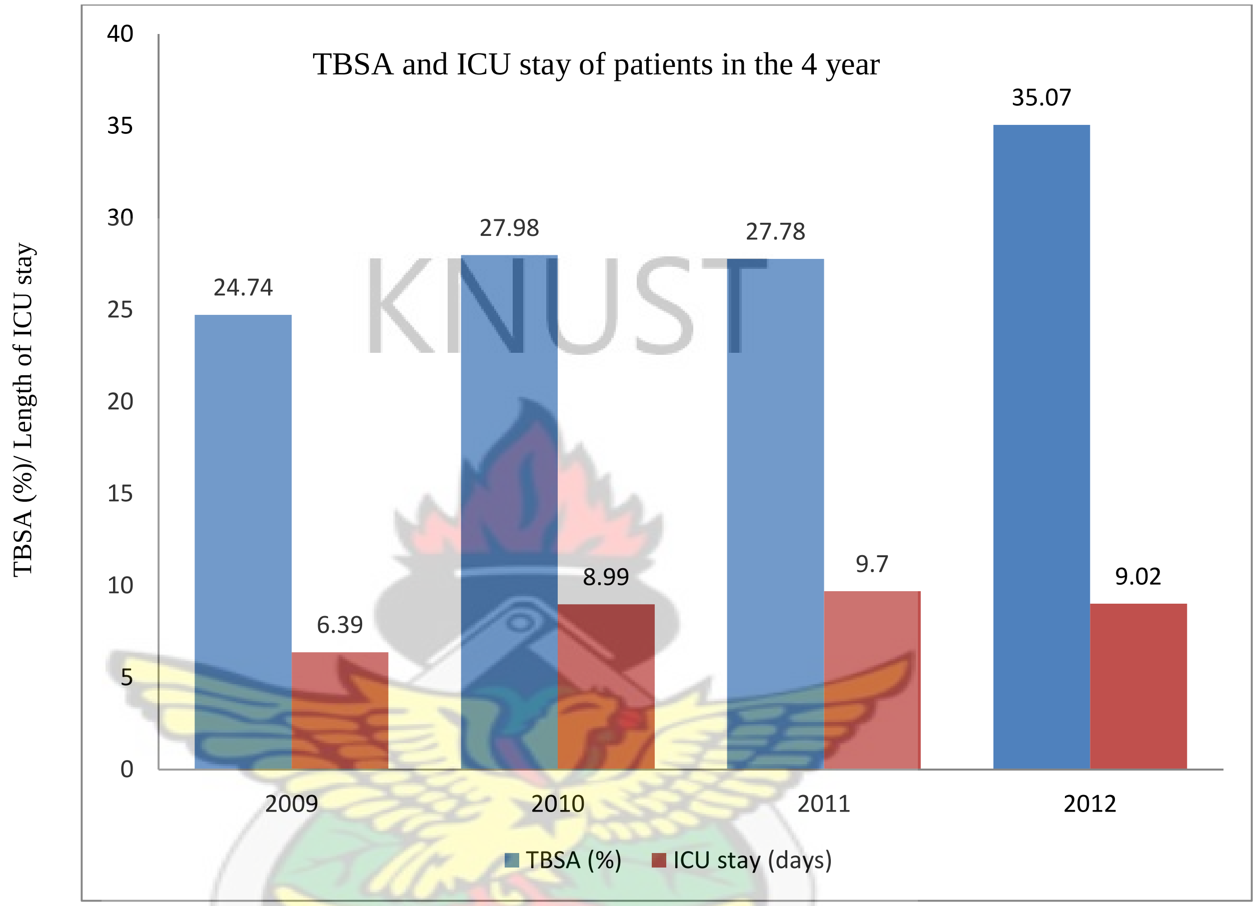


Fig. 4.1: Yearly comparison of the TBSA and length of stay in the ICU.

4.1.3 Mortality rate of burn patients for the period of 4 years.

The mortality rate of the patients under the period of review is represented in fig 4.2. The mortality rate was 20.5% and the yearly review showed an upward trend from 2009 to 2012.

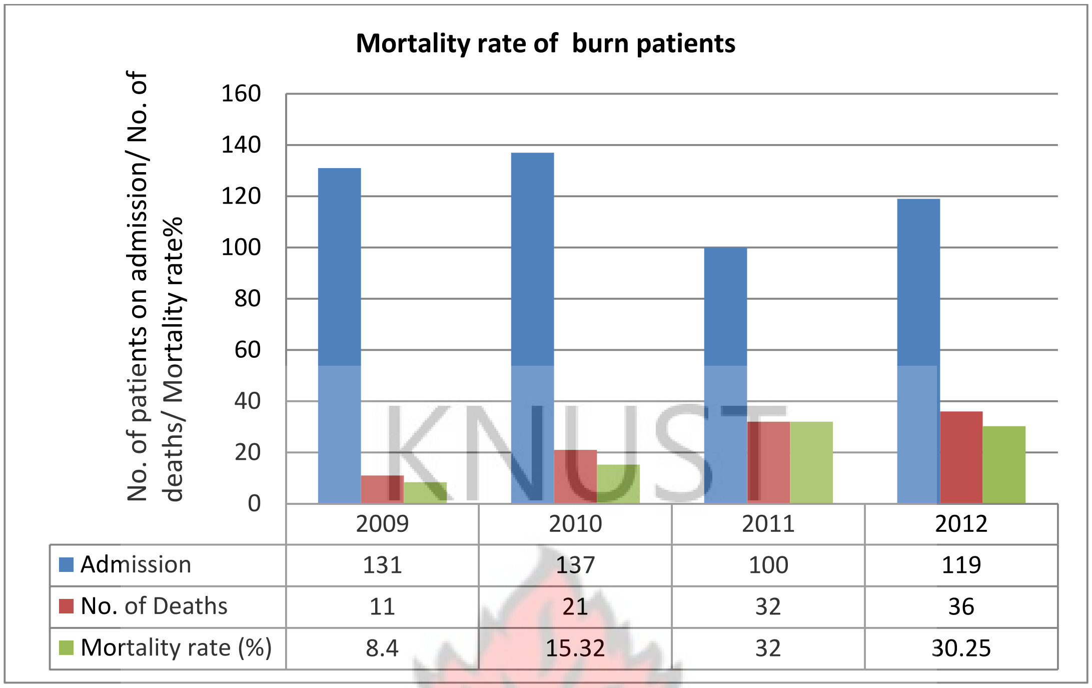


Fig 4.2 Mortality rate of burn patients

4.2 Results from the cross sectional study

Below are the results of the prospective study that was carried out at the Burns Unit at KATH.

4.2.1 Demographic profile of burn patients at Komfo Anokye Teaching Hospital

The demographic statistics of burn patients at the Komfo Anokye teaching hospital from March to May 2014 is shown in table 4.2. Out of the 40 patients, persons aged below 14 years recorded a majority of the burns representing 45%. The results also showed that more males suffered from burn injury (65%) than women (35%). Only 2 subjects, representing a total of 5% had a level of tertiary education with 30% of the subjects with no education, primary level of education (37.5%) and secondary education (27. 5%). It was also recorded that, 5% of the subjects were professionals in their fields with the rest being artisans (25%), traders (22.5%) and a majority being unemployed (47.9%).

Table 4.2 Demographic profile of burn patients

Characteristics	Number of Patients	
	N=40	%
Age (years)		
0 – 1.9 years	8	20.0
2 – 14 years	10	25.0
Above 14 years	22	55.0
Sex		
Male	26	65.0
Female	14	35.0
Marital Status		
Single	27	67.5
Married	10	25.0
Separated/Divorced	1	2.5
Widowed	2	5
Level of Education		
Primary School	15	37.5
Middle/Junior High School	8	20.0
Senior High School	3	7.5
Tertiary 1 to 3 years (Diploma/Certificate/Professional)	1	2.5
Tertiary 4 or more years		

(Degree/Postgraduate/Professional)	1	2.5
None	12	30
Occupation		
Artisan	10	25.0
Professional	2	5.0
Trader	9	22.5
Unemployed	19	47.5

4.2.2 Anthropometry, medical and dietary information of patients

The anthropometry, medical and dietary information of patients is recorded in table 4.2. A majority (32.5%) of the patients (adults) in this study had normal body mass index, with fewer (7.5%) of them being obese. The major cause of burn injury in this study was thermal causes, 92.5%. Chemical and electric causes recorded minimum injury, 2.5% and 5% respectively. Fifty percent of the patients suffered severe injury of above 25% Total Burn Surface area(TBSA), followed by 10 – 25% TBSA with 27.5% of the patients. Also 50% of the patients suffered partial thickness burns. The intake of dietary supplements before injury indicated that, 15% took multi nutrient supplement and 85% of them took none. The intake of supplements while on admission indicated that 21(52.5%) of the patients took prescribed supplements whilst 19 (47.5%) of them didn't receive any prescription from the doctors. Seventy five percent of the persons also had knowledge of the role of diet in the recovery outcomes and 85% of the patients did not receive any dietician consultation.

Table 4.3 Anthropometry, medical and dietary information of patients

Characteristic	N=40	%
Anthropometry		

Description of BMI*		
Underweight	0	0
Normal	13	32.5
Overweight	7	17.5
Obese	3	7.5
Medical information		
Cause of burn		
Electrical	2	5.0
Chemical	1	2.5
Thermal	37	92.5
Total Burn Surface Area(TBSA)		
Up to 10%	9	22.5
10 to 25%	11	27.5
Above 25%	20	50
Severity of burn		
First degree/superficial thickness	12	30.0
Second degree/Partial thickness	20	50.0
Third degree/full thickness	3	7.5
Mixed thickness	5	12.5
Dietary information		
#Intake of multi – nutrient supplement before injury		
Yes	6	15.0
No	34	85.0
#Intake of multi – nutrient		

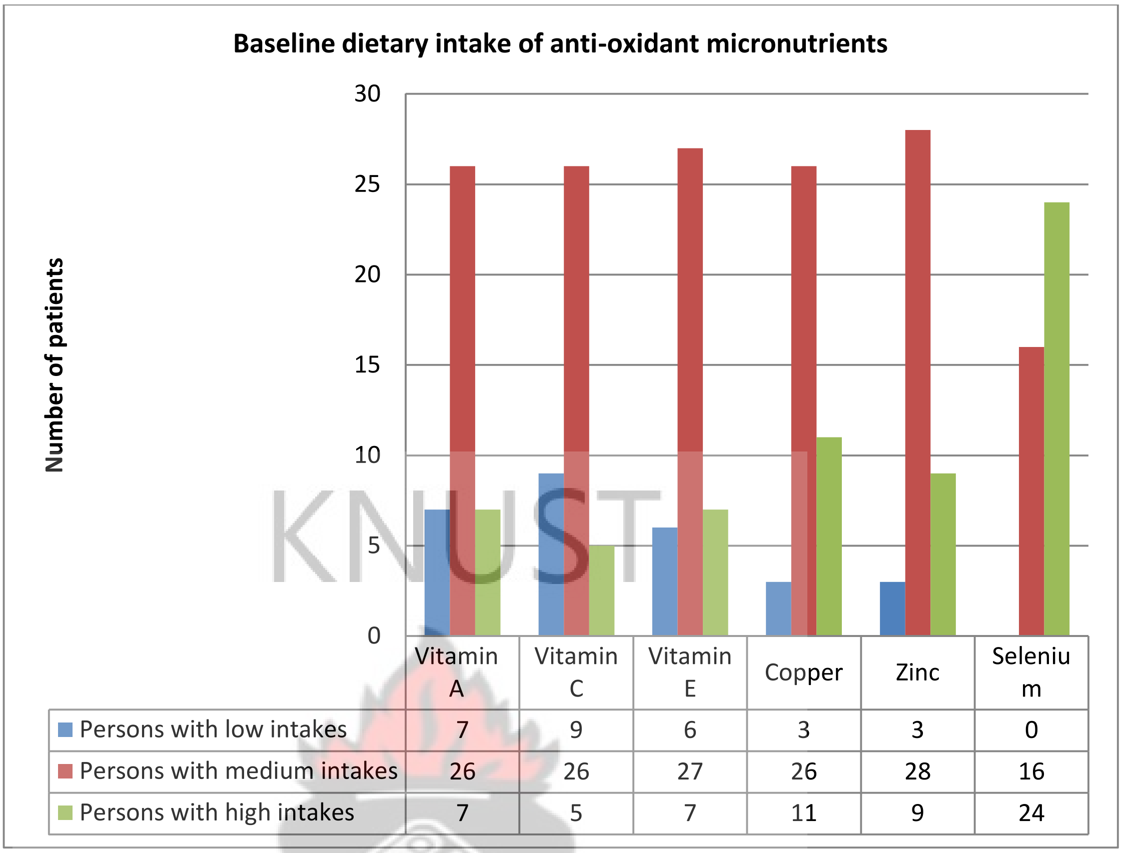
supplements on the ward		
Yes	21	52.5
No	19	47.5
#Knowledge of the role of diet and recovery outcomes		
Yes	30	75.0
No	10	25.0
#Refferal to Dietician		
Yes	6	15.0
No	34	85.0

⋆The nutritional status of children below age 10 was done with MUAC and all of them were within the required ranges.

There is no statistic relationship between these parameters and the recovery outcomes.

4.2.3 Baseline dietary intake of anti-oxidant micronutrients of patients before injury

The baseline dietary intakes of anti-oxidant micronutrient before injury are represented in Fig. 4.3.For all micronutrients except selenium, over 50% of the subjects recorded medium intakes based on the counts. Sixty percent of persons had high levels of selenium with 40% recording medium intakes.



	Vitamin A	Vitamin C	Vitamin E	Copper	Zinc	Selenium
Persons with low intakes	7	9	6	3	3	0
Persons with medium intakes	26	26	27	26	28	16
Persons with high intakes	7	5	7	11	9	24

Fig. 4.3 Dietary intake of anti-oxidant micronutrients before injury

4.2.4 Dietary intake of anti-oxidant micronutrients on the ward

The dietary intake of anti-oxidant micronutrients on admission is shown in Fig. 4.4. For Vitamin A, Vitamin E and Zinc, 28 (70%), 30(75%) and 21(53.5%) patients had inadequate amounts respectively. Copper, selenium and zinc recorded 35(87.5), 26(65%) and 26(65%) patients having adequate amounts respectively.

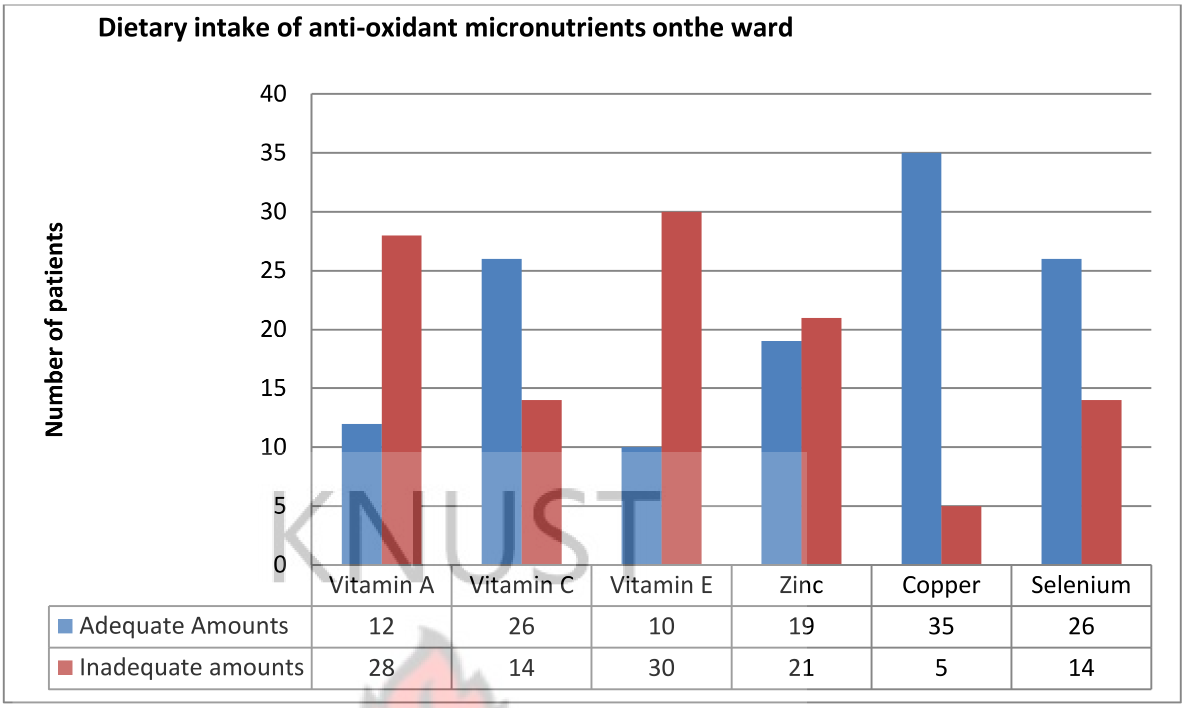


Fig. 4.4 Dietary intakes of anti-oxidant micronutrients on the ward

4.2.5 The energy and protein intake

The energy and protein intake of the subjects are represented in table 4.4. Only 12.5% (5) of subjects met 100% of their energy requirements and 25% (15) of the subject met 100% of their protein requirements. When their energy and protein intakes were compared to 75% of their requirements, 47.5% (19) had adequate amounts of energy and 50% (20) had adequate amounts of protein.

Table 4.4 Adequacy and inadequacy of energy and proteins

Macronutrients	Quantity	N=40

		Number of patients	%
100% of energy requirements	Adequate amounts	5	12.5
	Inadequate amounts	35	87.5
70% of energy requirements	Adequate amounts	19	47.5
	Inadequate amounts	28	70
100 % of protein requirements	Adequate amounts	12	30
	Inadequate amounts	28	75
70% of protein requirements	Adequate amounts	20	50
	Inadequate amounts	20	50

4.2.6 Assessment of recovery outcomes

The assessment of recovery outcomes (wound healing and infection) of patients in the study is represented in table 4.5. The first week reports a good wound healing outcome of 67.5%, whilst the second week records 65% of wound healing. The presence of wound infection after the study showed that, 13 (32.5%) subjects had infection of the wound.

Table 4.5 Assessment of recovery outcomes

Week	Parameter	N=40	%

Week 1	Positive wound healing	27	67.5
	Negative wound healing	13	32.5
Week 2	Positive wound healing	26	65
	Negative wound healing	14	35
End of week 2	Presence of infection	13	32.5
	Absence of infection	27	67.5

4.2.7 Comparison of the TBSA and outcome variable of patients

Table 4.6 compares the TBSA of patients with their recovery outcomes. Patients with TBSA above 25% spent more days in the hospital with average length of stay of 34 days. They were closely followed by patients with TBSA of 10 – 25% with 16 days. Patients with up to 10% TBSA had an average length of stay of 5 days. Similarly, patients with TBSA below 25% had progress in wound healing when they were assessed but patients with TBSA above 25% recorded various degrees of retardation in wound healing. Wound infection also increased considerably with respect to an increase in TBSA.

Table 4.6 TBSA and outcome variables of patients compared

	TBSA		
	Up to 10%	10 - 25%	Above 25%
Average length of stay(days)	5	16	34
Progress in wound healing (%)	100	100	52
Presence of infection (13)	0	3	9

4.2.8 Dietary intake of Vitamin A and wound healing outcomes

The dietary intake of Vitamin A and wound healing outcome is shown in Fig. 4.5.

The study of the wound healing outcomes for two weeks revealed that, out of the 12 patients who had adequate dietary intake of Vitamin A , 75% of them had a positive wound healing outcome during the first week with 58.3% of the patients recording positive wound healing outcomes in the second week. When this is compared to 28 patients with inadequate dietary intake of Vitamin A, it was observed that, 60.71% and 50% of the patients had positive wound healing outcomes showing a decrease in the wound healing outcomes. Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, $P > \alpha$, $\alpha = 0.05$.

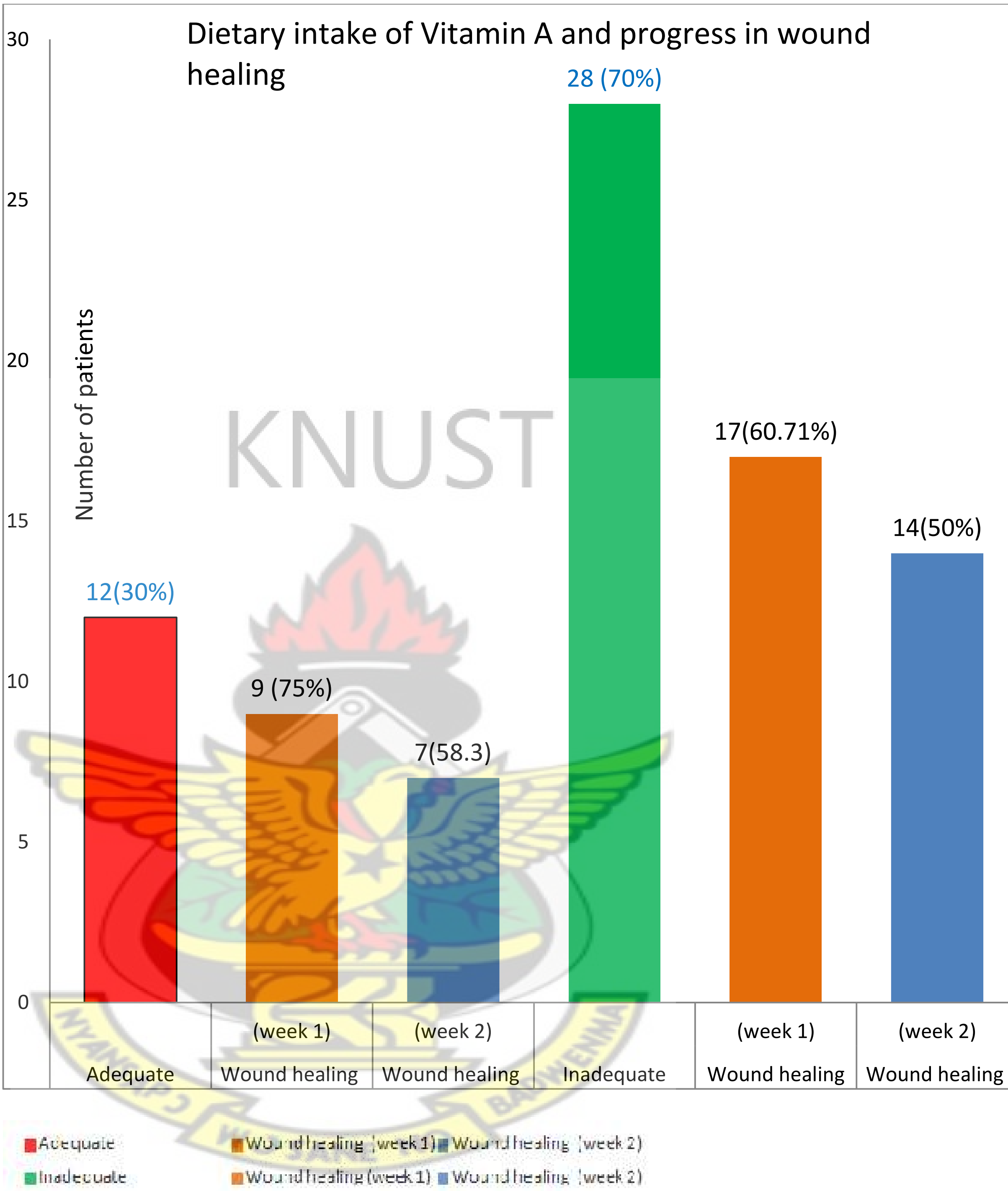


Fig. 4.5 Dietary intake of Vitamin A and progress in wound healing

4.2.9 Dietary intake of Vitamin C and the wound healing outcomes

The wound healing outcomes for patients with adequate intake of Vitamin C shown in Fig. 4.6 indicates a remarkable progress in wound healing. Out of 26 patients, 76.9% and 69.2% of them recorded positive wound healing outcomes for week one and week two respectively. In contrast there was progress in wound healing for only a half (50%) of the patients with inadequate dietary intake of Vitamin C. Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, P>α, α=0.05.

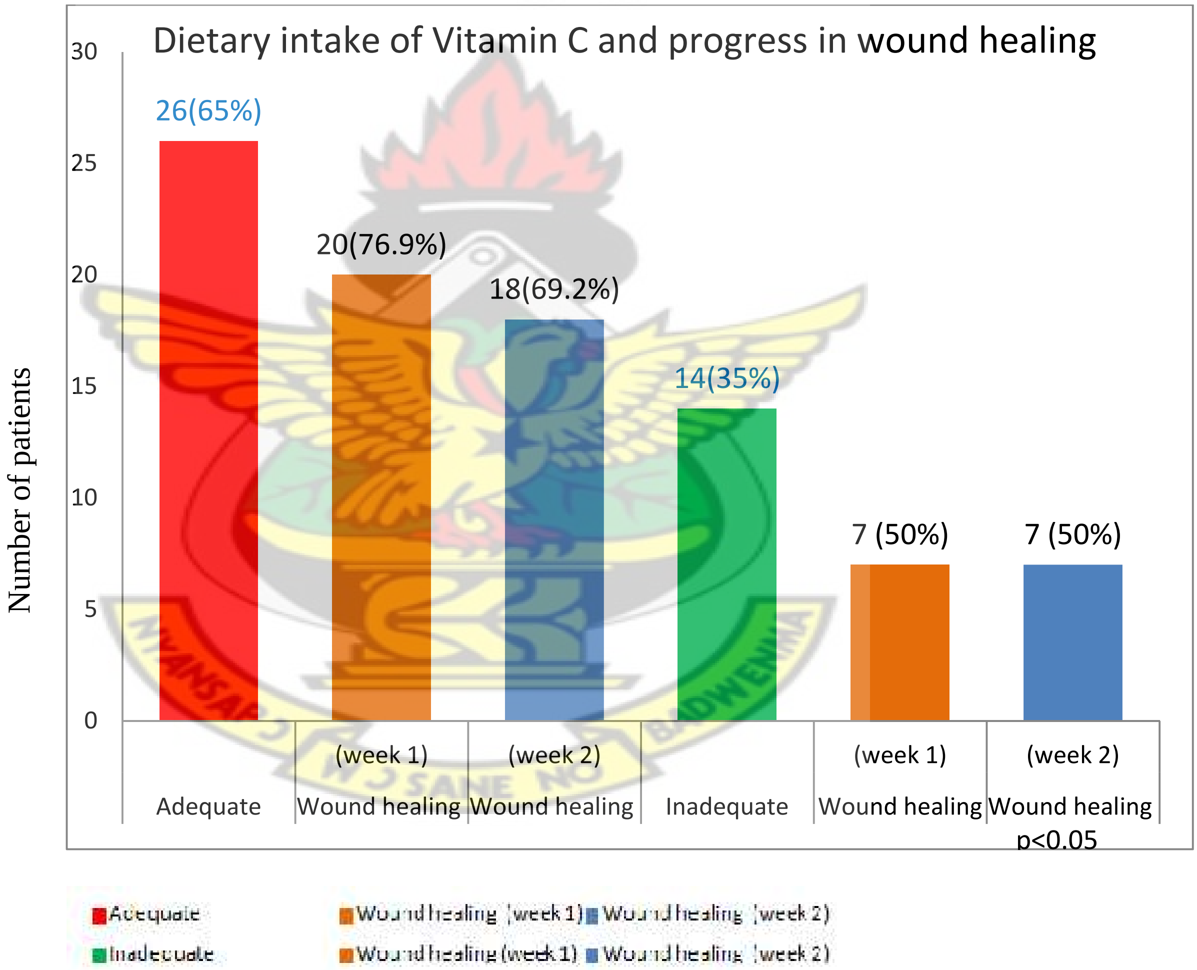


Fig. 4.6 Dietary intake of Vitamin C and the progress of wound healing

4.2.10 Dietary intake of Vitamin E and the wound healing outcomes

The role of Vitamin E in the progress of wound healing is shown in Fig. 4.7. It was observed that patients with adequate intake of Vitamin E recorded positive outcomes in wound healing in the first (70%) and second weeks (90%) as compared to those with inadequate dietary intake of the Vitamin who recorded 63.33% each week in their wound healing outcomes. Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, P>α, α=0.05.

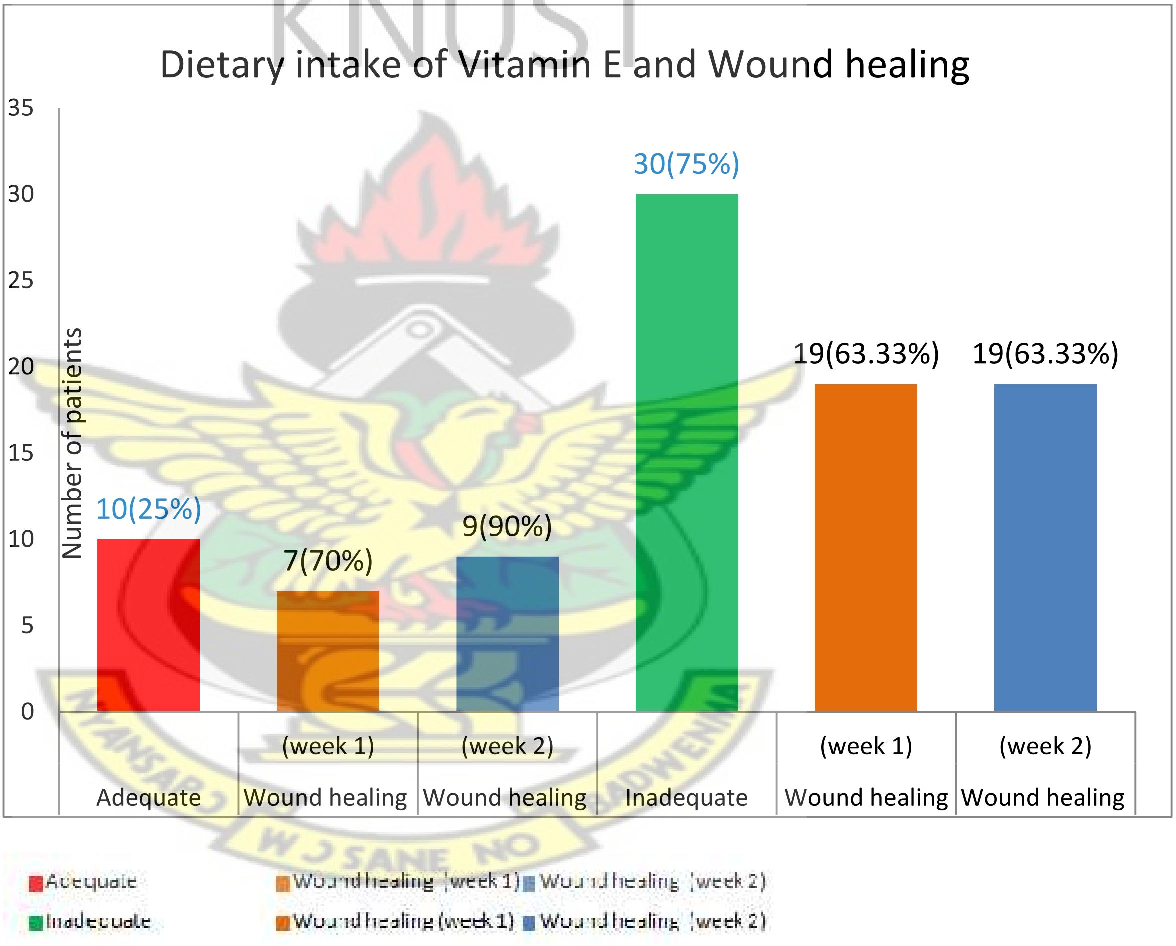


Fig. 4.7 Dietary intake of Vitamin E and Wound healing progress

4.2.11 Dietary intake of Copper and the wound healing outcomes

The adequacy in the dietary intake of copper yielded good wound healing outcomes and the results are shown in Fig. 4.8. The first and second weeks recorded a positive wound healing rate of 71.4% and 62.9% for patients with adequate dietary intake of copper. Patients with inadequate amounts of this trace element in their diet recorded a relatively lower progress in the wound health outcomes recording 40% for each week. . Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, P>α, α=0.05.

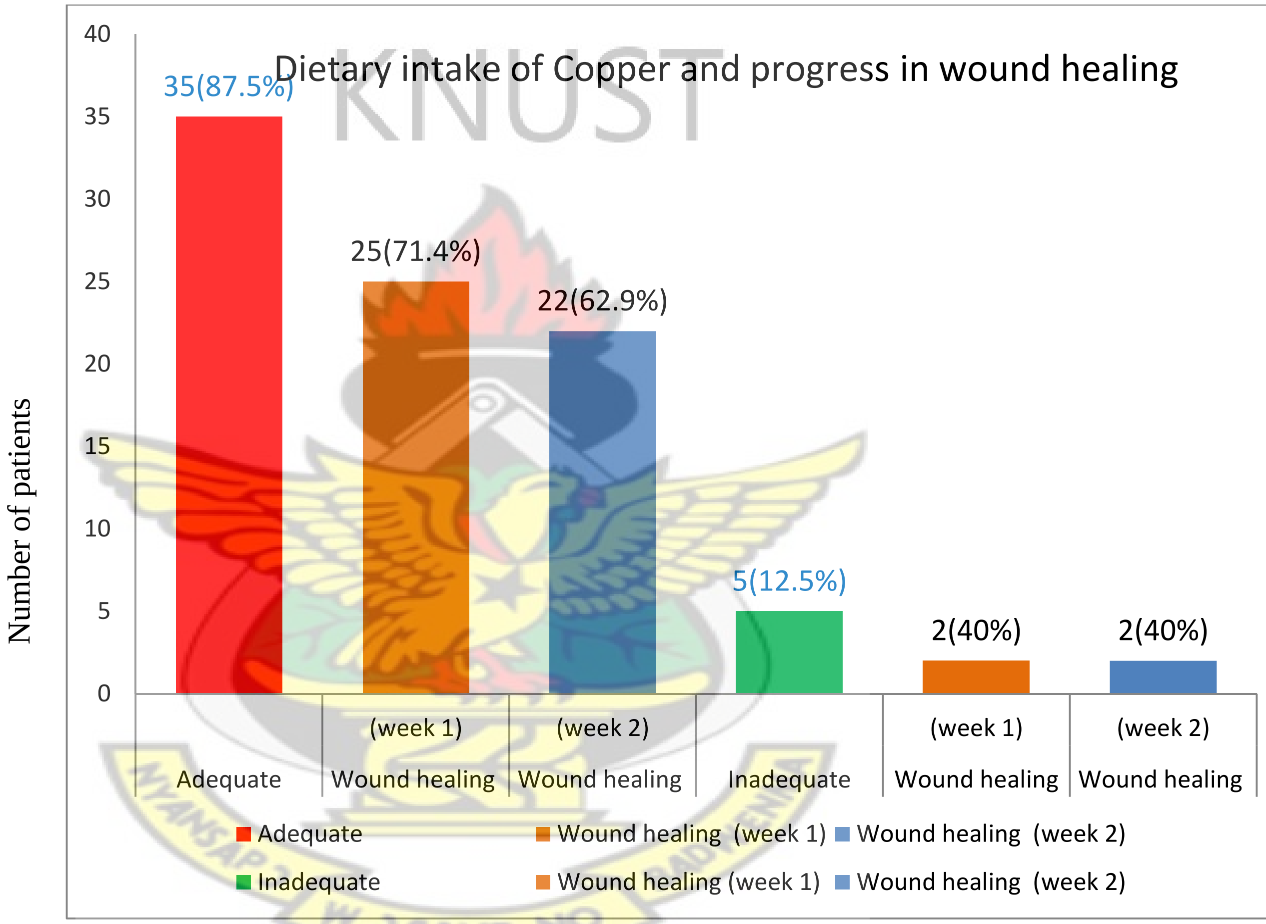


Fig. 4.8 Dietary intake of Copper and progress in wound healing

4.2.12 Dietary intake of Zinc and the wound healing outcomes

The wound healing progress in the patients who had adequate dietary intake of zinc is represented in Fig. 4.9. There was a corresponding increase in the number of patients with regards to their wound healing outcomes as seen in the previous anti – oxidants. About 63.10% and 73.10% of the patients recorded positive progress in wound health out of the 19 patients who had adequate dietary intake of the vitamin. There was also an increase in wound healing outcomes of patients with inadequate dietary intake of the vitamin in the first week (66.67%) as compared to those with adequate intakes (63.33%), but during the second week, there was a decline in the number of patients with positive wound healing when compared. Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, P>α, α=0.05.

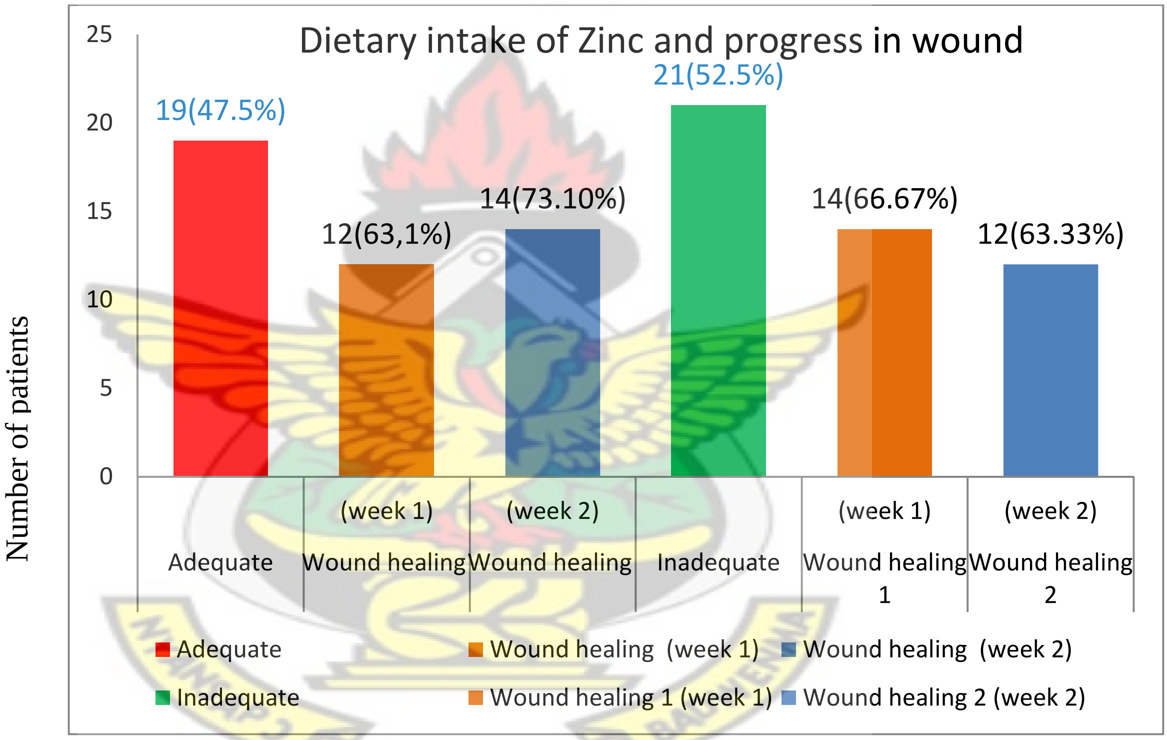


Fig. 4.9 Dietary intake of Zinc and progress in wound healing

4.2.13 Dietary intake of Selenium and the wound healing outcomes

The dietary intake of selenium and the wound healing outcomes are reported in figure 4.10. The adequacy of selenium in the diet of patients follows the same trend as the other anti – oxidant nutrients and it is represented in Fig. 4.10. There was a progress in the wound healing outcomes in the first week and the second weeks for patients who had adequate intake of selenium in their diet. It was also recorded that, there was a relative decrease in the number of patients who had inadequate amounts of selenium in their diet. . Chi square tests revealed that there was a significant increase in wound healing for patients with adequate amounts for the first week and second week, P>α, α=0.05.

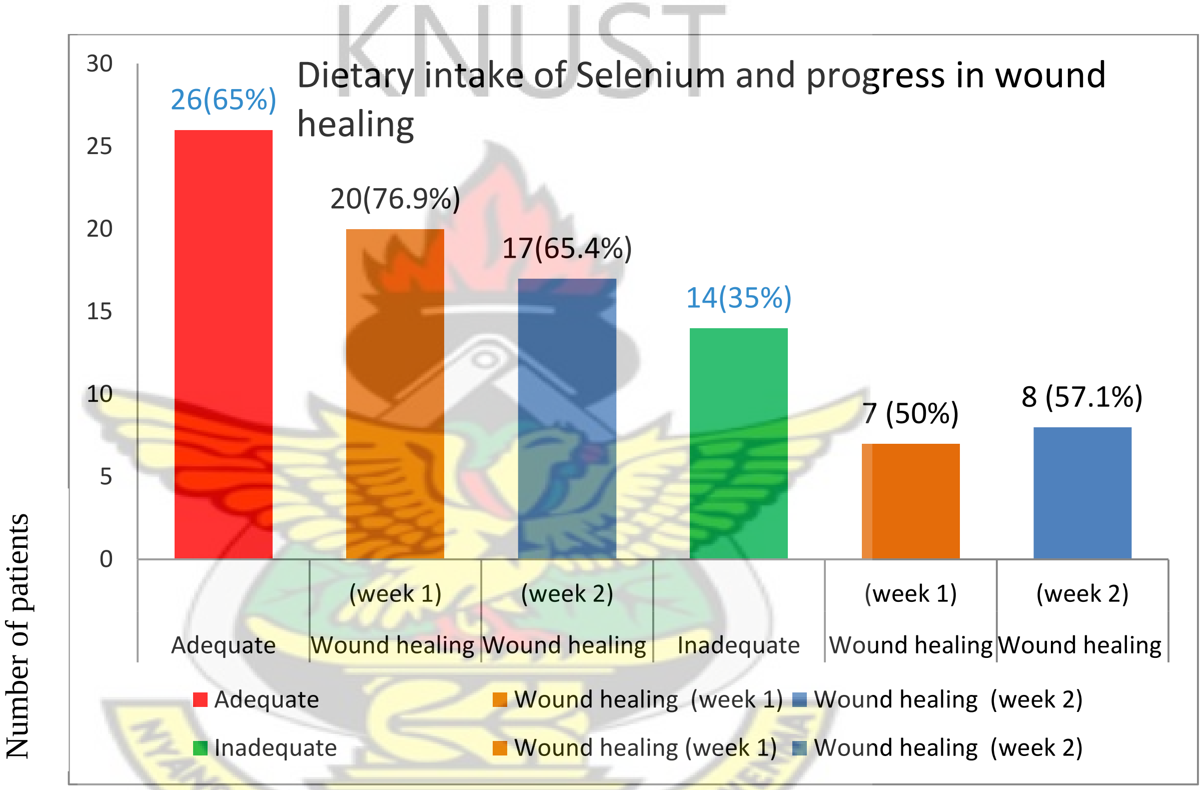


Fig. 4.10 Dietary intake of selenium and wound healing progress

4.2.14 Adequacy of anti oxidant vitamins and infection

The wound infection outcomes in patients are represented in Fig. 4.11. Patients with adequate dietary intake of Vitamin A who had infections were 25% compared to patients who had inadequate dietary intake recording a relatively higher figure, 32%. Patients with adequate dietary intake of Vitamin C also recorded a lower (26.9%) of infections compared with patients with inadequate dietary intake (35.7%). Though there were contrasting results, patients with adequate Vitamin E recorded wound healing rate of 33.3% compared with their counterparts with inadequate amounts recording a lower rate of infection (28.6%). The results are shown in Fig. 4.11

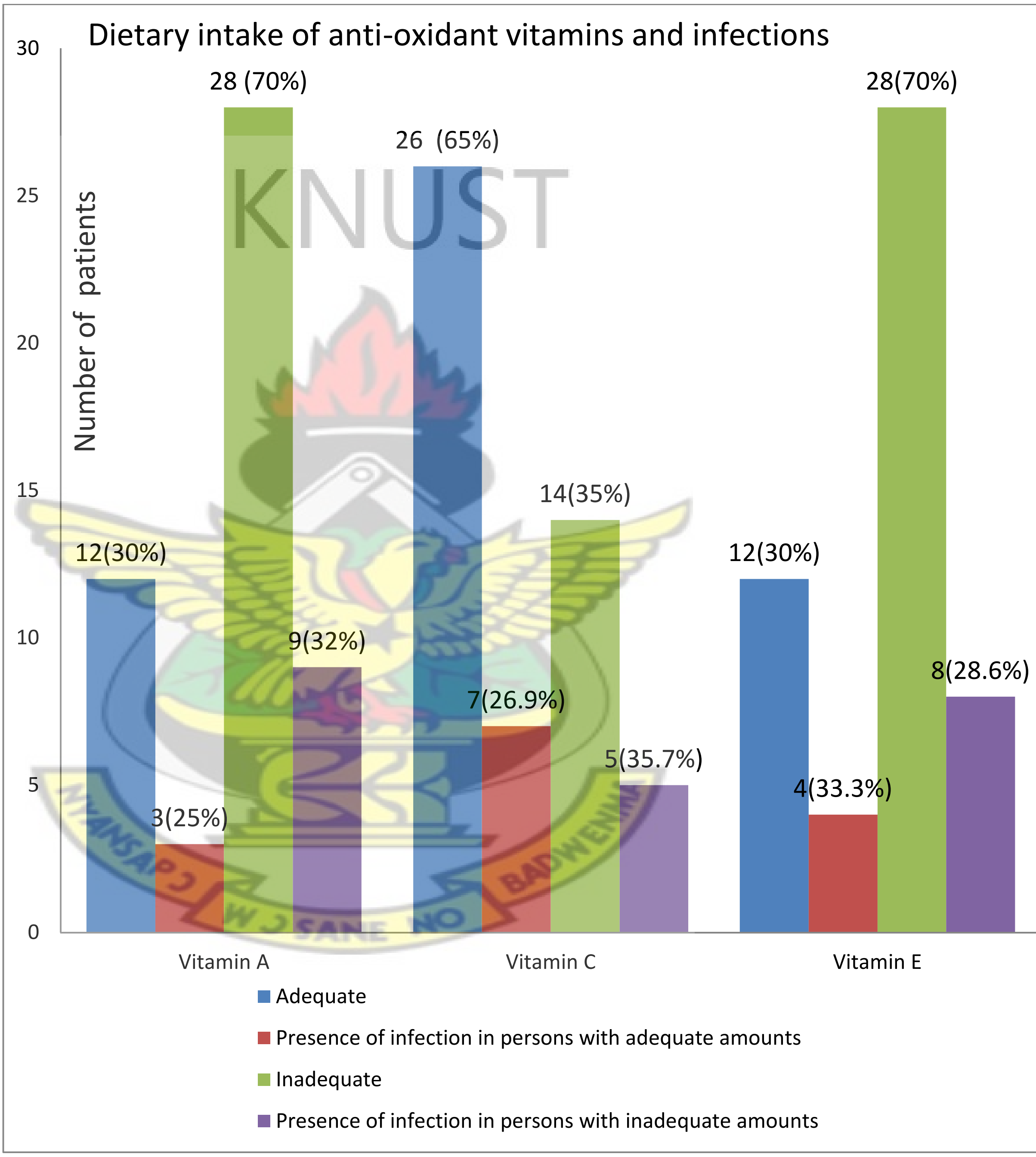


Fig. 4.11 Dietary intake of anti oxidant vitamins and infection

4.2.15 Adequacy of anti oxidant trace elements and infection

With regards to selenium, the infection rate was relatively lower in patients with inadequate amounts (23.1%) as compared to persons with adequate amounts (29.6%). These are contrasting outcomes to the expected results. Similar results were obtained for persons with inadequate and adequate amounts of Copper. Patients with adequate dietary intake of zinc recorded a lower rate of infection (26.3%) as compared to patients with inadequate amounts (33.33%). The results are shown in Fig 4.12

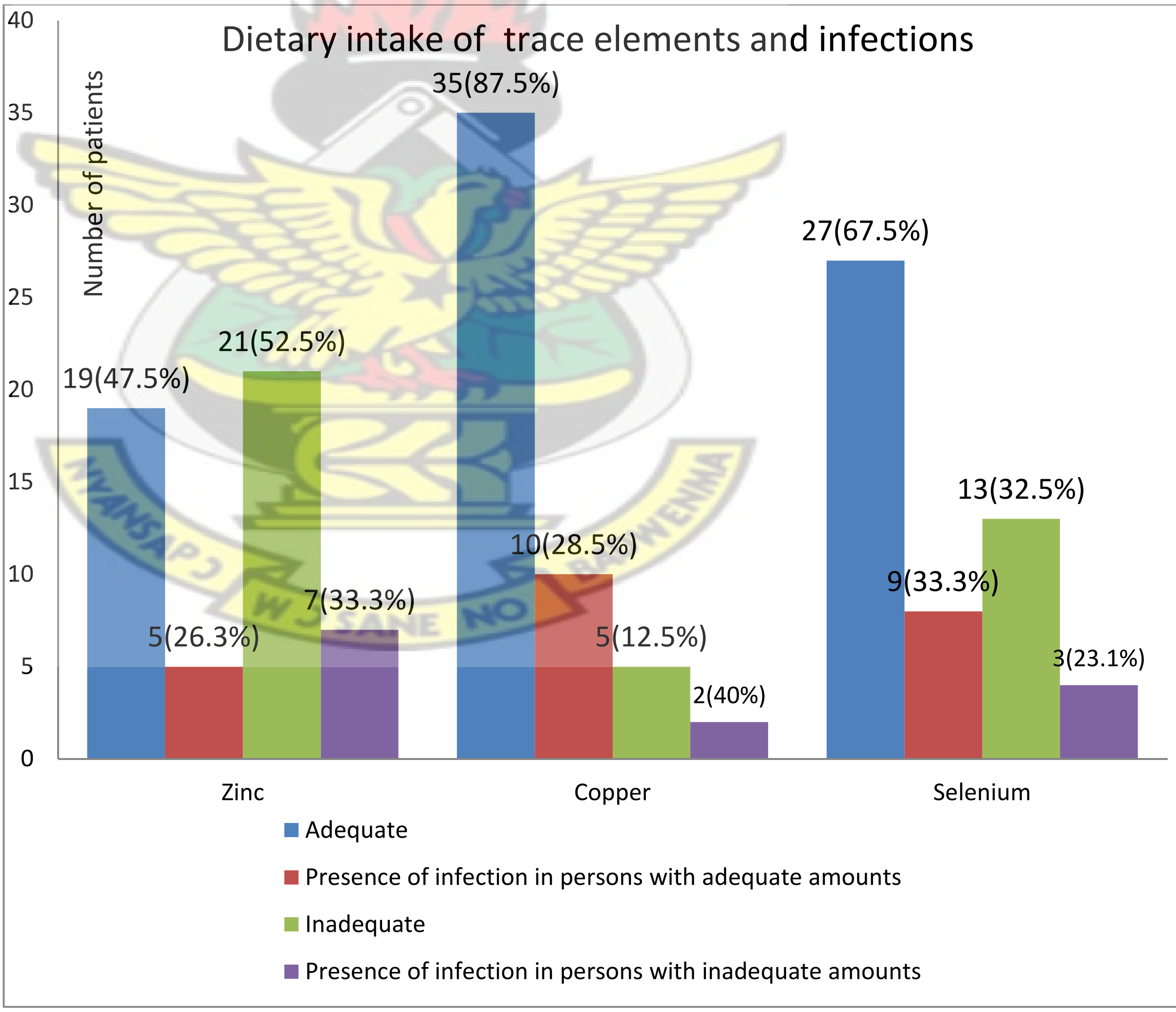


Fig. 4.12 Dietary intake of trace elements and infection

4.2.16 Concentration of Serum Vitamin A of patients

The serum concentration of Vitamin A is presented in fig 4.13. Generally, the results indicated an increase in the concentration of Vitamin for the patients after their stay in the hospital but it was not significant.

Blood samples of were obtained from only three patients because the patients were in pain hence were hesitant to give blood.

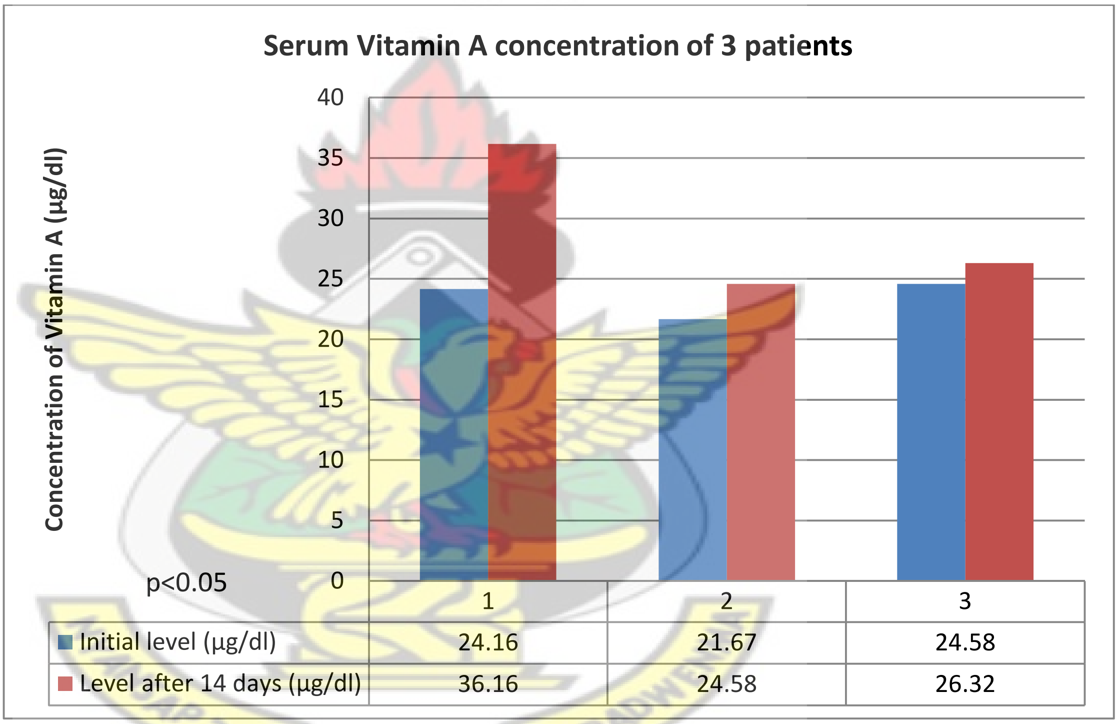


Fig. 4.13 Serum concentration of Vitamin A of 3 patients.

CHAPTER FIVE

DISCUSSION

The four year comprehensive study revealed that, there was high prevalence of burn injury with an increase in the mortality each year. This is alarming because there is possibility of an increase in the coming year. The severity of the burn injury also increased substantially each year with an increase in the length of ICU stay. This contradicts reports that states that burn injury is on the decline (Theodorou *et al.,* 2013). These increases can be as result of the increase in the use of open flames in most kitchens in Ghana (Rayner and Prentice, 2011).

Children below age 14 are known to have a high incidence of burn injury in developing countries and this could be a result of the roles played by most children with their mothers in the household (Brusselaer *et al*., 2011). Children in this category recorded a considerable high percentage (45%) of the total number of patients giving an indication that the child within this category needs to be protected from burn injury. Also, children below age 2years (20%) had burn injury which is quite high for such an age group. This may be attributed to negligence of mothers and caretakers, due to exposure of children to open flames in a typical setting of a home in a developed country (Rayner and Prentice, 2011). It is remarkable to know that, the four year comprehensive study gave similar results where majority of the subjects were children (48.7%).

The role of an African woman in the home that exposes her to a high risk of burn injury cannot be overemphasized. The results (cross sectional study and 4 year comprehensive study) revealed contrasting results as more males were affected by burn injury than women. Most of the males were children below 14 years and the results were so because male children are known to be very adventurous and some of them are known to think they have the ability to put out the fires they set (Peden *et al*., 2008). Brussaelers *et al*., 2011, Delgado *et* *al.*, 2002 and Courtright *et al*., 2013 report that, male children are at greater risk to burn injury than their female counterparts and this supports findings of this study.

In Africa, poverty, illiteracy and urban migration leads to overcrowding and unemployment and in most cases mothers leave their children unattended to in search for jobs, exposing these children to burn injury. In addition, the use of open flames in cooking is an important factor. The level of education and the occupation of individuals is a good determinant of the socio – economic status and were used in the study. The results obtained from the study show that majority of the persons had very low socio-economic background. Only 5% of the participants of this study were of a high socio – economic class corresponding to works done by Bell *et al*., 2009 which states that burn injury increase substantially with a lowered socio economic status.

The major cause of burn in this study was thermal (92.5%) comprising of open flames, scalds and gas explosion. Chemical (2.5%) and electrical (5%) causes recorded minimal results. It is remarkable to note that both the four year study and the cross sectional study gave similar results corresponding to the works done by Agbenorku *et al.*, 2010. The results from this study also show that, majority (50%) of the patients suffered a TBSA of above 25%. In addition, 70% of the participants had burn injury of second degree, third degree and mixed thickness, giving an indication that most of the injuries were very severe. According to Gokdemir *et al*., 2012, mortality increases with increasing TBSA and burn depth. Hence the results show that most persons in this study needed much attention in terms of treatment because of the severity of the burns they suffered. Clear evidence in this is the results obtained from the four year study, which reports an increase in mortality with a corresponding increase in year mean TBSA (Fig. 4.1 and Fig 4.2).

The pre- injury nutritional status of individuals has a great role on the recovery rates of patients. The results of the study shows that using the Mid Upper Arm Circumference as a nutritional assessment tool for children below 14 years indicated that all the children in the study had good nutritional status. The measure of nutritional status in the adults were the body mass index, (BMI) and this showed that 53% of the adults were within normal ranges of BMI with the remaining 43% being either overweight or obese. None of the patients were underweight. These shows that the entire subjects had good nutritional status before burn injury hence malnutrition before injury which could be a confounding factor to their rate of recovery was eliminated. The results from the food frequency also revealed that majority of the subjects had good intakes of the anti-oxidant micronutrients before injury, and this confirms their good nutritional status before injury.

Little is reported about pre-injury nutritional status and recovery outcomes in burn injury but it is believed that good nutritional status affects recovery of patients (National Academies Press, 2012). Pre-injury nutritional status is important because, as the patient progresses with acute phase of injury, the physiologic response to trauma deteriorates nutritional status. Sometimes this is regardless of the initial baseline (Prelack *et al.*, 2007). Results from this study show that, majority of the subjects had good pre- injury nutritional status based on their food frequency report. It was also observed that, majority of the subjects had inadequate intake of both macronutrients and micronutrients on the ward; hence it could have affected the recovery outcomes. There was a statistical difference between the baseline intakes (food frequency report) of the subjects and the intakes of the patients on the ward, $p<0.05$. It can be inferred from these that, there was reduction of the nutrient intake of the persons on the ward, hence that might have affected the recovery outcomes.

Apart from the decline of the nutritional status of patients after burn injury caused by inadequate dietary intake, loss of micronutrients and proteins in wound exudates and urine causes a further decline in nutritional status with time. This could account for the delay in the wound healing outcomes from the first and second week

Serum vitamin A obtained from the analysis for 3 patients revealed that the patients had adequate amounts of Vitamin A with none of the patients being deficient at baseline supporting the results obtained from the dietary assessments at baseline. There was a slight increase of the serum concentration of vitamin A though it was not significant. Some studies reported a decrease in Vitamin A, in burn patients (Vinha *et al.,* 2013), the results of this study showed no deficiency. This could be as a result of the stores of vitamin A in the liver of the individuals hence a deficiency can only determined when the liver stores are depleted (Watters and Tredget, 2002). It could also be that these patients were on multi nutrients supplements that contain Vitamin A.

Persons who took multi-nutrient supplement before injury and after injury were in the minority. There was no statistical relationship between rate of recovery and the intake of multi-nutrient supplement before and after injury however, it is known that supplementation of individuals with multi-nutrients have an impact on the recovery outcomes of patients. In studies by Al-Kaisy *et al*., 2006, Berger *et al.,* 2006 ,Sahib *et al*., 2010, intake of supplements had an effect on wound healing outcomes by decreasing wound healing time and decreasing the rate of infections.

Dietetic intervention in most burn injured cases is remarkable. It has been reported by Prins, 2009 that, patients with TBSA greater than 20% should be referred for nutrition support as this enhances recovery. From the results persons with TBSA greater than 20% were not referred hence it had a negative effect on their rate of recovery. Though there was no statistical relationship between dietetic intervention and recovery outcomes, there are several nutritional protocols that support this fact. Some of the reports also recommended various routes of nutrient delivery that could be beneficial to the critically ill patient (A'Beckett *et al*., 2004, Prelack *et al.,* 2007) but none of these were observed during the study. This could have had an effect on the recovery outcomes.

Adequate energy and protein are needed for recovery because various metabolic changes lead to proteolysis and protein oxidation and these lead to increased energy expenditure in the burn patients. Prelack *et al*., 2007 states that, once energy and protein requirements are established the pace is set for effective nutrient delivery. In this study, it was recorded that majority of the patients had low energy and protein intake when their intakes were compared with their requirements and this corresponds to a work done by Aryee *et al.,* 2011. This could be a very crucial factor in the progress of wound healing and recovery rates because the increase in the energy expenditure increases the energy needs of the patients, hence the any inadequacy can have an adverse effect on the patient.

Vitamin A is known to play various roles in the wound healing cascade. It enhances early inflammatory phase and promotes epithelial cell differentiation, collagen deposition and in immunity (Mckay and Miller, 2003), hence patients with adequate dietary intakes had progress in wound healing in the first two weeks. This is supported by Semba, 1994 which reported that intake of Vitamin A results in an increase in lymphocyte proliferation hence can prevent wound infection. The reduction of microbes on wound hastens wound healing (Australian Wound Management Association Inc, 2011) and this explains the results obtained from the study. Vitamin A is also known to aid the repair of damaged tissue hence may be beneficial in counteracting free radical damage (Noori, 2012), increasing the wound healing rate. Also the serum analysis revealed that patients with normal levels showed progress in wound healing in week one but in week two there was no progress, this could be as a result of deterioration of the nutritional status of the individuals.

Vitamin C plays vital roles in the anti oxidant defense network apart from its role in wound healing. It also plays diverse roles such as inhibiting oxidation of membrane lipids and preventing DNA damage (Noori, 2012). It is also responsible for neutrophil migration to the site of injury as well as a role in clotting when the skin is exposed. From this study it was noted that during the first two weeks of monitoring the patients, patients with adequate dietary intake of vitamin C recorded a remarkable progress in wound healing with statistical significance of $p<0.05$. This corresponds to work done by Barbosa *et al*., 2009 and Sahib *et al*., 2010 where supplementation of vitamin C reduced wound healing time in burn patients.

When the skin is exposed, the presence of micro organisms greater than 100,000 results in no epithelialization, and this delay wound healing. Vitamin E is responsible for preservation of macrophages which act by eliminating the micro organism by phagocytosis (MacKay and Miller, 2003). Due to its role in immunity, it was expected that patients with adequate amount in their diet should have good wound healing outcome as compared to patients with inadequate amounts in their diet. Results of this study showed that persons with adequate Vitamin E had reduced infection rate and progress in wound healing. This is similar to works done by Barbosa *et al*., 2009: Sahib *et al*., 2010. Vitamin E also plays roles in the inhibition of free radicals and prevents the lipid membranes from peroxidation, hence its effects in the results obtained.

The results in the study showed that there was significant increase in the number of persons who had adequate amounts of the nutrients (Vitamin A, C, E, Zinc, Copper, Selenium) when their wound healing outcomes for week one and week two were compared. This shows that persons with adequate amounts of the nutrients had good wound healing outcomes.

The body's anti-oxidant defense network is premiered by the Glutathione peroxidase and Selenium is known to be a major component of glutathione transferase enzyme, an important enzyme for this anti-oxidant (Noori, 2012). The roles of these are not fully known, but their effects on various recovery outcomes in patients are prominent (Tinggi 2008). Copper and Zinc are also co-factors of superoxide dismutase enzyme, and their adequacy in the diets of the patients was outstanding. The results obtained from this study revealed that, patients who had adequate Zinc, Copper and Selenium in their diet had positive wound healing outcomes and fewer reports of infections and this led to a reduction in the length of stay in the hospital.

However, some persons with adequate amounts of Vitamin E, Copper and Selenium had higher infection rates than persons with inadequate amounts. This contrasting result can be as result of bioavailability of the nutrients to a critically ill patient. Also there could be drug-nutrient interactions as well as nutrient-nutrient interaction (Heldt and Loss, 2013) In addition to these; there are other confounding factors that affect the recovery of burn patients. These can account for these disparities. Some of these confounding factors include TBSA. The recovery outcome of an individual depends on the TBSA. The greater the TBSA, the bigger the wound size and the wound healing takes much longer time. Also nosocomial infection on the ward and Methicillin – resistant *Staphylococcus aureus* that could be present in some of the health workers could be a factor, leading to more infections Danzeman *et al*., 2013. The effectiveness of surgical procedures and medications are also factors worth noting.

CHAPTER SIX

CONCLUSION AND RECCOMENDATIONS.

The results revealed that most persons on the ward did not meet their daily requirements of both macronutrients and micronutrients and this had a negative effect on their wound healing outcomes and infection rates. Also in cases where dietetic referral was needed the patients were not referred this could also be a contributor to delayed recovery.

With the presence of all confounding factors, Vitamin C was the only nutrient that showed statistic signification on the recovery outcomes on burn patients. In view of this, daily rations of foods that contain the Vitamin, such as fruits and vegetables can be delivered to burn patients on the ward to boost the recovery rates. In view of these, there is a need for well planned meals by dieticians to suit individual requirements. In addition, there is also the need for public education on the nutrition of burn patients.

It was also noted that the referral to the dieticians were low hence the dieticians could also take the initiative and collaborate with the doctors so that they can create awareness on the importance of dietary intervention in burn injury. This could be done when the dieticians participate actively in the ward rounds.

In addition, though burn injury is on the increase there is little work that has been done, hence if funds are allotted for research in the area it will be beneficial.

The major limitation to this work is the nutritional assessment tool for pre – injury nutritional status. The measures of pre-injury anthropometric measurements were done mostly with estimations as some of the patients had burned limbs hence could not stand well for measurements to be taken. A more efficient assessment tool for nutritional status such as serum protein and albumin levels can be used in a repeated study

Venous blood samples were obtained from only three (3) patients and this is a major limitation to the work, hence a greater number would have been beneficial.

Also the presence of other confounding factors limited the results. Works can also be done but confounding factors can be monitored to ascertain clear facts of the case.

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APPENDIX 1 Questionnaire for patients

ASSESSING DIETARY INTAKE OF ANTI – OXIDANT MICRONUTRIENT ON THE RATE OF RECOVERY OF BURN PATIENTS

SECTION 1

PERSONAL DATA

1.1 PATIENT ID ……………………………

1.2 AGE:…………………… Years

1.3 Sex: 1=Male 2=Female

1.4 Marital Status

1=single 2=married 3=separated/divorced

4=widowed

5=other
(specify)……………….…………………………………………………...
1.5 What is your highest level of education?
1= Primary School
2= Middle/Junior High School
3=Senior High School
4=Tertiary 1 to 3 years (Diploma/Certificate/Professional)
5=Tertiary 4 or more (Degree/Postgraduate/Professional)
6=None
7=Other
(Specify)…………………………………………………………………..
1.6 Occupation:
……………………………………………………………………….

1.7 Contact phone number if any:
……………………………………………………….

<u>SECTION 2</u>
<u>ANTHROPOMETRIC DATA</u>

2.1 HEIGHT: ……… m   2.2 WEIGHT: ………….. Kg
2.3 BMI…………….Kg/m^2 2.4 MUAC:……………… cm

2.5 Description of BMI:

1= Underweight (<18.5)

2= Normal (18.5-24.9)

3= Overweight (25.0-29.0)

4= Obesity, Class I (30.0 – 34.9)

5= Obesity, Class II (35.0-39.0)

6= Extreme Obesity, Class III (≥ 40)

SECTION 3: MEDICAL HISTORY
3.1 Cause of burn injury

1=Electrical

…………………………………………………………………….

2=Chemical

……………………………………………………………………

3=Thermal (hot liquid, gas explosion, open flame, hot objects etc. specify)……....

4=Other………………………………………………………………………

…………..

2.2 Date of burn injury: ....

2.3Did the patient receives any medical care before reporting to the hospital?

1=Yes 2=No

2.4 Date of

admission………………………………………………………………..

2.5How many days has patient been on admission?

....

2.6 Percentage Total Body Surface Area burned (%

TBSA)……………………..……...

2.7 Estimation of (major) degree(s) of burn or burn depth:

1= 1st degree / superficial burn

2=2nd degree / partial thickness burn

3= 3rd degree / full thickness burn

2.8 Presence of any ailment before injury.

……………………………………………………………………………

SECTION 4 A: DIETARY HISTORY (Food Frequency questionnaire)

4.1 Were you taking in any of these foods before you were injured?

	Foods	1=Yes 2=No	Average number of times per week

	Fruits		
1	Pineapple.		
2	Citrus(Orange, tangerine, grape fruit)		
3	Mango		
4	Guava		
5	Avocado		
6	Pawpaw		
7	Water melon		
8	apple		
9	Other:		
	Vegetables		
10	kontomire		
11	Other dark green leafy vegetables		
12	Carrots		
13	Okra		
14	Cabbage		
15	Garden egg		
16	Other:		
	Protein foods		
17	Meat		
18	Liver		
19	Chicken		
20	Fish		
21	Eggs		

22	Shell fish (shrimps, clams, lobster)		
23	Sausage		
24	Other:		
	Cereals and grains		
25	Rice		
26	Wheat		
27	Millet		
28	Sorghum		
29	maize		
30	Other:		
	Roots and tubers		
31	Yam		
32	Cocoyam		
33	Sweet potato		
34	Cassava		
35	Other:		
	Legumes		
36	Beans, , etc.		
37	cowpea		
38	soyabeans		
39	bambara beans		
40	Other :		
	Nuts, oils, toppings		

41	Peanut		
42	Tiger nut		
43	Cashew nut		
44	Palm oil		
45	Vegetable oil		
46	Salad cream/mayonnaise		
	Other :		
	Diary and milk products		
47	milk		
48	cheese		
49	wagashi		
50	Other :		

4.2Were you on multi nutrient supplements before the injury. (If no skip to 4.3)
1=Yes
2=No
4.3 If yes which type of multi – nutrient supplement were you taking.
…………………………………………………………………………………
……………

SECTION 4B

4.10 Has the patient been referred to the dietician?
1=Yes 2=No
4.11What is the current mode of feeding?
1= Oral feeding
2= Enteral (tube feeding)
Other: (specify)……………..............................
4.12 Is patient on any vitamin or mineral supplement (s)
1= Yes 2=No

4.13 If Yes, what type(s) of vitamin or mineral supplements are being taken by the patient?
....
....
....
....
....
....

4.14 Nutritional information of supplements

Vitamin A .... Zinc : …………………………….

Vitamin C.................. Copper : ………………………….

Vitamin E.................. Selenium : ………………………..

4.15 What is the dosage of the supplement.

....………

....

4.16 Do you use any herbal preparations?

1=Yes 2=No (Skip 3.8 and 3.9)

4.17 If yes, what exactly do you take?...

4.18 If yes who prescribed it?

1=Doctor

2=Family Member / Friend

3=Other (specify)……………………………………………………………………

4.19 Do you eat the hospital food?

1=Yes 2=No

4.20 Dietary intake

Weekday 1 (Day of the week: ___________________________)

Menu & Time	Food	Handy Measure (Estimated portion size)	Weight (g) / volume (ml)
Breakfast	1.		
Time:	2.		

( )			
	3.		
	4.		
Mid-morning snack Time: ( )	1.		
	2.		
Lunch Time: ( )	1.		
	2.		
	3.		
	4.		
Mid-afternoon snack Time: ( )	1.		
	2.		
Supper Time: ( )	1.		
	2.		
	3.		
	4.		
Evening snack Time: ( )	1.		
	2.		

Weekday 2 (Day of the week: ____________________________)

Menu & Time	Food	Handy Measure (Estimated portion size)	Weight (g) / volume (ml)
Breakfast Time: ( )	1.		
	2.		
	3.		
	4.		
Mid-	1.		

morning snack Time: ( )	2.		
Lunch Time: ( )	1.		
	2		
	3.		
	4.		
Mid-afternoon snack Time: ( )	1.		
	2.		
Supper Time: ( )	1.		
	2.		
	3.		
	4.		
Evening snack Time: ( )	1.		
	2.		

Weekend (Day of the week: ___________________________)

Menu & Time	Food	Handy Measure (Estimated portion size)	Weight (g) / volume (ml)
Breakfast Time: ( )	1.		
	2.		
	3.		
	4.		
Mid-	1.		

morning snack Time: ( )	2.		
Lunch Time: ( )	1.		
	2.		
	3.		
	4.		
Mid-afternoon snack Time: ( )	1.		
	2.		
Supper Time: ( )	1.		
	2.		
	3.		
	4.		
Evening snack Time: ( )	1.		
	2.		

4.21 Calculations of the nutrients in food eaten by patient

Food	Grams/mls of food	Zinc	Copper	Selenium	Vitamin A	Vitamin C	Vitamin E

Estimated Total							

4.22 Protein requirement: ……………………………………………………………..
4.23 Protein intake: ………………………………………………………………………...
4.24 Energy requirement: …………………………………………………………….
4.25 Energy intake: ………………………………………………………………………...

SECTION 5: BIOCHEMICAL

Micronutrient	Total blood level at baseline	Total blood level after 2 weeks
Vitamin A		
Vitamin C		
Vitamin E		
Selenium		
Copper		
Zinc		

SECTION 6: ASSESSMENT OF RATE OF RECOVERY

6.1 Presence of any infection
1= Pneumonia 2. Common colds
3= Others specify: ……………………………..
6.2 Length of ICU stay:

1= 1-3 days 2=4 -6 days 3=beyond 7 days

6.3Length of stay in the hospital:

6.4 Progress in wound healing

1=

2=

3=

THANK YOU AND MAY GOD BLESS YOU!!!

APPENDIX 2

Calculations for Estimated Energy Expenditure

Table 1.1: MODIFIED SCHOFIELD EQUATION:

Female kcal/day **BMR**		**Male kcal/d** **BMR**	
15-18 years	**13.3W + 690**	**15-18 years**	**17.6W + 656**
18-30 years	**14.8W + 485**	**18-30 years**	**15.0W + 690**
30-60 years	**8.1W + 842**	**30-60 years**	**11.4W + 870**
Over 60 years	**9.0W + 656**	**Over 60 years**	**11.7W + 585**

W = weight in kg

EER = BMR x IF x AF

Injury Factor (IF)

Up to 10% burn 1.0-1.1

10-25% 1.1-1.3

25-90% 1.2-1.7

These injury factors appear to be based on expert opinion or consensus only.

Activity Factor (AF) – including diet induced thermogenesis

Bed bound immobile 1.1

Bed bound mobile/ sitting 1.15-1.2

Mobile on ward 1.25

For persons below age 15 the following formulae were used to calculated for the BMR. For this study, REE and BMR are used interchangeably for children below 15.

Table 1. 2 Schofieds equations for calculating BMR (kcal/day) in infants and children

Gender	Equation	Age
Male Female	BMR=59.48*Wt –30.33 BMR=58.29*Wt – 30.15	0 – 3 years
Male Female	BMR = 22.7 3 *Wt + 505 BMR = 20.3 3* Wt + 486	3 – 10 years
Male Female	BMR = 13.4 3* Wt + 693 BMR = 17.7 3* Wt + 659	10 – 18 years

*Wt = body weight in kilograms; Ht = Length in meters.

APPENDIX 3

STATISTICS

1. **Relationship between intake of multi-nutrient supplement on the ward and wound healing**

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.273[a]	1	.601		
Continuity Correction[b]	.020	1	.888		
Likelihood Ratio	.279	1	.598		
Fisher's Exact Test				.715	.451
Linear-by-Linear Association	.266	1	.606		
N of Valid Cases[b]	38				

2. **Relationship between intake of multi-nutrient supplement on the ward and infection**

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.335[a]	1	.563		
Continuity Correction[b]	.047	1	.828		
Likelihood Ratio	.330	1	.565		
Fisher's Exact Test				.720	.409
Linear-by-Linear Association	.327	1	.568		
N of Valid Cases[b]	40				

3. **Relationship between intake of multi nutrient supplement before injury and wound healing**

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.335[a]	1	.563		
Continuity Correction[b]	.047	1	.828		
Likelihood Ratio	.330	1	.565		
Fisher's Exact Test				.720	.409
Linear-by-Linear Association	.327	1	.568		
N of Valid Cases[b]	40				

4. **Relationship between intake of multi-nutrient supplement before injury and infection**

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.754[a]	1	.385		
Continuity Correction[b]	.256	1	.613		
Likelihood Ratio	.779	1	.377		
Fisher's Exact Test				.484	.311
Linear-by-Linear Association	.735	1	.391		
N of Valid Cases[b]	40				

5. **Relationship between knowledge of the role of diet and recovery outcomes and wound healing**

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.058[a]	1	.809		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.058	1	.810		
Fisher's Exact Test				1.000	.549
Linear-by-Linear Association	.057	1	.812		
N of Valid Cases[b]	38				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

b. Computed only for a 2x2 table

6. **Relationship between knowledge of the role of diet and recovery outcomes and infection**

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.273[a]	1	.811		
Continuity Correction[b]	.020	1	.888		
Likelihood Ratio	.279	1	.528		
Fisher's Exact Test				.725	.681
Linear-by-Linear Association	.266	1	.606		
N of Valid Cases[b]	38				

7. **Relationship between dietician involvement and wound healing**

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)

Pearson Chi-Square	.058[a]	1	.809		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.058	1	.810		
Fisher's Exact Test				1.000	.549
Linear-by-Linear Association	.057	1	.812		
N of Valid Cases[b]	38				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

b. Computed only for a 2x2 table

8. Relationship between dietary intake of Vitamin A and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.273[a]	1	.601		
Continuity Correction[b]	.020	1	.888		
Likelihood Ratio	.279	1	.598		
Fisher's Exact Test				.715	.451
Linear-by-Linear Association	.266	1	.606		
N of Valid Cases[b]	38				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

b. Computed only for a 2x2 table

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.058[a]	1	.809		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.058	1	.810		
Fisher's Exact Test				1.000	.549
Linear-by-Linear Association	.057	1	.812		
N of Valid Cases[b]	38				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

b. Computed only for a 2x2 table

9. Relationship between Vitamin A and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.273[a]	1	.701		
Continuity Correction[b]	.020	1	.888		

Likelihood Ratio	.279	1	.528		
Fisher's Exact Test				.715	.651
Linear-by-Linear Association	.266	1	.606		
N of Valid Cases[b]	38				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.68.

b. Computed only for a 2x2 table

10. Relationship between dietary intake of Vitamin C and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.642[a]	1	.031		
Continuity Correction[b]	3.265	1	.071		
Likelihood Ratio	4.584	1	.032		
Fisher's Exact Test				.043	.036
Linear-by-Linear Association	4.526	1	.033		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.90.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.130[a]	1	.144		
Continuity Correction[b]	1.237	1	.266		
Likelihood Ratio	2.098	1	.147		
Fisher's Exact Test				.178	.133
Linear-by-Linear Association	2.077	1	.150		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.90.

b. Computed only for a 2x2 table

11. Relationship between Vitamin C and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.130[a]	1	.144		
Continuity Correction[b]	1.237	1	.266		
Likelihood Ratio	2.098	1	.147		
Fisher's Exact Test				.178	.133
Linear-by-Linear Association	2.077	1	.150		

N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.90.

b. Computed only for a 2x2 table

12. Relationship between dietary intake of Vitamin E and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.335[a]	1	.563		
Continuity Correction[b]	.047	1	.828		
Likelihood Ratio	.330	1	.565		
Fisher's Exact Test				.720	.409
Linear-by-Linear Association	.327	1	.568		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.20.

b. Computed only for a 2x2 table

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.380[a]	1	.240		
Continuity Correction[b]	.687	1	.407		
Likelihood Ratio	1.402	1	.236		
Fisher's Exact Test				.311	.204
Linear-by-Linear Association	1.345	1	.246		
N of Valid Cases[b]	40				

13. Relationship between Vitamin E and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.162[a]	1	.141		
Continuity Correction[b]	1.282	1	.258		
Likelihood Ratio	2.208	1	.137		
Fisher's Exact Test				.186	.129
Linear-by-Linear Association	2.108	1	.147		
N of Valid Cases[b]	40				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.18.

b. Computed only for a 2x2 table

14. Relationship between dietary intake of zinc and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.380[a]	1	.240		
Continuity Correction[b]	.687	1	.407		
Likelihood Ratio	1.402	1	.236		
Fisher's Exact Test				.311	.204
Linear-by-Linear Association	1.345	1	.246		
N of Valid Cases[b]	40				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.70.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.162[a]	1	.141		
Continuity Correction[b]	1.282	1	.258		
Likelihood Ratio	2.208	1	.137		
Fisher's Exact Test				.186	.129
Linear-by-Linear Association	2.108	1	.147		
N of Valid Cases[b]	40				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.18.

b. Computed only for a 2x2 table

15. Relationship between zinc and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.754[a]	1	.385		
Continuity Correction[b]	.256	1	.613		
Likelihood Ratio	.779	1	.377		
Fisher's Exact Test				.484	.311
Linear-by-Linear Association	.735	1	.391		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.20.

b. Computed only for a 2x2 table

16. Relationship between dietary intake of copper and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.598[a]	1	.440		

Continuity Correction[b]	.084	1	.772		
Likelihood Ratio	.656	1	.418		
Fisher's Exact Test				.648	.405
Linear-by-Linear Association	.583	1	.445		
N of Valid Cases[b]	40				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.80.
b. Computed only for a 2x2 table

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.985[a]	1	.321		
Continuity Correction[b]	.270	1	.603		
Likelihood Ratio	.934	1	.334		
Fisher's Exact Test				.370	.293
Linear-by-Linear Association	.961	1	.327		
N of Valid Cases[b]	40				

17. Relationship between copper and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.754[a]	1	.465		
Continuity Correction[b]	.256	1	.613		
Likelihood Ratio	.779	1	.377		
Fisher's Exact Test				.484	.411
Linear-by-Linear Association	.735	1	.391		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.20.
b. Computed only for a 2x2 table

18. Relationship between dietary intake of selenium and wound healing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.008[a]	1	.931		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.008	1	.931		
Fisher's Exact Test				1.000	.599
Linear-by-Linear Association	.007	1	.931		

N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.88.

b. Computed only for a 2x2 table

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.436[a]	1	.231		
Continuity Correction[b]	.733	1	.392		
Likelihood Ratio	1.420	1	.233		
Fisher's Exact Test				.310	.196
Linear-by-Linear Association	1.400	1	.237		
N of Valid Cases[b]	40				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.25.

b. Computed only for a 2x2 table

19. Relationship between Selenium and infection

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.754[a]	1	.385		
Continuity Correction[b]	.256	1	.613		
Likelihood Ratio	.779	1	.377		
Fisher's Exact Test				.484	.311
Linear-by-Linear Association	.735	1	.391		
N of Valid Cases[b]	40				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.20.

b. Computed only for a 2x2 table

20. Differences in serum Vitamin A at baseline and at 14 days (t – test)

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	99% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Vit_A_before_two_weeks - Vit_A_after_two_weeks	-5.55097	5.61163	3.23988	-37.70623	26.60429	-1.713	2	.229

21. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Vitamin A

Vit A week 1

	adequate	Inadequate
Chi-Square	1.600[a]	1.286[b]
df	1	1
Asymp. Sig.	.206	.257
Exact Sig.	.344	.345
Point Probability	.234	.160

Vit A week 2

	adequate	inadequate
Chi-Square	.400[a]	2.286[b]
df	1	1
Asymp. Sig.	.527	.131
Exact Sig.	.754	.185
Point Probability	.410	.098

22. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Vitamin C

Vit C week 1

	adequate	inadequate
Chi-Square	7.538[a]	.286[b]
df	1	1
Asymp. Sig.	.006	.593
Exact Sig.	.009	.791
Point Probability	.007	.367

Vit C week 2

	adequate	inadequate
Chi-Square	5.538[a]	.000[b]
df	1	1
Asymp. Sig.	.019	1.000
Exact Sig.	.029	1.000
Point Probability	.020	.209

23. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Vitamin E

Vit E week 1

	adequate	inadequate
Chi-Square	.333[a]	3.571[b]
df	1	1
Asymp. Sig.	.564	.059
Exact Sig.	.774	.087
Point Probability	.387	.051

Vit E week 2

	adequate	inadequate
Chi-Square	3.000[a]	1.286[b]
df	1	1
Asymp. Sig.	.083	.257
Exact Sig.	.146	.345
Point Probability	.107	.160

24. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Zinc

Zinc week1

	adequate	inadequate
Chi-Square	6.368[a]	.048[b]
df	1	1
Asymp. Sig.	.012	.827
Exact Sig.	.019	1.000
Point Probability	.015	.336

zinc week 2

	adequate	inadequate
Chi-Square	6.368[a]	.048[b]
df	1	1
Asymp. Sig.	.012	.827
Exact Sig.	.019	1.000
Point Probability	.015	.336

25. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Copper

Copper week 1

	adequate	Inadequate
Chi-Square	4.829[a]	.200[b]
df	1	1
Asymp. Sig.	.028	.655
Exact Sig.	.041	1.000
Point Probability	.024	.625

Copper week 2

	adequate	Inadequate
Chi-Square	3.457[a]	.200[b]
df	1	1
Asymp. Sig.	.063	.655
Exact Sig.	.090	1.000
Point Probability	.049	.625

26. Comparison between outcomes of wound healing in week one and wound healing in week two for persons with adequate and inadequate amounts of Selenium

Selenium week 1

	adequate	inadequate
Chi-Square	4.481[a]	.077[b]
df	1	1
Asymp. Sig.	.034	.782
Exact Sig.	.052	1.000
Point Probability	.033	.419

Selenium week 2

	adequate	inadequate
Chi-Square	3.000[a]	.692[b]
df	1	1
Asymp. Sig.	.083	.405
Exact Sig.	.122	.581
Point Probability	.070	.314

APPENDIX 4

The grouping of food into high, medium and low contents of the micronutrients.

Foods	Zinc	Copper	Selenium	Vit C	Vit A	Vit. E
Pineapple.	-	1	-	3	1	-
Citrus(Orange, tangerine, grape fruit)	-	1	1	3	1	-
Mango	1	1	-	3	1	1
Guava	-	1	-	3	1	1
Avocado	-	-	-	1	1	2
Pawpaw	1	1	1	3	1	1
Water melon	1	1	1	1	1	1
apple	-	-	-	1	1	2
banana	1	1	1	2	1	1
Coconut water	1	1	1	1	-	-
Fruit drink	-	-	1	3	-	-
Vegetables						
kontomire	1	2	1	3	3	1
Other dark green leafy vegetables	1	1	1	1	1	1
Carrots	1	1	-	1	3	1
Okra	1	1	-	1	1	1
Cabbage	-	-	-	2	1	1
Garden egg	1	1	-	1	1	1
Protein foods						
Meat	2	1	2	-	-	1
Liver	1	1	3	1	3	1

Chicken	1	1	3	-	1	1
Fish	1	1	3	1	1	1
Eggs	1	1	3	-	2	1
Shrimps	1	1	2	1	1	1
sausage	1	-	-	-	-	-
Cereals and grains						
Rice	1	1	1	-	-	-
Wheat	1	2	3	-	-	1
Millet	1	1	1	-	-	-
maize	1	2	2	-	1	1
Roots and tubers						
Yam	1	1	1	1	1	1
Cocoyam	1	1	1	1	1	1
Sweet potato	1	1	1	2	1	1
Cassava	1	1	1	2	1	1
Legumes, nuts, oils, toppings						
Beans,	1	2	1	3	-	-
Peanut	1	2	1	1	-	2
Tiger nut	2	3	1	1	-	3
Palm oil	-	-	-	0	2	1
Vegetable oil	-	-	-	-	-	1
Salad cream/mayonnaise	1	0	1	-	-	3
Diary and milk products						
milk	1	-	1	-	1	1
cheese	2	-	2	-	1	1
wagashi	2	-	2	-	1	1

Mary Adjepong – madjepong2020@gmail.com