MINERAL STATUS OF APPARENTLY HEALTHY NORMAL PREGNANT WOMEN AND THEIR NEONATES AT PARTUBITION

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DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.

SIGNED_____
ICCE DANLADI (AUTHOR)

DATE_____

CERTIFICATION

This thesis titled Mineral status of apparently healthy normal pregnant women at parturition and their cord blood by ICCE DANLADI meets the regulation governing the award of the degree of Master of Science, Ahmadu Bello University, Zaria and is therefore approved for its contribution and literary presentation.

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DEDICATION

To my ilk for being who we are.

To my parents for having me.

To my wife for everything else.

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ABSTRACT

The mineral status, hematologic and socioeconomic status of 55 apparently healthy parturient mothers resident in Northern Nigeria and their neonates were evaluated. The mineral status of 20 apparently healthy non-pregnant women of child-bearing age who served as the control subjects were simultaneously determined. Their mineral status was evaluated by measuring the serum concentrations of 5 trace and 2 macro-elements namely Fe,Cu,Zn,Mn,Cr and Ca Mg respectively while Hb and PCV served as the hematological parameters evaluated. Base-line data from the present study indicate that with the exception of Ca and Cu, the control subjects had adequate mineral status/ Although the parturient women had lower ($p<0.05$) Hb and PCV indices than the control subjects, it is evident from the study that mineral levels are in creased following pregnancy. The mean serum Fe, Cu and Ca concentrations of the control subjects were 82.00 ± 23.30, 6.67 + 4.88 ug\100ml and 8.62 ± 2.75 mg\100ml respectively while the maternal mean serum levels for the same elements were 149.18 ± 54.87, 125.47 ± 113.20 JJg/100ml.

and 11.90 + 3.30 mg/1OOml respectively. Fetal Fe, Cu and *Ca* levels were also 194.73 + 104.67, 110.32 ± 86.69 ug/1OOml and 12.3 + 3.98mg\100ml respectively. Regression analysis revealed significant (P< 0.05) positive association between Cu and Zn(r=o.713), and Zn and Mn(r=0.522) in the control Subjects. Age and Mg, Cu and Mn and PCV and Mg bore a onverse correlation in the maternal serum. With the Exception of Fe which bore a negative correlation, the maternal - fetal mineral interrelationships were positive for each element suggesting that maternal circulation is the main fetal source of the elements. Maternal age, Parity, hematologic and socioeconomic status had no significant (P>0.05) effect on the fetal mineral status. The various interrelationships evident between the numerous parameters in the present study are discussed.

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CHAPTER ONE

INTRODUCTION

The onset of pregnancy, which refers to the time of the attachment of one or more potential offsprings to the uterine lining, is a complex physiological process which imposes additional metabolic demands upon the gravid individual (Collins 1990). In developing countries, pregnancy is often repeated at frequent intervals and its nutritional stress may induce such classical deficiency diseases as anemia due primarily to iron deficiency. In some parts of the world, which includes Nigeria, pregnancy is known to occur at an early stage in life thus predisposing the immature mother to various health and nutritional hazards. The problem is further compounded by obstetric complications that accompany pregnancy such as toxemia of pregnancy which is characterized by *edema, proteinuria and hyertension* - gestosis (EPHG) which is speculated to be due to mineral deficiency.

Shaw (1980) reported a high incidence of maternal and neonatal mortality in developing countries and Naeye (1979) attributed this to maternal undernutrition. An interrelationship has therefore been reported between maternal nutritional status and pregnancy outcome (Naeye

1980 and Naismith 1981). Studies by other investigators have indicated that the incidence of low birth weight neonatal mortality and morbidity are higher in poor communities as compared with the more affluent ones (Lechtig et al 1975, Rush 1975 and Sibert et al 1978). The role of trace elements in human nutrition has long been recognized (SassKortsak and Sakar 1973, Hambidge 1976 and Solomons 1979). The concentrations of mineral elements in the human body for instance are variable and are characteristic for each element. It is therefore virtually important to maintain these concentrations and functional forms of these elements within narrow limits if the structural and functional integrity of tissues are to be safe guarded. Further, the prevalence of impaired growth, health and fertility of the individual would be minimized. However, continued ingestion of diets, or exposure to environments that are deficient, imbalanced or excessively high in a particular element may promote changes in the functioning forms, activities or concentrations of these elements. The consequences of such mineral imbalances include the development of biochemical defects (Some of which are known to occur at the very early stages of life), alteration of physiological functions and structural disorders.

Reports suggesting that trace element deficiences result in a number of physiological and structural abnormalities during infancy are well documented (Comline et al 1973, Henkin et al 1973, Rajalakshni and Srikantia 1980 and Mclaren 1981). Graham and Cordano (1969) for instance revealed the practical importance of copper deficiency in Peru where they observed that one-third of the infants studied had evidence of copper deficiency. Depressed activity of thymidine kinase a zinc-dependent enzyme has been reported. Swenerton et al 1969, and Hurley (1969) linked this to the teratogenic effect of maternal zinc deficiency in the rat. There is some evidence to suggest that human congenital malformations of the central nervous and skeletal systems may also result from maternal zinc deficiency (Hambidge et al, 1975). It is also believed that some of the basic problems of zinc deficiency occur at a very early stage of development (Hurley 1969). Tafari et al, (1977) and Appelbaum et al, (1979) ascertained that maternal zinc deficiency during pregnancy could lead to lack of antimicrobial activity in the amniotic fluid.

Poor nutritional status and other factors such as low income (Beal et al 1962, Parsons et al 1990 and Mutale et al 1991), high parity (Launer et al 1990), complications of pregnancy (Trimor-Tritsch et al 1988, Saunders et al 1990), biological

immaturity (under 17 years of age), infections and a history of unsuccessful pregnancies (Mclaren 1981) have also been pointed out as contributing factors to maternal and neonatal wastages.

In general, foods of animal origin which are generally expensive remain to be excellent sources of these minerals. Poverty hinders various population groups from consuming these expensive animal foods thus predisposing them to increased risk of specific trace element deficiencies. In order to delay or minimize the onset of these diet induced deficiencies which may have detrimental effect on maternal or neonatal development, it is important that the mineral status of the healthy gravid individual receive paramount attention. Since conception is a product of various hormonal changes accompanying pregnancy, it is evident that observations in nonpregnant individuals or pregnant laboratory animals may be inapplicable to the human gravid state. Although scattered studies have been conducted on vitamin status of pregnant Nigerian women, there appears to be no documented studies on the mineral nutriture of pregnant women resident in Northern Nigeria. It is against this background that the present study was designed to investigate the mineral status of Nigerian pregnant women at parturition and their cord blood. The specific aim

of the investigation includes:

(a) evaluation of the serum concentrations of seven mineral elements namely; iron, copper, zinc, manganese, chromium, calcium and magnesium with a view of establishing a baseline data.

(b) comparison of maternal and fetal serum mineral levels.

(c) identification of associations and interactions existing between the mineral elements studied in the blood circulation and

(d) postulation of models for such associations if need be.

It is expected that results from this investigation will give an insight into the mineral status of parturient mothers and their babies and may possibly be an index for providing solutions to mineral deficiencies in pregnancy.

CHAPTER TWO

REVIEW OF LITERATURE:

2.1. Pregnancy:

The onset of pregnancy is a complex physiological process which commences at puberty (Guyton 1981). The delivery of a new individual occurs at the moment when chromosomes from the male and female pronuclei associate to form the first mitotic figure of the first cleavage (Begley et al, 1980). However, Collins (1990) identified the onset of pregnancy to commence following the attachment of one or more potential offspring to the uterine lining and that this event is often dated in completed weeks from the first day of the last menstrual cycle (LMP). Furthermore, a natural pregnancy is dated as day 0 from the day of follicular rupture or that of Luteinizing Hormone (LH) peak based on the assumption that the life span of the ovum is short and fertilization occurs within the next 48hrs.

2.2. The menstrual Cycle:

The repoductive system of the female has long been known to show cyclic changes that may be regarded as periodic preparation for ovum production,

ovulation, fertilization and the maintenance of the resultant product of conception (Jones et al. 1989). These processes in turn have been reported to be under hormonal control (Guyton 1981) involving the estrogens and progesterone whose release is controlled by the follicle stimulating hormone (FSH). The commencement of the menstrual cycle is thus the development of ovarian follicle (Graafian follicle) under the influence of FSH. Subsequenctly, it is known that the follicular fluid contains increasing amounts of estrogen which is eventually released into the circulation where it subsequently reaches the hypothalamus to initiate and maintain the signs of estrus. The physiological events from the beginning of one menses to the next is what is known as the menstrual cycle. It has been established that the duration of this cycle is approximately twenty-eight days with a range of 24-35 days. It has also been established (Guyton 1981) that the last two days to the end of the cycle witnesses a sharp decrease of the ovarian hormones (estrogen and progesterone) which subsequently cummulates into a chain of physiological events that finally lead to the shedding of about 40ml of blood and an additional 35ml of serous fluid in a normal menstruation.

2.3. Ovulation

At a point during the menstrual cycle an ovum is released from the ovary (ovarian follicle) and is transported to the top half of the oviduct a region that has been identified as the ampulla. In humans, ovulation has been known to occur at about the 14th day of a 28-day cycle. Schiphurst et al (1985) have however, reported a variation in ovulation time from 12 to 25 days from day 1 of menses which occurs even in women whose menstrual cycles are regular.

A peaking of estrogen blood levels leading to the eventual decrease of FSH and a rapid release of LH has been ascribed to the physiological process of ovulation (Guyton 1981). These events have been known to bring about follicular rupture which releases an ovum or ova into the finbrinated end of the oviduct. In the ampulla, the ovum is known to remain viable only for some hours usually about 12-24 hrs during which time fertilization must occur otherwise it disintegrates and is reabsorbed by the body.

2.4. Fertilization:

It has been established (Jones et al, 1989) that sperm introduced into the female genitalia during coitus meets the ovum at the ampulla where fertilization occurs. However, it has been

reported (Guyton 1981) that the fertile life span of spermatozoa is uncertain but that generally spermatozoa maintain their fertility for at least 48 hrs and possibly 72 hrs under favourable conditions. Further, the transport of sperm into the uterus is facilitated at the time of ovulation by the presence of copious watery mucus which allows easy passage of sperm through the cervix into the uterus and subsequently the oviduct. It is known that capacitation of spermatozoa takes place in the oviduct to make them capable of fertilization.

Following fertilization, it has been established (Collins 1990) that peristaltic and ciliary movement of the oviduct transport the ovum to the uterus. This process is known to occur at about 5 days after follicular rupture and the pre-embryo is known to enter the uterus as a morula (16 cell stage). Lichtig et al, (1988) reported that the changes in vascularity and decidual formation results to the thickening of the endometrium and implantation of a blastocyst, a physiological process which occurs after 7-9 days following follicular rupture. It has also been known that following implantation, the fetal-maternal complex also provides its own gonadotropin - placental gonadotropin referred to as human chorionic

gonadotropin (HCG). Twelve days after implantation HCG concentration is observed to increase significantly in the maternal circulation. Subsequently, amniotic fluid, yolk sac and primitive streak are formed. Trimor-Tirtsch et al, (1988) have reported that between the 3rd and 4th completed weeks after follicular rupture fetal heart beat becomes detectable.

The signs of early pregnancy are based on a combination of physiological signs and symptoms which include missed menses, early morning sickness, (nausea and vomiting), breast tenderness and weight gain (Collins, 1990). The reasons behind these signs and symptoms are not properly documented.

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2.5. Parturition:

Parturition refers to the process by which the baby is born. According to Guyton (1981) the uterus has been known to experience strong rhythmic contractions at the end of pregnancy which is known to be the major force that finally expels the baby out. These contractions in turn are under hormonal control and the hormones responsible are estrogen, progesterone and oxytocin.

Further, the onset of labour has also been linked (Guyton 1981) to the periodic contractions

of the uterus which progressively become stronger toward them, then suddenly change within hours to become exceptionally strong contractions. In the early part of this process, the contractions are known to occur about once every 30 minutes and as labour progresses, they appear as often as once every one to three minutes. Toward the end of pregnancy the cervix has been observed to soften and the period during which the cervix is progressively dilated is known as the first stage of labour which lasts 8-24 hrs in the primigravidae but often only a few minutes in the multiparous. The time during which the fetus traverses the birth canal having passed the cervix is referred to as the second stage of labour and may last from as little as a minute in the multigravidae and up to half an hour or more in the first pregnancy. These processes are often accompanied by considerable pain and are referred to as labour pains. Lastly, the third stage of labour refers to the time the placenta is expelled out.

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2.6. Complications of pregnancy:

Isichei and his colleagues (1978) in their study of serum and urine electrolytes in primigravid Africans during pregnancy reported a tendency toward toxemic symptoms as a fairly frequent complication of pregnancy. This syndrome

is characterized by edema, urinary protein loss and high blood pressure.

Crowther (1990) also reported eclampsia as one of the complications of pregnancy in most countries and that it remains one of the major causes of both maternal and perinatal mortality. Gibb (1990) and Dommisse (1990) reported that the condition occurs much more frequently in developing countries.

Numerous investigators have suggested calcium supplementation as a therapeutic means of decreasing the incidence of eclampsia (Kawasaki et al. 1985, Villar et al, 1987 and Lopez-jaramillo et al, 1989). Crowther (1990) in a recent study also reported the effectiveness of magnesium sulphate in the management of eclampsia.

2.7. Maternal Nutrition in Pregnancy:

A vast body of literature exists stressing the importance of adequate maternal nutrition during pregnancy. However, there exists differences in opinion as to the rationale for increased dietary intake during pregnancy. While some investigators have failed to identify a rationale for increasing the habitual dietary intake by pregnant women (Delgado et al, 1977, Thomason and Hyllen 1977, Widdowson 1981 and Hytten 1990). Others (Robertson 1980, Mclaren 1981 and

Naismith 1981) reported fetal demands as an overriding factor that necessitates increased dietary intake for women during pregnancy. Darby (1977) in support of this view argued that the need for increased requirements of all nutrients for gestating and lactating mothers is precipitated by culture, maternal size, the level of physical activity maintained, reserves of nutrients with which the mother enters pregnancy and a variety of other sociocultural, environmental and economic factors associated with pregnancy. Rosso (1977) also observed that in order to meet the higher requirements of pregnancy, increased food consumption which is paralleled by an increase in body size, is one of the adaptive changes undergone by the gestating woman. Similarly, Van Tha (1975) in a study of the impact of nutrition on pregnancy and lactation observed that poorly fed pregnant women were more disposed to pregnancy complications. Dapoz et al (1981) also reported increased average food consumption during the first six months of gestation which decreased in the third trimester with caloric intake being lower at the end of pregnancy compared with the pre-pregnancy period. In an attempt to justify the need for increased nutrient consumption during pregnancy, Robertson (1980) observed that dietary protein

insufficiency during pregnancy results in fetal growth retardation. A high dietary allowance has therefore been recommended for pregnant women (Darby 1977). Present recommended daily allowances (RDAs) suggest that caloric increments of 20 and 30mg/day respectively is required for pregnancy and lactation. Further, percentage increments for other nutrients during pregnancy include 20-50% for vitamin A, 50% for calcium and 50-100% for folacin. The increments in most other vitamins and minerals being in the range of 25-40% above those allowances for non-pregnant women (See Table 1).

2.8 Maternal Weight gain in Pregnancy:

It is customarily observed that pregnancy is associated with weight gain with the primigravidae gaining relatively more weight than the multigravidae (Hytten and Leitch 1971). They however, inferred that within the limits of ordinary hospital experience there is no extreme reached which has been shown to be incompatible with a satisfactory reproductive performance. McClaren (1981) reported an average weight gain during normal pregnancy of about 10.9kg which is ascribed to the fetus as contributing (3.5kg), the placenta (0.65kg), amniotic fluid (0.8kg), the uterus (0.9kg), breasts (0.4kg), interstitial fluid (1.2kg), maternal blood (1.8kg) and 1.6kg for

e 1. Food and Nutrition Board, National Academy of Sciences-National Research. Good Nutrition of practically all healthy people in the U.S.A RDA

	Age(yrs)	Weight (kg)	Height (cm)	Energy (kcal)	Protein(g)	Fat Soluble Vitamins: Vit A (iu)	Vit D (iu)	Vit E (iu)	As.Acid(mg)	Water Soluble Vitamins: F. Acid(mcg)	Niacin(mg)	Riboflavin(mg)	Vit.B6(mg)	Vit.B12(mg)	Thiamin(mg)	Minerals: Ca(mg)	P(mg)	I(ug)	Fe(mg)	Mg(mg)
ants	0.0 - 0.5	c	60	kg x 117	kg x 2.2	420	1400	400	4	35	50	5	0.4	0.3	0.3	0.3	3	360	240	35	10	60
ales	11 - 14	44	155	2400	44	800	4000	400	12	45	400	16	1.5	1.2	1.8	3.0	15	1200	1200	115	18	300
	15 - 18	**54**	**162**	**2100**	**46**	**800**	**4000**	**400**	**12**	**45**	**400**	**14**	**1.4**	**1.1**	**2.0**	**3.0**	**15**	**1200**	**1200**	**115**	**18**	**300**
	19-22	58	162	2100	46	800	4000	400	12	45	400	14	1.4	1.1	2.0	3.0	15	800	800	100	18	300
	23- 50	58	162	2000	46	800	4000		12	45	400	13	1.4	1.1	2.0	3.0	15	800	800	100	18	300
nant				+300	+30	1000	5000	400	15	60	800	+2	+0.4	+0.3	2.5	4.0	20	1200	1200	125	18	450
ating				+500	+20	1200	6000	400	15	80	800	4	+0.5	+0.3	2.5	4.0	25	1200	1200	150	18	450

maternal fat storage. Moller et al. (1989) however, reported a maternal weight increase of 6.0kg for Tanzanian women.

Existing reports have indicated that a unique relationship exists between birth weight and maternal weight gain. Lawton et al (1988) for instance have observed a significant association between birth weight and maternal weight gain while Dawes and Grudzinskas (1991) failed to confirm this assertion. Dawes and Grudzinskas (1991) have also shown that weekly weight gain and maternal size at booking significantly affect fetal weight.

2.9 Mineral Nutriture during Pregnancy:

Dietary requirements of trace elements are small and their distribution is wide spread in the environment. However, Hambidge and Droegemueller (1974) have observed that the risk of trace deficiency is no exception to the increased demand for nutrients imposed on the pregnant woman. Some investigators were quoted for instance, to have reported sub-optimal intakes of zinc in pregnant women. The roles of some trace elements in a viable pregnancy have been documented. Hambidge and Droegemueller (1974) have, for instance, quoted other investigators as reporting from animal studies that as adequate supply of zinc to the mother in the third trimester of pregnancy is

required for the maintenance of the fetus to term. In contrast, other investigators were quoted as reporting elevated plasma copper levels during pregnancy. This phenomenon has been partly associated to the elevations in estrogen and progesterone concentrations of pregnant women. Other investigators (Robertson 1980) observed that iron deficiency characterized by a decline in hemoglobin and serum iron concentrations is prevalent in pregnant women belonging to both the non-affluent and the affluent communities. However, the need for mineral supplementation in pregnancy has not been validated. Although some investigators have ascribed the decrease of hemoglobin level to Fe depletion which must be augmented (Apted and Iyangar 1970 and Mclaren 1981) by Fe supplementation, others (Fentom et al. 1977, Murray et al. 1978 and Southon et al, 1989) consider this phenomenon as being a normal physiological adjustment.

Shenolikar (1970) has reported that adults require a habitual dietary intake of about 400-450mg/day to be in a state of positive calcium balance. He however, observed that the diets of pregnant women belonging to the low income groups provide between 259 and 374mg Ca/day and that regardless of the amount of dietary intake of calcium, negative Ca balance is a common occurrence

during the first stages of pregnancy. Allen et al. (1979) reported that the consumption of protein reduces the amount of Ca reabsorbed by the kidney. Wide-Swensson et al, (1990) have indicated that calcium deficiency during pregnancy is a possible etiologic factor of toxemia of pregnancy.

Underwood (1981) reported that magnesium is widely distributed among plant and animal tissue. Henry (1973) also indicated that there exists in man efficient homeostatic mechanisms for Mg such that low intakes of less than 4 percent of the normal intake can maintain balance of the element. Prasad (1978) however, reported low levels for serum Mg in normal and in abnormal pregnancies.

According to Robertson (1980) existing evidence does not warrant generalized trace element supplementation of the usual mixed diet during pregnancy.

2.10 Fetal Nutrition in Pregnancy:

Rosso (1977) reported three basic mechanisms for maternal-fetal transfer of nutrients to ensure that fetal nutritional needs are met during pregnancy. These include:-

i. maternal transfer of nutrients to the blastocyst which is presumed to occur through the outer layer of cells otherwise referred to as trophoblast during the pre-implantation phase;

ii. maternal transfer of nutrients to the sinusoidal space that is formed between the fetal and maternal side prior to placental formation following implantation and

(iii) maternal transfer of nutrients to the fetus via the placenta following its development.

The placenta thus plays a central role in pregnancy with primary functions of nutrient transfer to the fetus and the induction of certain metabolic changes in the mother that are essential for fetal survival and well being,

Widdowson et al, (1974) ascertained that trace elements must be available to the fetus early in gestation for normal development. For instance, copper and zinc which are essential trace elements are recognized as being required for normal growth and development where Cu is known to play a vital role in the development for protein synthesis (Henkin et al. 1971).

2.11. The Placenta:

The placenta has been defined as a connecting tissue or structure developed by the embryo to anchor itself to the wall of the uterus in order to procure nutrients from the maternal blood (Hytten and Leitch 1971). Begley et al. (1980). have reported that the offspring can be fed, but also

protected.

It is well established that normal growth and development of the fetus is only possible if there is adequate placental exchange of nutrients, oxygen and metabolic waste (Robertson 1980). Further, the penetration of substances such as salts, nutrients and macromolecules which are exchanged or accumulated relatively slowly by the fetus is limited by the barrier characteristic of the placenta. In contrast, the rate of placental blood flow is the most important limiting factor for highly diffusible substances such as the blood gases. Lunell and Sarby (1978) have observed that the utero-placental blood flow increases throughout pregnancy. They linked the increase to the physiological dilation of the utero-placental arteries, resulting in a reduced vascular resistance. These workers further stated that the maternal blood reaches the placenta mainly through the uterine arteries. These are known to divide into myometrial branches (radial arteries) which further subdivide into decidual arteries terminating in the intervillous space. The maternal blood circulating through this space exchanges gases and nutrients across the trophoblastic and capillary layers of the placenta to the fetal circulation.

2.12. Placental Transfer of Nutrients:

Existing evidence (Robertson 1980) indicates that placental nutrient transfer from mother to fetus is accomplished via four basic transfer mechanisms. These include :

i. simple diffusion; the transport system for the transfer of sodium, potassium, pyridokine and the fat-soluble vitamins;

ii. facilitated difusion the established transport system for placental transfer of glucose the primary fetal source of energy.

iii. active transport; mediating amino acids, water-soluble vitamins, calcium and magnesium transport into the fetal circulation and

iv. placental synthesis. This is the mechanism employed in cholesterol and fatty acid transportation to the fetus as they are believed to be synthesized in the placenta and subsequently supplied to the fetus. Widdowson (1981) in a comprehensive review indicated that only non-seruloplasmin copper crosses the placenta as the fetal serum generally contains no ceruloplasmin. He also ascertained that only amino acid-bound Zn may be the source of fetal Zn via the placenta. Zinc transport is believed to occur via active transport due to high fetal Zn concentration observed in neonates relative to maternal levels.

2.13. Placental Weight:

It is well established that obstetric and gynecological precautions following conception involves accurate measurement of placental weight (Hytten and Leitch 1971). The procedure employed in weighing the placenta however, is rather a routine by delivery room staff and consequently there is no special preparation before the weight is recorded. Hytten and Leitch (1971) reported that on the average male babies have slightly higher placental weight than female babies. The basis of such measurement may not be unrelated to speculations of some investigators that the relationship between fetal growth and maternal size may be evaluated from the size of utero-placental circulation and possibly the placental itself. They further observed that fetal and placental weights are positively associated with sex, parity and gestational groups.

2.14. Fetal Birth Weight:

i. Length of Gestation: Fetal age has been indicated to be of primary importance in the determination of the weight of the fetus. According to Hytten and Leitch (1971) at any age there exists a wide range of fetal weights whereby an infant may be more than twice as heavy as another of the same gestational age. They related

this finding to the genetic potential of the mother. Maternal characteristics are therefore viewed as dominating fetal growth pattern.

Fetal age begins from the time of fertilization. The average "gestational" age (Hytten and Leitch 1971) for the normal full-term baby is thus 280 days at birth (40 weeks or 10 lunar months).

ii. Sources of Variation in fetal growth and birth Weight: A number of factors have been reported to affect birth weight (Lechtig et al., 1975. Prentice et al, 1983, Brooke et al., 1989, Morrison et al. 1989, Hytten 1990, Oakley et al., 1990 and Mutale 1991). These include maternal nutrition, parity and the sex of the infant. Conflicting reports exist in literature as regards the interrelationship between maternal nutrition and birth weight. For instance, Lechtig et. al. (1975). and Prentice et al. (1983) independently reported a relationship between maternal nutrition and birth weight. Naeye (1980) is however, of the opinion that only fetuses of thin mothers depend on maternal nutrient intake during pregnancy. In more recent studies (Brooke et al. 1989), Morrison et al. 1989 and Hytten 1990) failed to observe such a relationship. Camilleri and Gremona (1970) have however observed that the average male infants are

heavier than their female counterparts and first babies are lighter, on the average, than subsequent ones. Hytten and Leitch (1971) partly attributed the sex difference to the genetic constitution of the product of conception most especially when the fetal sex hormones begin to have effects on growth. Mutale et al. (1990) also revealed that a previous low birth weight and bleeding during pregnancy were significant predictors of low birth weight. Oakley et al (1990) reported that social support improves maternal and infant well being which includes birth weight. Launer et al (1990) observed that mothers engaged in manual work run the risk of a small-for-gestational age (SGA) births. Dawes and Grudzinski (1991) also reported that in addition to maternal gestation, age, smoking habit and parity, weekly weight gain and maternal size at booking are other factors that may affect fetal birth weight. Present evidence, however, finds to suggest that low birth weight (<2.5kg) of neonates is associated with high risks of infant mortality and morbidity (Sagen et al, 1984 and Saunders et al, 1990).

2.15. Minerals in Human Nutrition:

Existing evidence reveals the importance of trace- and macro-elements in human nurition and reports suggesting that trace element deficiences

can lead to imppaired growth during infancy and childhood are also available (Hurley 1979 and Rajalakshni and Srikantia 1980). Hambidge (1976) has emphasized the importance of adequate quantities of trace elements in infant nutrition. He further revealed that some of the effects of deficiency states of these micronutrients in infants include anemia, neutropenia anemia, osteoporosis, impaired appetite and growth retardation.

2.16. Sources:

Food of animal origin provide the best dietary sources of many of the trace elements. For instance, Underwood (1977) reported that the liver and spleen usually contain the highest concentrations of iron followed by the kidney, heart, skeletal muscles and the brain. Similarly, the richest sources of copper in human dietaries are crustaceans and shellfish especially oysters and the organ meats such as lamb or beef liver. Appreciable quantities of Cu have also been reported in nuts and legumes; chromium is also obtained from the liver and the kidney and to a lesser extent from lean meats, although the highest concentrations are found in spices. The highest Mn levels occur normally in nuts and whole cereals, variable amounts in vegetables and low

concentrations in meat, fish and dairy products. The richest sources of Zn are also oysters and to a lesser extent other sea foods and the muscle meats. Calcium is best obtained (Latner 1975) from milk and milk products and also from green vegetables while Mg is obtained from the following foods in decreasing order of concentration (Prasad 1978) nuts, cereals, seafoods, meat, legumes, vegetables, dairy products, refined sugar and fats.

2.17. Metabolism:

Trace and macroelements have one or more specific biologic functions which are vital to a wide variety of metabolic processes. In the body, they occur either as components of body fluids or exist as cofactors in enzyme systems or as an integral part of metalloenzymes.

The metabolism of iron has been effectively studied (Prasad, 1978). The homostasis of iron for instance, is known to be maintained primarily by the adjustment of iron absorption because of the body's limited capacity for its excretion. Further more, its absorption is known to be dependent on upon a number of factors such as age, iron status and the individual's state of health; gastrointestinal tract conditions, the amount and chemical form of the ingested iron and the amounts and proportion of various organic and inorganic

dietary components. According to Hazzel and his co-workers (1978) iron is better absorbed from animal food stuff than from inorganic sources. Ascorbic acid, fructose and sorbitol have been reported (Underwood 1977) to enhance ferrous iron absorption, high levels of phosphates, phytates, cobalt, zinc, cadium, copper and manganese interfere with its absorption through competition for absorption binding sites. However, increased iron absorption has been documented in iron deficiency, hemolytic anemia, pernicious anemia and other disease states associated with increased erythropoiesis. Furthermore, iron absorption in children is about twice that of adults.

According to Underwood (1977) iron is poorly excreted by the body but the losses are of nutritional significance . For instance, the total amount of Fe lost via urine, feces and sweat is about 0.6 - 1.0mg/day in most individuals. In addition to losses through these routes, women are subjected to regular losses of Fe via the menstrual blood. In pregnancy, considerable iron loss is also evident during parturition while important losses are also incurred through breast feeding.

Absorbed iron is continually redistributed throughout the body in an intricate process involving the hemoglobin shunts (Prasad, 1978).

The incorporation of iron into ferritin occurs rapidly and requires energy-yeilding reactions through which ATP is produced which together with ascorbic acid reduce the ferric iron of transferrin to the ferrous state. However, the reverse process, the release of iron from hepatic ferritin to the plasma has been known to be mediated by the molybdenum and iron-containing enzyme Xanthine oxidase which acts as a dehydrogenase (Osaki et al, 1966). Further, these investigators reported that ceruloplasmin, a ferroxidase; is also essential for mobilization of iron from its store.

The metabolism of Cu has been fairly defined. THe absorption of Cu for instance is known to occur in the stomach and all parts of the small intestine, particularly the upper small intestine (Underwood, 1977). The absorption, is however, poor from diets of most species. The extent of this absorption is influenced by the amount and chemical form of Cu ingested, the dietary level of several other metal ions and organic substances and the age of the animal. For example, several inorganic dietary factors markedly affect Cu absorption, retention and distribution within the body. These include particularly calcium, cadmium, zinc, iron, lead, silver, molybdemum and sulphur. Widdowson et al (1974) reported that copper forms stable

complexes with many organic molecules in the tissues and blood. In the serum, copper is bound to plasma proteins but more loosely bound to albumin and amino acids.

The excretion of Cu occurs mostly in the bile, the feces and urine (underwood, 1977). Negligble amounts are however, excreted via the sweat gland while comparatively small amounts are lost in the normal menstrual flow. There is no evidence to suggest that the loss at the peak of lactation imposes any nutritional stress although the loss may amount to about 0.40 mg Cu/day.

It has been reported (Underwood, 1977) that variable excretion rather than variable absorption is the regulator of Mn homeostatis. However, the absorption of Mn takes place equally throughout the length of the small intestine with Mn competing with Fe and Co for common binding sites. It is apparent that the absorption mechanism of Mn and Fe are similar but they have different excretory processes. The availability of Mn is further influenced by the levels of calcium in the diet. High Ca levels have been indicated to affect Mn metabolism by altering the absorption and retention patterns of Mn in the body. Further, its availability is influenced by estrogens and adrenocortical hormones.

Under normal conditions the bile flow is the

main route of excretion. Excretion may also occur via the pancreatic juice, the duodenum, jejunum and to a lesser extent in the terminal ileum. Very little manganese is excreted in the urine.

The trace element chromium, has been identified as an important nutrient in intermediary metabolism. Prasad (1978) cited some investigators who indicated that the absorption of inorganic Cr is poor in man and animals regardless of the dose and the dietary Cr status. Yet little is known about the site of or mechanism of chromium absorption. This may be attributed to the lack of *in vivo* studies of Cr absorption. Existing data, however, tend to indicate that the natural complexes in the diet are better available than simple chromium (Prasad 1978).

It appears that the excretion of Cr is mainly by the kidneys.

According to Hahn and Evans (1975) the homeostatic control of body zinc in accordance with body needs is achieved in part through the regulation of its absorption. The extent of zinc absorption has been known to vary with its level and with the range of other dietary components.For instance, zinc from animal protein is more available for absorption, whereas certain dietary components , such as phytate, fiber and metals such

as Cu and Ca decrease zinc absorption (Underwood 1977).

The major excretory route of zinc is also reported to be via the feces. The excretory zinc pool is derived from both the unabsorbed metal and through losses from the intestinal mucosa, bile and pancreatic secretions. Zinc excretion has also been shown to occur via urine and sweat.

Shroeder (1973) reported efficient homeostatic mechanism for magnesium and calcium. The organs controlling the homeostasis of Mg and Ca are the intestinal tract and the kidney. The coordinated excretion of excess Mg or retention when intakes are low is conducted by the kidney and this is so efficient that less than 4 percent of the normal intake can maintain balance.

The majority of absorbed Mg is excreted by the kidney while the unabsorbed fraction appears in the feces. Magnesium is also excreted through sweat glands (Prasad, 1978).

The metabolism of calcium within the body is well documented. Prasad (1978) reported that Ca is actively absorbed in the small intestine. About 25 - 75% of the consumed Ca have been shown to be excreted. Underwood (1981) observed that irrespective of the forms in which Ca is ingested its solubility at the point of contact with the absorbing membranes determines its absorption. Thus

acidic medium, fatty acids, vitamin D and lactose all favour Ca absorption. While oxalates, phytates and excess phosphorus inhibit Ca absorption. These inhibitors bind to the divalent Ca forming insoluble Ca-complexes thereby preventing its absorption.

2.18 Functions

The metabolic role of minerals in human nutrition cannot be overemphasized. According to Underwood (1981) iron is present in hemoenzymes-cytochromes where it plays a unique role in cellular processes that involve oxidative mechanisms. Iron is also known to play a greater quantitative function in oxygen transport as part of the hemoglobin molecule. In hemoglobin, iron is stabilized in the ferrous state which reversibly binds oxygen thus functioning as an oxygen carrier. Furthermore, the relationship of iron to basic biochemical processes in the tissue was revealed by the discovery of its presence in flavoprotein enzymes.

Sas-Kortsak and Sarkar (1973) ascertained that Zn and Cu are involved in cell and tissue growth where zinc is reported to play an important role in DNA and protein synthesis as well as being intimately involved as a cofactor in several impor-

tant enzyme systems. These include carbonic anhydrase, carboxypeptidases, alkaline phosphatase and alcohol, lactic and glutamic dehydrogenases. Copper is involved in the mylenation of nerves, the synthesis or metabolism of steroid hormones as well as being a cofactor in several important enzymes. For example, ceruloplasmin, is an important ferroxidase that facilitate the release of iron from iron stores by oxidizing ferrous iron Fe^{2+} to ferric iron Fe^{3+} prior to its incorporation into transferrin. Cytochrome c oxidases involved in the cytochrome chain contain Cu and being electron donors catalyse the reduction of molecular oxygen to water. Lysyl oxidase is a copper -containing enzyme involved in the cross-linking of the peptide chains of collagen and elastin while tyrosinase catalyses the first steps in the synthesis of melanin the absence of which results in albinism (Shaw 1980).

Shaw (1980) has also reported the presence of Mn in a few metalloenzymes which include pyruvate carboxylase and mitochondrial superoxide dismutase. Manganese is also known to activate a number of enzymes particularly glcosyltransferases involved in the synthesis of polysaccharide and glycoproteins. Underwood (1977) also reported the involvement of manganese in the biosynthesis of cholesterol where it increases cholesterol synthesis.

Two sites have been defined that require Mn for this purpose which are acetate and mevalonate. Further, fernesylpyrophosphate synthetase is now known to require Mn and the two react together to add 5-carbon unit to geranyl pyrophosphate to make fernesylpyrophosphate.

Lack of fernesylpyrophosphate could inhibit squalene production an important cholesterol precursor.

Prasad (1978) observed that the role of chromium remains unknown except in the form of glucose tolerance factor (GTF) which is a naturally occurring organic chromium complex. The only recognised physiologic role for chromium is as a cofactor for insulin where trace quantities of Cr are required for the optimal effect of insulin.

According to Underwood (1981) magnesium is greatly involved in carbohydrate and lipid metabolism as a catalyst of a variety of enzymes that require Mg for their activity. These include reactions such as cellular oxidation, i.e. oxidative phosphorylation leading to ATP formation; Mg also activates the enzymes that oxidises pyruvate and convert a-ketoglutarate to succinyl CoA; and also catalyses most phosphate transfers, including alkaline phosphatase, hexokinase and deoxyribonuclease. Further evidence exist that Mg

catalyses the transketolase reaction of the pentose monophosphate shunt. Magnesium ions are also known to exert a potent influence on neuromuscular activity where low levels induce tetany.

Robinson (1973) observed that apart from being a component of bones and teeth, calcium in body fluids functions as a catalyst for the conversion of prothrombin to thrombin one of the steps in the clotting of blood; it also increases the permeability of cell membranes and activates a number of enzymes such as lipases, adenosine triphosphate and some proteolytic enzymes; it plays a role in transmission of nerve impulses; and it is directly involved in muscle contraction.

2.19 Deficiency and Toxicities.

Marginal or deficient intakes of adequate minerals in diets have been indicated to precipitate deficiency of these nutrients (Prasad 1978). Similarly, mineral toxicities which may be classified as acute or chronic toxicities have equally been observed in cases of exposure to excesses of these elements (Underwood 1977).

The clinical manifestation of iron deficiency in human adults are listlessness and fatigue, sometimes a sore tongue, angular somatitis, dysphagia and koilonychia. In children anorexia depressed growth and decreased resistance to

infection are commonly observed (Underwood 1977). Iron deficiency is further observed to result to an anemia of the hypochromic microcytic type accompanied by normoblastic , hyperblastic bone marrow containing little or no hemosiderin. Iron deficiency anemia has also been associated with decreased serum iron and serum ferritin concentrations.

Unlike iron requirement levels, data which permit the delination of toxic levels of Fe are not available (Underwood 1977). However, long term toxicity has been observed in malnourished Pantus in South Africa (Bantu siderosis).

Hambidge (1976) observed that Cu deficiency is characterised by an anemia promoted by the absence of ceruloplasmin the copper -containing feroxidase required for hemogenesis. Other symptoms include defective blood vessels which rupture easily due to lack of the Cu enzyme amine oxidase required for the cross-linkage of elastin and collagen. Cavel and Widdowson (1964) also observed that Cu deficiency also manifests in skeletal lesions as a result of lack of amine oxidases and ascorbic acid oxidases. Tyrosinase is also another Cu-containing enzyme whose absence leads to impaired melanin synthesis. However, deficiency of Cu is very rare (McClaren 1981).

Graham and Cordano (1969) however, have reported hypocupremia in malnourished children especially if fed exclusively on milk. Widdowson et al,(1974) observed that on the contrary healthy term infants do not appear to be at risk of Cu deficiency even if fed with relatively low-copper milk products because of the large hepatic Cu stores. However, in contrast to the term infant, they observed that the premature infant does not start postnatal life with adequate Cu stores. In the infant, Al-Rasheed and Spangler (1971) reported neutropenia and anemia that is unresponsive to oral Fe therapy as early manifestation of Cu deficiency in infants.

Mcclaren (1981) observed that acute poisoning results from the ingestion of grams of copper which is usually consumed as copper sulphate. Chronic toxicity results to Wilson's disease or hepatolenticular degeneration which is usually hereditary.

Very little is known about manganese deficiency in man. Doisy (1974) proposed that Mn deficiency and hypocholesterolemia are probably related and that marginal or deficient intakes may reduce the biosynthesis of steroids and sex hormones. Shaw (1980) observed that the only reported case of Mn deficiency in man precipitated mild dermatitis, slight reddening of hair and depressed vitamin K-dependent clotting factors.

However, animal studies have revealed that the manifestation of Mn deficiency, namely, impaired growth, skeletal abnormalities, disturbed or depressed reproductive function, ataxia of the neonate and defects in lipid and carbohydrate metabolism, are displayed in all species studied (Underwood 1977).

Shaw (1980) reported that chromium deficiency in animals is manifested by impaired glucose tolerance with fasting hyperglycemia, impaired growth, corneal opacities, hypercholesterolemia and glycosuria. Chromium particularly trivalent chromium has a low toxicity. A wide margin of safety exists between amounts usually ingested and those likely to induce adverse effects (Prasad 1978).

Conflicting reports exist about the consequences of maternal zinc deficiency during pregnancy. Tafari et al, (1977) and Applebaum et al (1979) could not find the consequences of maternal dietary deficiency of zinc levels in fetal organs.

However, they observed that such deficiency may lead to lack of antimicrobial activity in the amniotic fluid. On the other hand, Hambidge et al,(1975) observed that evidence exist to suggest that human conginetal malformations may result from maternal zinc depletion. They further observed that

in animals, postnatally, anorexia, impaired food utilization and growth failure are prominent features of zinc deficiency. Zinc is also required for the development of the immune system and for sexual maturation (Prasad 1978). Animal studies have also shown that zinc deficiency during perinatal life rather than the growth period has very striking effects on the development of the embryo (Hurley 1979). Sandstead et al (1975) reported that brain growth of neonate is adversely affected by maternal zinc deficiency in the rat.

McClaren (1981) ascertained that zinc poisoning results to vomiting and diarrhoea but that this is usually associated with the intake of large amounts of zinc by the ingestion of an acid food or drink from a galvanized container.

Prasad (1978) reported that despite the low contents of dietary Mg under some circumstances, magnesium deficiency does not occur in humans with healthy kidneys. However, there are manifestations of magnesium deficiency under some conditions. Depending on the severity and duration of the deficiency the symptoms include muscular twitching and tremour of any or all muscles, including the tongue, muscle wasting and weakness. Others are numbness and tingling, convulsions, sweating depression, poor memory, mild to severe delirium (confusion, disorientation, hallucinations and

paranoia) comma and death.

Infants born to mothers having received $MgSO_4$ treatment for eclampsia are at risk of developing intoxication manifested as depression and hypotonia (Sokal et al (1972).

Clinical manifestation of disturbances of calcium metabolism are reflected in abnormalities of serum calcium, skeletal mineralization and certain neuromuscular disorders. The factors of greatest importance to calcium homeostasis are those concerned with its absorption, deposition in and mobilization from the bone and its excretion by the kidneys (McClaren 1981).

Further, it has never been proved that dietary intake of Ca in man is harmful. However, adverse effects of excessive intake of Ca seem to be limited to its influence upon utilization of other nutrients especially Mg, Fe, Zn and Mn.

2.20 Requirements

The nutritional requirements for all nutrients can be defined as the optimum level of nutrients required by an individual at which the risk of deficiency is overcome. Although trace elements are generally required in small amounts , available reports (Prasad 1978) have indicated that the demands for iron by the body are greatest during three periods. These consist of the first two years

of life, the period of rapid growth and hemoglobin increase of adolescence, and throughout the child-bearing age in women. The physiological requirements of the infant for iron averages approximately 0.6mg/day (Underwood 1977) but may be so high as 1mg/day during the first two years of life. Further, at age 15 - 16 years in the male the requirements increases temporarily due to the rapid growth and accretion of hemoglobin that occurs following the characteristic growth spurt in adolescence. About 2mg/day of iron has to be absorbed if the needs of 95 percent of normal menstruating women are to be met.

Similarly, about 2 - 5 mg Cu/day is considered adequate to maintain a positive Cu balance in older children and adults. However, adequate copper intakes is difficult to ensure in infants who have been calculated to require at least 50ug Cu/kg of body weight/day. Hambidge (1976) observed that in spite of the supplementation of infant formulae with copper, the optimal copper concentrations of formulae fed to premature infants have not been defined. Underwood (1977) concludes that because of the influence of other mineral elements on copper absorption a series of Cu requirements exists which are dependent upon the extent of such factors and on the criteria of sufficiency employed. Similarly,

he reported a variation of manganese requirements with the species, the chemical form in which the element is ingested and the dietary composition. Zinc requirements are observed to follow the same trend but in addition depends on the temperature where excessive temperature may be a contributory factor. The chromium requirement has however, not been defined.

Latner (1975) puts the adult daily Ca requirements at about 0.45g but observed that the recommended allowance is 1.0g (10 - 15mg/kg body weight), increasing to 1.5g or more during pregnancy and lactation. Growing children are reported by him to require about 45mg/kg body weight.

CHAPTER THREE

MATERIALS AND METHODS;

3.1. Chemicals:

Potassium cyanide was supplied by Sigma chemical company, U.S.A., potassium ferrocyanide, sodium bicarbonate, lanthanum chloride and nitric acid were supplied by BDH chemicals, Poole, England. Trichloroacetic acid was supplied by Hopkin and Williams, England. All other chemicals used were of analytical grade.

3.2. Subjects:

Fifty-five apparently healthy normal pregnant women and their resulting offsprings served as subjects for this study. All deliveries were taken at the Ahmadu Bello University Teaching Hospital, Zaria. Clinically, each pregnancy and delivery was uncomplicated, single, vaginal and at term. The socio-economic status of these parturient women was assessed based on their average family income, academic standard and occupation. Detailed information which includes age, parity, whether or not such patients had been attending antenatal clinics, and the average annual income of the family were obtained via a questionnaire. Similarly, twenty apparently healthy non-pregnant women of child-bearing age selected from the Ahmadu Bello University (Samaru Campus) and Samaru village

served as controls.

3.3. Birth Weights:

Birth weights of infants were obtained from hospital records. The weights were measured on carefully adjusted infant scale according to standard hospital procedure as reported by Murray et al, (1978).

3.4. Collection of blood Samples:

Blood samples for the determination of hematocrit and hemoglobin concentrations and mineral analysis were collected from the mothers by veinipuncture. Fetal blood was collected from the severed umblical cord at delivery. The samples were collected from the mothers after delivery. The blood samples were collected and divided into two for mineral analysis and hematocrit determinations. The samples for hematocrit and Hb determinations (5ml) were collected in heparinized blood sample bottles while fifteen millilitres (15ml) of blood was collected for mineral analysis. The samples were then processed for mineral analysis according to the method of Henkin et al, (1971).

3.5. Preparation of samples for Analysis:

All the elements assessed were determined by atomic

absorption spectrophotometry (AAS) on an instrument (Schimadzu double beam digital atomic absorption/flame photometer AA-650). Mineral assay precautions were observed by washing all the plastic tubes used with nitric acid and repeatedly rinsing them with distilled deionized water.

Serum samples for the determination of calcium and magnesium concentrations were diluted (according to the procedure in the manual for the use of the instrument) in the ratio 1:50 with 0.10% (w/v) lanthanum chloride to overcome any interferrence from phosphates and protein.

The concentrations of zinc, copper, chromium and manganese were measured by diluting the serum in the ratio 1:20 with distilled deionized water.

Serum iron concentration was measured by diluting the serum in a ratio 1:1 with 20% (w/v) trichloroacetic acid to precipitate the proteins. The mixture was centrifuged and the supernatant obtained was aspirated into the AAS to evaluate the iron content of the serum.

All the prepared samples were subsequently aspirated into the instrument using the air-acetylene flame and the appropriate lamp for the determination of each element.

3.6. Hematocrit determination (PCV):

The PCV was determined by the microhematocrit

technique. Serum was put into a heparinized capillary tube and the tube was flame sealed at one end. This was then spun for 5min on a microhematocrit centrifuge (Hawksley-England). The PCV level was then read on an hematocrit reader (Hawksley-England) as percentage values.

3.7. Hemoglobin determination (Hb) = Principle):

The Fe(II) of hemoglobin is oxidized to Fe(III) by ferricyanide and then converted into stable cyanmethemoglobin by the addition of potassium cyanide. The reaction is represented as:

$HbFe(II)+Fe(III)(CN)_6^{3-}\text{---->}HbFe(III)+Fe(II)(CN)_6^{4-}$

$Hb\ Fe(III)+CN^{-}\text{---->}Hb\ Fe(III)\ CN.$

Where HbFe(II) represents hemoglobin; HbFe(III),methemoglobin and HbFe(III)CN; Cyanmethemoglobin. Non reactive ions are omitted. The absorbance of cyanmethemoglobin is then measured at 540nm, where it exhibits a broad absorbance peak (Drabkin 1951)

Hemoglobin concentration of maternal and cord blood was measured by the cyanmethemoglobin method (Drabkin 1951). Aliquots (0.02ml) of blood was added to 5ml of Drabkins 's solution (prepared by dissolving in succession, 0.20g of $K_3Fe(CN)_6$, 0.05g of KCN and 1.0g of $NaHCO_3$ in distilled water and diluting to 1 litre). The mixture was allowed to stand for 10mins for full colour development. The

absorbance was then read at 540nm on a colorimeter (Corning Colorimeter 253) having set the instrument with a blank (5ml Drabkins solution). The absorbance of the standard (cyanmethemoglobin standard 80mg/dl) was also read after adjusting the instrument and the concentration was calculated as:

$$[Hb]\ g/dl = 251\ \frac{(As \times Cst)}{Ast}$$

where (Hb) represents hemoglobin concentration, As; absorbance of sample; Cst; concentration of standard and Ast absorbance of standard.

CHAPTER FOUR

RESULT AND DISCUSSION:

4.1. Mineral Status of Control Subjects (Non-Parturient Women):

Available evidence indicates that the mineral status of non-pregnant women of reproductive age and parturient women resident in Northern Nigeria has not been previously evaluated. Baseline data obtained for the non-pregnant control subjects in the present study revealed that the mean iron concentration for these subjects were 82.0 ± 23.3 ug/100ml of serum, while the Zn concentration was 149.33 ±36.87 ug/100ml respectively. Bothwell and Finch (1962) in a review had earlier indicated a serum iron concentration of 100 ug/100ml to account for the lower limit of normalcy for adequate iron status among women. Data from the present study thus indicate that the control subjects maintain acceptable iron level. This finding was corroborated by acceptable Hb and PCV levels observed for the subjects (Table 4.1).

The Ca and Cu concentrations for the subjects were 8.62 ± 2.75 mg/100ml of serum and 6.67 ±4.27 ug/100ml respectively. These values were close to the serum Ca levels of 9- 11mg/100ml and 10mg/100ml reported by previous investigators (Pitkin 1975, Sunderman and Carol, 1965)

Table 4.1 Hematologic and mineral concentration of the control subjects based on Hb and Parity

Hb :g/100ml	parity	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
		g/100ml	%	ug/100ml	ug/100ml	ug/100ml	ug/100ml	ug/100ml	mg/100ml	
<= 11.00 (n=1)	3	11.00	32.00	90.00	-	-	360.00	-	6.63	2.40
11.10-12.00 (n=1)	0	12.00	36.00	100.00	-	-	480.00	-	6.12	1.85
12.10-13.00 (n=5)	5.00 ± 2.0	12.72 ± 1.31 (12.30-13.00)	38.00± 1.22 (36-39)	70.00 ± 24.36 (50-80)	8.60 ± 5.95 (4.0-20)	86.40 ± 55.25 (20-120)	528.00 ± 257. (220-780)	-	10.97 ± 3.2 (7.40-14.54)	2.14 ± 0.21 (1.90-2.45)
>13.00 (n=13)	2	13.80 ± 0.35 (13.30-14.30)	40.63 ± 1.30 (39-42)	86.26 ± 28.50 (50-130)	7.50 ± 5.35 (5-20)	230.50 ± 189.6 (20-680)	462.50±234.5 (140-700)	-	7.70 ± 1.68 (5.87-9.97)	2.04 ± 0.43 (1.15-2.40)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean ± SD

and Underwood (1977).

The marked decrease evident for serum Cu concentrations of the control subjects relative to these investigators may not be unconnected to suboptimal intakes of the mineral element from the regular diets of these subjects. It is well established that dietary Ca is provided by milk and milk products and foods of animal origin which are generally within the reach of the generality of the populace.

On the contrary the Mn levels of the control subjects (which ranged from 140-780 ug/100ml; mean, 478.67 ± 120.19) was significantly higher than the 44 ug/100ml reported by Papavasiliou and Coworkers (1960) and 68.80 ± 0,86 ug/100ml independently reported by Underwood (1977) for women in other countries. The high consumption of cereal-based diets which have been shown to supply appreciable levels of Mn may account for these observed results.

The Mg concentration for the control subjects (mean 2.09 ± 0.54) was similar to those reported by Seelig and Berger (1974) who reported a serum Mg concentration of 1.62 - 2.0mg/100ml for a group of non-pregnant females. In the present study, chromium levels were not detected for all control subjects evaluated. The lack of detection of Cr in the present study may not necessarily be a

Table 4.2 Age, Parity, Hematological and Serum mineral concentraton of non-pregnant women

Age (Years)	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
	g/100ml	%		Ug / 100ml				mg / 100ml	
14-19 (n=6)	13.56 ± 0.53 (13.0-14.3)	39.6 ± 1.5 (38-42)	87.00 ± 29.42 (50.0-115.0)	4.90 ± 2.98 (4.5-20.0)	132.00 ± 95.16 (40.0-220.0)	544.00±320.00 (160.0-780.0)	-	8.47 ±2.30 (5.41-10.46)	1.91 ± 0.45 (1.15-2.30)
20-25 (n=7)	13.20 ± 0.97 (12.0-14.0)	39.26 ± 3.03 (36-42)	89.00 ± 26.32 (65.0-130.0)	15.65 ± 14.19 (4.0-20.0)	280.00±154.95 (40.0-680.0)	380.00±216.79 (140.0-700.0)	-	8.87 ±3.26 (6.12-14.54)	2.14 ± 0.27 (1.85-2.45)
> 26 (n=7)	12.64 ± 1.05 (11.0 - 13.9)	37.26 ± 3.05 (32.0 41.0)	74.00 ± 13.47 (60-90)	4.80 ± 2.90 (4.5-20.0)	136.00 ± 80.50 (20-180)	512.00±225.21 (220-780)	-	8.52±3.21 (6.12-14.03)	2.22 ± 0.28 (2.00-2.55)
parity 0 (n=15)	13.25 ± 0.75 (12.0-14.30)	39.10 ± 2.09 (36-42)	79.00 ± 21.96 (50-130)	9.20 ± 5.33 (2.8- 18.0)	208.00 ± 35.88 (160.0-680.0)	514.00±235.90 (140.0-780.0)	-	9.33 ± 3.11 (5.41-14.54)	2.13 ± 0.48 (1.15-2.40)
parity 1 (n=1)	14.00	42.00	130.00	20.00	160.00	260.00	-	7.85	1.95
parity > 2 (n=4)	12.62 ± 1.21 (11.0 -13.9)	35.50 ± 3.87 (32-41)	155.00 ± 25.1 (120.0-180)	-	-	445.00±194.16 (220.0-660.0)	-	7.14 ± 1.02 (6.12-8.42)	2.28 ± 0.29 (1.90-2.55)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean +- SD

consequence of a state of deficiency of the element in tissue stores but may be a culmination of the need of an induction of Cr from tissues to promote detectable amounts within the blood. Hambidge and Drogemueller (1974) for instance observed that non-pregnant subjects have been shown to have paramount increase in plasma Cr following an oral glucose load, and this increment has been shown to indicate adequate Cr nutrition/ The increase has been attributed to be due to the release of a biologically active glucose tolerance factor chromium from a specific body pool.

4.2. Effect of age and parity on the mineral and Hematological status of Non-Pregnant Women:

The effect of age and parity on the mineral status of the non-parturient control subjects are presented in Table 4.2. Adolescent women had relatively lower Cu and Zn levels than older subjects. The Mn concentration for the adolescents was however slightly higher than those observed for older women Previous investigators have reported an age-dependent relationship in serum Cu concentration of healthy human subjects.Sass-Kotsak (1973) for instance attributed this phenomenon to constant changes in serum levels of ceruloplasmin, the transport protein for copper. Cox (1966) in an

earlier study also observed a negative significant association between ceruloplasmin and total serum Cu relative to age. Underwood (1977) also indicated that Cu absorption from diets is age dependent. It is expected that in adolescence, which is a period of attenuated growth, that there must be a relative increase in the absorption of all nutrients. It is therefore expected that Cu concentration of these subjects be higher. Available evidence however, indicate that of all social strata, female adolescents have the poorest food habits all over the world, hence poor intakes peculiar to this population may be associated with decreased Cu levels for the subjects. Sonkes (1970) had also reported the possible involvement of growth hormone in preventing the rise in hepatic Cu. The Author indicated the existence of some factor in the pituitary which ensures the elimination of Cu from the liver and consequently prevents its uptake. The adolescent period is a period where the activities of growth hormones are heightened. The resultant effect of these hormones might also have contributed to the observed phenomenon.

In the present study, age had no effect on the Hb, PCV, Fe and Ca concentration of the control subjects (Table 4.2). Control subjects who had not previously delivered had slightly higher Hb and Mn than their other counterparts who had given birth

to children. However there, appears to be no significant variation in the mineral levels of the primigravidae and the multi-parous subjects in this study. It is important to note that the similarity evident for these subjects as regard their hemato-logical data may be as a result of the fact that all the subjects evaluated were of menstruating age.

4.3. Hb, PCV and mineral status of control Subjects:

Table 4.2 presents the concentration of Hb, PCV and serum mineral levels of the control subjects. Only 2 subjects (10%) had Hb < 12.0g/dl suggestive of anemia according to WHO standards. Most of the subjects had Hb > 13.0. Subjects with higher Hb (>13) had significantly higher ($P \leq 0.05$) iron than subjects with lower Hb levels. These findings support previous findings that higher iron stores promote hemopoiesis in normal subjects especially women. The mean Hb and PCV levels for all the control subjects was 13.13 ± 0.90g/100ml and 38.8 ± 2.70% respectively. These values closely agree with the 13.9 ± 1.4 and 14.04 ± 1.48g/100ml and values of 36.2 and 38.5% reported for Hb and PCV, respectively, by other investigators for similar population groups (Sagen et al 1984).

Table 4.3: The relationships between serum mineral concentration of the control subjects.

Parameter	Regression equation	Pearson's Correlation Coefficient	Level of Significance
Age & Parity	y = -5.523 + 0.274*X	r = 0.714	P < 0.05
Hb & PCV	y = 0.951 + 2.887*X	r = 0.969	P < 0.001
Cu & Zn	y = 33.999 + 17.3*X	r = 0.73	P < 0.001
Zn & Mn	y = 538.935 - 0.225*X	r = 0.522	P < 0.05

4.4. Interrelationships Between Serum Mineral Concentration of the Control Subjects:

The interrelationships evident between the various parameters evaluated in the present study are presented in Table 4.3. A positive significant ($P < 0.05$) association was observed between age and parity, Hb and PCV, Cu and Zn, and between Zn and Mn concentrations of the subjects. Data from this study indicate that a serum Cu concentration of; for example; 100ug/100ml suggests the presence of 3.82ug/100ml of Zn and 43.80mg Ca/100ml respectively. Adopting the 123ug Cu/100ml suggested by previous investigators will imply a viable 5.14ug/100ml Zn and ~4.3.08 mg/100ml Ca status for women.

With the exception of the significant correlation observed between age and parity and Hb and PCV, other investigators, based on available data, have not previously reported distinct associations in the mineral status of non-pregnant women. Since the present study appears to be the first known report establishing interrelationships among these minerals in women, it is therefore difficult to speculate or advance a hypothesis for these observed interrelationships. It is well documented, however, that various synergistic and antagonistic interractions exist among minerals at

various levels of their metabolism, especially in absorption, transportation and excretory routes. It has for instance been indicated that divalent elements like Cu and Zn antagonistically compete for similar absorption sites and a consequent increase of one of the metals may promote the precipitation of the other. Animal studies (Forth 1970) for instance, have also revealed that Fe deficient rats under experimental conditions not only selectively absorb more iron, but also Co, Mn and Zn. A similar mechanism has thus been proposed for the transcellular transport of Fe and Zn in the intestinal mucosa. Other investigators (Kahn et al 1965) have also reported that a degree of interaction is evident between most of the minerals as a result of their similarity in binding to similar transport proteins. For example, Cu, Zn and Mn have been indicated to selectively bind to serum albumin. Copper for instance, has been shown under distinct conditions to bind to transferrin, the iron binding plasma protein.

The interrelationships evident between Zn and Mn in the present study, for example, may not be unconnected with the similarity of both metals in solution to form octahedral complexes (Worwood 1974) and the fact that both elements share a common excretory route. It has been known for instance (underwood 1977) that the excretory Zn

pool is derived from both the unabsorbed metal that comes from the intestinal mucosa, bile and pancreatic secretion. The excretion of Mn which is the major mechanism of its homeostasis is also primarily via the bile.

It is advocated from the present study that more studies are required to elucidate the nature of the mechanism and hypothesis to account for these observed phenomena as the observation is relatively preliminary.

4.5. Maternal Nutriture: Effect of age and Parity:

On Table 4.4 is presented the mineral status of pregnant women at parturition according to their age and parity. Eleven (20%) of the parturient women were adolescents while 28 (50.91%) of them were between the ages of 20 and 25 years. All the adolescents in the study were primigravidae. The primigravid women had slightly higher levels for all nutrients evaluated when compared to the multiparous subjects. Women who are 26 years old and above appear to have slightly higher Cu and Mn concentrations than the women between the ages of 20 and 25 years old. The Ca levels are however, lower among these women than the younger women. Magnesium levels for the parturient women also appear to decrease with increasing age.

Table A.4 Mineral status of Parturient mothers according to age and Parity

Age (years	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
	g/100ml	%		Ug / 100ml				mg / 100ml	
14-19 (n=11)	10.85 ± 2.37 (5.30-13.70)	33.18 ± 7.85 (16-43)	148.18 ±69.31 (75.00-240.00)	102.74 ±69.58 (20-199)	93.45 ±58.19 (32-192)	249.90 ±110.5 (56-305)	-	12.65 ±3.20 (9.05-20.20)	1.82±0.45 (1.15-2.45)
20 - 25 (n=28)	11.67 ± 1.46 (7.30-13.5)	35.71 ± 4.35 (27-42)	106.70 ±99.86 (60.00-210.00)	119.54 ±73.60 (20-297)	102.42 ±71.68 (24-320)	151.10 ±140.4 (16-239)	-	13.05 ±4.06 (6.15-22.20)	1.69±0.42 (0.60-2.80)
>26 (n=16)	11.97 ± 1.09 (9.90-14.90)	36.75 ± 4.04 (33-48)	146.57 ±52.54 (100-360)	190.89 ±91.84 (40-298	104.00 ± 78.34 (20-272)	287.69 ±185.3 (33-315)	-	9.63±2.83 (4.95-14.90)	1.20±0.54 (0.50-1.80)
Parity 1(n=25)	11.24 ± 1.94 (5.30-13.70)	32.96 ± 8.50 (16-42)	151.60 ±78.71 (120-375)	138.17 ±80.87 (20-297)	106.08 ±78.88 (24-320)	184.62 ±172.0 (33-226)	-	11.83±5.49 (6.15-20.20)	1.29±0.54 (0.50-2.45)
>=2 (n=30)	11.90 ±1.23 (10.70-14.90)	36.39 ± 4.16 (34-38)	147.17 ±109.4 (100-400)	135.42 ±77.19 (20-298)	96.60 ±63.33 (20-232)	173.41 ±83.91 (16-187)	-	11.71 ±4.13 (6.00-21.35)	1.53±0.55 (0.50-2.80)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean ± SD

4.6. Hb Concentration of Parturient Women:

Parturient women in this study were classified according to their Hb levels (Table 4.5). Parity had no significant effect ($P > 0.05$) on the Hb concentration of these subjects. Women with Hb < 10 had lower PCV, Zn and Mn than the women with higher Hb values. Their Ca and Mg values however, appear to be slightly higher than the women with higher Hb levels. Parturient women with Hb>12.0g/100ml had higher iron and Mn than those in the Hb range of 11-12.0g/100ml. There is however, no significant variation ($P>0.05$) in their Cu, Zn and Mg concentrations. The mean Hb and hematocrit values for the parturient mothers was 11.59 ± 1.6g/100ml and 35.5 ± 5.2% respectively. Murray et al (1978) reported a mean Hb value of 12.6g/100ml in Nigerian women. Harrison (1966) also reported Hb concentration of 9.2g/100ml among 12 primigravid women in a Southern Nigerian village. Koller et al (1980) indicated the normal range for gravid individuals to be within 8.7-14.4g/100ml. It appears therefore, that the women in the present study have acceptable Hb level.

Table 4.5 Mineral concentration of parturient mothers based on Hb concentration

maternal Hb level g/100ml	Hb g/100ml	PCV %	Fe	Cu	Zn	Mn	Cr	Ca	Mg
			Ug / 100ml					mg / 100ml	
<10 (n=5)	(5.3-9.9)	25.8±6.3 (16-31)	191.00±22.29 (150-250)	195.09±62.95 (20-252)	48.00±47.66 (20-128	167.75±119.90 (46-392)	-	12.77±0.72 (12.05-13.65)	1.62±0.59 (0.80-1.80)
10 - 11 (n=10)	10.36±1.07 (10-11)	31.67±2.18 (30-34)	156.00±61.49 (150-380)	100.37±42.87 (20-112)	109.60±54.88 (24-192)	184.76±81.26 (46-212)	-	12.15±4.56 (6.3-20.2)	1.80±0.57 (0.65-2.40)
11.10-12.00 (n=23)	11.78±0.22 (11.3-12.0)	35.09±3.50 (29-38)	133.69±74.5 (60-325)	135.12±86.18 (20-160)	115.83±71.51 (20-272)	146.58±125.30 (18-284)	-	11.30±3.39 (6.15-20.20)	1.50±0.52 (0.50-2.40)
>12 (n=17)	13.08±0.73 (12.2-14.9)	40.07±2.92 (37-48)	203.51±123.54 (150-460)	143.80±70.95 (20-156)	91.76±38.13 (20-320)	181.39±78.54 (56-206)	-	10.78±3.40 (6.00-14.20)	1.52±0.46 (0.50-1.90)

n= number of subjects
()= range of values
all results are expressed as mean +- SD

Table 4.6 The effect of socioeconomic status on maternal mineral status.

maternal socioeconomic status	Hb g/100ml	PCV %	Fe	Cu ug / 100ml	Zn	Mn	Cr	Ca mg / 100ml	Mg
Low (n=10)	11.90±1.00 (9.90-13.50)	35.40±3.72 (29-41)	118.00±58.57 (100-285)	163.57±114.03 (20-390)	99.20±52.82 (40-200)	209.87±184.98 (24-378)	-	13.23±4.87 (4.32-15.55)	1.55±0.41 (0.65-2.00)
Middle (n=31)	11.46±1.61 (5.30-14.90)	35.13±5.43 (16-48)	153.23±91.15 (120-250)	137.38±169.93 (20-186)	114.58±62.03 (24-272)	193.51±90.57 (16-206)	-	12.03±3.98 (6.38-21.35)	1.64±0.54 (0.50-2.45)
High (n=14)	11.74±1.98 (7.30-13.90)	36.4±5.77 (23-43)	162.50±92.15) (120-315)	116.57±69.67 (20-190)	72.57±61.09 (20-230)	220.07±118.40 (56-392)	-	12.61±4.36 (6.00-13.35)	1.68±0.43 (0.50-2.40)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean +- SD

4.7. Effect of Socioeconomic Status on Maternal Mineral Status:

Table 4.6 depicts the effect of socioeconomic status on hematologic and mineral status of parturient women. Socioeconomic status had no effect on the Hb and PCV of the parturient women. The women rated as falling under low socioeconomic status had slightly higher Cu levels than those women of middle or high class. There appears to be no significant difference (P>0.05) in mineral status of the parturient women irrespective of their socio-economic strata.

4.8. Mineral Status of the Parturient Women:

Chromium was not detected in the serum of all the parturient women in this study. The mean iron concentration for all the subjects was 149.18 ± 54.85. The mean Cu and Zn levels for the subjects was 125.47 ± 113.20 and 109.02 ± 66.54 respectively. The Mn concentration of the subjects varied widely from 16-384 ug/100ml (mean 181.39 ± 109.21 while the Ca and Mg concentration for all the subjects evaluated ranged from 4.9-24.3 (mean 11.9 ± 3.8) and 0.50-2.85 mg/100ml (mean 1.57 ± 0.52), respectively. The mean serum Fe concentration reported in the present study is slightly higher than the 125 ug/100ml serum iron observed for women on iron supplementation at 37-40

weeks of gestation. Widdowson et al, (1974) however, reported lower levels of 60 ug/100ml for serum Fe at parturition. Data from the present study thus indicate that the parturient women in question maintain positive iron balance. Widdowson et al, (1974) also reported a mean Cu value of 250 ug/100ml. Henkin et al (1971) has also reported an average value of 48 ± 3 ug/100ml for Zn.

The lack of detection of chromium in parturient mothers have been earlier observed in late pregnancy. Hambidge and Drogemueller (1974) for instance had observed that 60% of women in late pregnancy had no detectable Cr even when Cr is induced by administration of oral glucose load.

Pitkin (1975) has reported a wide range of mean serum Ca levels of pregnant women at parturition. These range from 9.0mg/100ml to 12.2 ± 1.4 mg/100ml. Based on these data it is evident that the parturient women in this study had adequate supply of calcium.

4.9. Comparison of Mineral Status of Parturient and Non-Pregnant Women

Parturient women had significantly lower Hb and PCV ($P<0.05$) than the control subjects. With the exception of Zn and Mg levels, parturient women had significantly higher mineral levels than the

control group.

The phenomenon of increased serum Cu levels in the parturient women has been ascribed primarily to increase in ceruloplasmin-bound Cu, which in turn increases as a result of elevated levels of maternal estrogens (Henkin et al, 1971). Hambidge and Drogemueller (1974) in turn indicated the possible involvement of progesterone levels in addition to estrogens in elevating plasma levels of copper during pregnancy. More recently, Shaw (1980) has reported elevated copper and ceruloplasmin levels during pregnancy being highest at term and falling back to normal by about the 6th week following delivery.

Heaney and Skillman (1971) have also reported enhanced intestinal absorption of Ca and progressive retention throughout the course of pregnancy. Since pregnancy is known to be associated with increased nutrient intake, it is likely that enhanced absorption of Ca by the gravid individual, explains the normal maternal Ca levels despite foetal transfer.

4.10. Interrelationships between the various Parameters in the Maternal Serum:

The regression analysis data for the interrelationships evident in mineral nutriture of parturient mothers is presented in Table 4.7.

Table 4.7: The interrelationships between the various parameters studied in the maternal serum.

Parameter	Regression equation	Pearson's Correlation Coefficient	Level of Significance
Age & Parity	y = -4.006 + 0.268*X	r = 0.800	P < 0.001
Age & Mg	y = 2416.433 - 36.1477*X	r = -0.332	P < 0.01
Hb & PCV	y = 0.959 + 2.983*X	r = 0.906	P < 0.001
PCV & Mg	y = 2566.93 - 27.919*X	r = -0.274	P < 0.05
Cu & Mn	y = 545.697 - 0.363*X	r = -0.371	P < 0.001
Ca & Mg	y = 674.939 +0.076*X	r = 0.615	P < 0.001
Mn & Fe	Y = 230·318+0·165*X	r = 0·354	P<0.001

Negative correlations were evident between age and Mg, PCV and Mg and Cu and Mn.

According to Prasad (1978) the reactivity of the skeleton declines with age and that the exchange of Mg expressed as bone/serum specific activity, occurs more rapidly in younger animals than older ones. In addition, Mg has been known to accumulate in the bones of young rats approximately twice as fast as in the bones of adult rats. It has also been suggested (Wacker 1980) that Mg acts as a second messenger for insulin and leads to increased protein synthesis induced by insulin. All these processes may probably be more active in the gravid individual and less in the non-pregnant women. That is probably why such a relationship was not observed in the control subjects. The metabolic mechanism for significant negative association between Mg levels and hematocrit levels is unknown. However past investigators (Williams 1971) have indicated that during pregnancy Mg is mobilized from the red blood cells to the more active tissues. Wacker (1980) for instance reported that nucleated erythrocytes of ducks had a higher Mg concentration than the annucleated mammalian erythrocytes and consequently the former are known to have greater metabolic activity than the latter. Furthermore, the Mg/Ca ratio has been known to be higher in active tissues than the

relatively inactive ones such as in the erythrocytes.

Like Cu, manganese metabolism is also influenced by the estrogenic hormones of the ovary (Underwood 1977). This might probably explain the low but significant negative correlation ($r = -0.371$, $P<0.001$) observed between maternal serum levels of both elements which was not observed in the control group. In addition both elements are involved in hormone synthesis.

Positive significant correlations ($P<0.001$) were observed between age and parity, Hb and PCV, Ca and Mg and Mn and Fe. All the associations were statistically insignificant. The positive association between Mn and Fe obseved in this study may not be unrelated to the findings (Worwood 1974) that Mn binds to transferrin which has long been recognized to be the transport protein for iron.

4.11. Fetal Birth Weight:

In Table 4.8 is presented the effect of maternal age, parity and socio-economic status on fetal birth weight. There were twenty-four (24) female babies in the present study with a mean birth weight of 3.0kg and twenty-one (21) male infants averaging about 3.2kg. This finding is in agreement with that reported by Camelleri and

Table 4.8 The effect of maternal age, parity, hemologic and socioeconomic status on fetal birth weight.

	Age (years)			Parity		Socio-economic status			Hb g/100ml			
	14-19 n=19	20-25 n= 20	>26 n=16	1 n=25	>=2 n=20	Low n=10	Middle(n=31)	High(n=14)	<10 (n=5)	10-11(n=10)	11.1-12.0(n=23)	>12.0(n=17)
Mean birth weight	3.09±01.33 (2.80-3.90)	3.08±0.37 (2.40-4.00)	3.06±0.68 (2.00-3.85)	3.03±0.31 (2.40-3.30)	3.11±0.53 (2.30-4.00)	2.86±0.66 (2.00-4.00)	3.05±0.37 (2.00-3.90)	3.29±0.34 (2.70-3.85)	3.20±0.35 (2.70-3.60)	3.08±0.25 (2.75-3.40)	3.04±0.51 (1.55-4.00)	3.09±0.50 (1.90-3.90)

n= number of subjects
()= range of values
all results are expressed as mean ± SD

Cremona (1970) who reported a slight difference between the birth weights of female and male infants with the male being heavier. However, the over all mean birth weight of all the infants was 3.08 ± 0.45kg. This falls within the range of most birth weights reported from Europe, Asia and Africa. The values reported by Camelleri and Cremona (1970) from Europe were 3.40 for a diverse group of women and 3.3 from the welfare service group. From West Indies a value of 3.4kg was also reported for the higher class women and from Africa a mean birth weight of 3.1kg was reported from Senegal and 3.19kg from Ghana (Hytten and Leitch 1971). However, the observed value in the present study is slightly higher than that reported by Morley and Knox (1960) for Yoruba babies whose mean birth weight was reported as 2.8kg. Also observed in this study, was a slight increase in birth weight with improved social status although this was of no statistical significance. Also the mean birth weight of the babies was similar for the primigravidae and the multiparous women. Based on the hematological findings from this study, it appears that the weight of the babies was not influenced by the maternal hemoglobin levels.

A number of factors have been cited in the literature which have been found to affect birth weight. The mean birth weight observed in

the present study was higher than the value reported for the Yoruba babies (Morley and Knox 1960). The disparity might probably be due to improved standard of living and health facilities available now compared to the prevailing conditions in the 1940s and 50s when these investigators carried out the study. Maternal age had no significant effect on the birth weight of the babies.

4.12. Fetal Status: Effect of Maternal age and Parity on Fetal indices:

The effect of maternal age and parity on fetal hematological and mineral status is presented in Table 4.9. Adolescent parturient women gave birth to babies that had slightly lower Cu, Zn and Hb than older women. The primigravidae gave birth to neonates that had higher Fe and Cu levels whereas multigravidae infants had slightly higher Mg. Parity had no effect on the Zn nutriture and hematological status of the neonates.

4.13. The Effect of Hb on Fetal Status:

The effect of maternal Hb on fetal mineral nutriture is presented in Table 4.10. Parturient women with Hb values >12 produced babies with significantly ($P<0.05$) higher Hb and PCV levels than parturient mothers with Hb <12.0. Neonatal iron level was significantly higher for parturient

Table 4.9 The effect of maternal age and parity on fetal hematologic and mineral status.

Maternal parameter		Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
		g/100ml	%		Ug / 100ml				mg / 100ml	
Age	14-19 (n=11)	12.4+-1.74 (10-15.2)	38.55+-7.97 (27-53)	211.82+72.75 (120-350)	87.17+44.23 (40-144)	93.82+56.72 (20-192)	237.46+212.84 (48-272)	-	11.98+3.78 (4.9-19.60)	1.70+0.55 (0.45-2.35)
y	20-25 (n=28)	13.49+-1.40 (10.7-16.7)	43.36+-6.57 (32-59)	183.22+112.15 (120-410)	109.71+72.83 (20-185)	104.71+64.79 (20-288)	169.69+70.49 (64-207)	-	12.64+3.89 (5.0-23.65)	1.64+0.52 (0.55-2.85)
e	>26 (n=16)	12.94+-1.99 (10-16)	42.06+-9.07 (30-58)	196.25+87.80 (120-370)	128.92+90.66 (20-236)	133.50+91.73 (40-352)	196.23+75 (42-206	-	11.92+4.45 (6.50-24.30	1.69+0.46 (0.75-2.35)
a										
r										
s										
P	1 (n=25)	13.22+-1.65 (10-16.70)	42.04+-7.25 (30-51)	215.40+91.80 (100-310)	125.16+79.02 (20-185)	108.80+79.16 (20-288)	178.75+44.00 (42-209)	-	11.76+3.35 (4.90-17.60	1.59+0.51 (0.45-2.35)
a										
r										
i	>=2 (n=30)	13.02+-1.73 (10-16)	42.0+-8.21 (30-58)	173.83+99.85 (120-400)	98.82+73.14 (20-236)	112.67+67.87 (20-352)	101.82+81.39 (64-207)	-	12.74+4.45 (5.00-24.30	1.76+0.47 (0.75-2.45)
ty										

n = no of subjects
() = range
(-) = not detected
All results are expressed as mean +_ SD

Table 4.10 The effect of maternal Hb levels on fetal parameters.

maternal Hb level g/100ml	Fetal Parameters								
	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
	g/100ml	%	Ug / 100ml					mg/100ml	
<10 (n=5)	12.04±1.74 (10-14.7	37.00±8.80 (27-51)	247.00±102.90 (115-350)	51.01±43.33 (40-119)	62.40±31.01 (20-152)	134.94±108.12 (44-321)	-	12.05±4.44 (4.9-16.75)	1.68±0.69 (0.45-2.05)
10 - 11 (n=10)	12.51±1.62 (10-14.2)	39.90±7.28 (30-50)	162.00±81.25 (60-325)	116.10±74.16 (40-144)	124.4±51.96 (80-192)	243.69±230.87 (88-264)	-	12.75±3.95 (7.55-19.60)	1.63±0.31 (90.90-2.00)
11.1 - 12.0 (n=23)	13.10±1.69 (11.2-16.7)	41.70±7.04 (30-54)	190.21±104.45 (60-410)	123.20±87.26 (20-236)	118.61±85.91 (16-352)	169.67±159.78 (42-273	-	11.87±3.42 (6.50-17.60)	1.55±0.54 (0.55-2.45)
>12 (n=17)	13.81±1.52 (10.7-16.0)	45.18±7.91 (32-58)	198.24±96.30 (120-400)	108.46±71.96 (20-185)	106.82±32.45 (20-152)	206.76±184.07 (48-268)	-	12.68±5.03 (5.00-24.30)	1.85±0.45 (1.05-2.35)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean ± SD

women with Hb >12.0 than women with Hb levels between 10 - 12. Maternal Hb however, does not appear to have any effect on Zn and Mn levels of the neonates.

4.14. Fetal Indices and Maternal Socio-Economic Status:

The women of high socio-economic status had slightly heavier babies than the women of middle or low socio-economic status. The babies of women with higher socio-economic status also had higher Hb and PCV than the low socio-economic and middle class women. The mineral status of babies of women belonging to the high social class was however lower ($P<0.05$) than those in the low or middle class (Table 4.11).

4.15. Mean Values of Fetal Indices Studied:.

The mean fetal Hb and PCV values for this study was 13.11 ± 1.67g/100ml and 42.02 ± 7.72 respectively. The concentrations ranged from 10-16.7g/100ml for Hb and 27-58% for PCV. Iron mean concentration for the newborn was 194.73 ± 104.67 while the Cu concentration was 110.82 ± 86.69 respectively. Chromium was not detected in the blood samples of these neonates while Zn and Mn concentrations for the cord blood was 115.09 ± 70.53 and 191.12± 96.34 respectively. The Ca and Mg concentration was 12.3 ± 3.98mg/100ml and 1.67±

Table 4.11 The effect of maternal socioeconomic status on the fetal hematologic and mineral status.

maternal socioeconomic status	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
	g/100ml	%		Ug / 100ml				mg / 100ml	
Low	13.07±1.41 (11.3-15.60)	41.00±6.69 (34-54)	149.00±95.56 (120-400)	100.60±83.01 (20-172)	95.20±29.20 (48-140)	191.44±74.28 (42-209)	-	12.82±2.68 (9.8-17.6)	1.54±0.64 (0.55-1.60)
Middle	13.09±1.91 (10-16.70)	41.74±8.46 (27-54)	208.23±92.01 (120-400)	120.80±74.09 (20-236)	126.58±77.13 (16-352)	141.85±93.15 (96-206)	-	12.61±4.36 (11.08-23.65)	1.68±0.43 (0.65-1.75)
High	13.34±1.38 (10.7-16.00)	43.29±6.99 (32-58)	189.65±108.23 (60-410)	96.17±77.89 (20-185)	87.43±78.55 (20-285)	100.62±79.97 (42-109)	-	11.24±3.93 (9.69-16.75)	1.73±0.56 (0.45-2.45)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean ± SD

Table 4.13: The interrelationships between fetal parameters evaluated.

Parameter	Regression equation	Pearson's Correlation Coefficient	Level of Significance
PCV & Hb	y = 4.267 + 0.211*X	r = 0.965	P < 0.001
Fe & PCV	y = 37.814 + 0.11*X	r = 0.276	P < 0.05
Mn & Cu	y = 458.424 - 0.298*X	r = -0.313	P < 0.01
Mg & Ca	y = 1119.51 + 0.044*X	r = 0.363	P < 0.001

0.50mg/100ml respectively. These serum values ranged from 4.9-24.3mg/100ml and 0.45-2.8mg/100ml for the two elements Ca and Mg respectively (Table 4.12) Widdowson et al, (1974) reported a mean neonatal serum Fe of 160 ug/100ml. It appears that the infants in this study have higher iron levels than the reported values in the literature. Similarly, a value of 29 ± 11 ug/100ml was reported by Henkin et al, (1971) for Cu in the sera of 15 infants at delivery while Widdowson et al, (1974) reported a mean serum Cu level of 50 ug/100ml. It thus also appears that the neonates in the present study maintain positive Cu balance. Similarly, the Zn levels observed in the present study compares favourably well with the 125 ug/100ml reported by Widdowson et al, (1974).

4.16. Interrelationships between Fetal Parameters:

The regression data for fetal nutriture is presented in Table 4.13. With the exception of the negative correlation evident between Mn and Cu; positive correlations were observed for PCV and Hb,Fe and PCV, and Mg and Ca.

Fletcher and Suter (1969) had earlier provided evidence to indicate that maternal iron might be the predominant source of fetal iron. Furthermore, the iron released from the placenta into the fetal circulation is mainly taken up by the

Table 4.13: The interrelationships between fetal parameters evaluated.

Parameter	Regression equation	Pearson's Correlation Coefficient	Level of Significance
PCV & Hb	y = 4.267 + 0.211*X	r = 0.965	P < 0.001
Fe & PCV	y = 37.814 + 0.11*X	r = 0.276	P < 0.05
Mn & Cu	y = 458.424 - 0.296*X	r = -0.313	P < 0.01
Mg & Ca	y = 1119.51 + 0.044*X	r = 0.363	P < 0.001

Table 4.12 The maternal, fetal and control subjects mean hemologic and mineral values

Subjects	Hb	PCV	Fe	Cu	Zn	Mn	Cr	Ca	Mg
	g/100ml	%		Ug / 100ml				mg / 100ml	
Maternal	11.59±1.61 (5.30-14.9)	35.51±5.20 (16-48)	149.18±94.85 (50-400)	125.47±113.20 (20-298)	109.02±66.54 (20-320)	191.39±109.21 (16-384)	-	11.97±3.84 (4.90-24.30)	1.57±0.52 (0.50-2.85)
Fetal	13.11±1.68 (10-16.7)	42.02±7.72 (27-58)	192.73±104.67 (60-210	110.82±86.69 (20-259)	115.09±0.53 (20-288)	191.12±98.34 (42-2723)	-	12.3±3.98 (4.9-24.3)	1.67±0.50 (0.45-2.85)
Control	13.13±0.90 (11.00-14.30)	38.87±2.70 (32-42)	82.00±23.30 (50-130)	6.67±4.27 (4-20)	149.33±36.87 (20-680)	478.67±120.19 (140-780)	-	8.62±2.75 (5.41-14.54)	2.09±0.54 (1.15-2.55)

n= number of subjects
()= range of values
(-) = not detected
all results are expressed as mean ± SD

liver and is not immediately available for Hb synthesis. This might probably explain the low positive correlation between the fetal serum iron and PCV. It was further speculated by the authors that the placental transferrin binding sites might work more efficiently at low levels of iron saturation than those on red cell precursors.

The possible hormonal involvement appears to be further strengthened by the observed association between fetal Mn and Cu in this study which are both known to be elevated by hormones. Such relationships were absent in the control subjects but were observed in both fetal and maternal sera. It appears that whatever mechanism that operates in the maternal serum to bring about the relationship observed between Mg and Ca is also active in the fetal serum as evidenced by the correlation coefficient and the level of significance (Tables 4.7 and 4.13) observed in this study.

4.17. Relationship between Maternal and Fetal Mineral Status:

With the exception of Cu, maternal indices were significantly ($P<0,05$) lower than those observed for the neonates in all the parameters studied (Table 4.12). The interrelationships between maternal and fetal levels are presented in

Table 4.14: The interrelationships between maternal and fetal hematologic and mineral levels.

Parameter	Regression equation	Pearson's Correlation Coefficient	Level of Significance
Hb(f) & Hb(m)	y = 9.050 + 0.350*X	r = 0.343	P < 0.01
Hb(f) & PCV(m	y = 8.344 + 0.134*X	r = 0.404	P < 0.01
PCV(f) & Hb(m	y = 23.992 + 1.5555*X	r = 0.328	P < 0.01
PCV(f) & PCV(	y = 20.849 + 0.596*X	r = 0.398	P < 0.001
Fe(f) & Fe(m)	y = 276.131 + 0.366*X	r = −0.355	P < 0.001
Cu(f) & Cu(m)	y = 164.945 + 0.415*X	r = 0.637	P < 0.001
Cu(f) & Mn(m)	y = 435.381 − 0.285*X	r = −0.288	P < 0.01
Zn(f) & Zn(m)	y = 30.892 + 779*X	r = 0.800	P < 0.001
Mn(f) & Cu(m)	y = 628.102 − 0.411*X	r = −0.408	P < 0.001
Mn(f) & Mn(m)	y = 68.058 + 0.992*X	r = 0.888	P < 0.001
Ca(f) & Mn(m)	y = 11118.28 + 2.866*X	r = 0.296	P < 0.01
Ca(f) & Ca(m)	y = 6470.419 + 0.493*X	r = 0.526	P < 0.001
Mg(f) & Mg(m)	y = 1230.795 + 0.269*X	r = 0.274	P < 0.01

(f) = fetal
(m) = maternal

P < 0.01

P < 0.001

(Table 4.14) With the exception of Fe, a positive association existed between the maternal mineral and fetal mineral concentrations. A controversy, however, exists over the relationship between maternal Fe nutrition and the Fe status of the fetus. It has been suggested that in rats, the fetus is supplied with Fe from storage Fe and from absorption, after maternal requirements have been met (Fenton et al, 1977). Several other studies on pregnant women have revealed that the amount of Fe received by the developing fetus is independent of the mother's status (Murray et al, 1978).
Fletcher and Suter (1969) have however, reported the possibility of the existence of a unidirectional pumping system for Fe in the placenta. There has also been a great deal of speculation about the possibility of iron deficiency in the mother hindering Fe storage in the fetus, although iron deficiency anemia in the mother does not lead to anemia in her newborn infant (Hytten and Leitch 1971).

It is also likely that the events taking place in the maternal serum also operate in the maternal-fetal system with respect to Cu and Mn nutriture as reflected by the negative association observed in the maternal serum and the maternal-fetal serum. Fetal calcium also bore a significant high positive correlation($r = 0.526$, $P<0.001$) with

maternal Mn. Calcium metabolism in pregnancy has been known (Pitkin 1975) to be a complex process involving Ca, vitamin D and parathyroid hormone (PTH). Parathyroid hormone released in response to a falling ionised serum Ca level, acts on bone cells to increase the rate of mobilization of Ca ions. Guggenheim and Gaster (1973) also reported that under certain experimental conditions dietary calcium carbonate was without effect on the Mn content of bone. However, Mn has been known to be involved in the synthesis of steroids and sex hormones.

In conclusion, based on the observed interrelationships between the maternal serum mineral levels and the corresponding fetal levels; it can be tentatively concluded that with the exception of Fe, maternal mineral deficiency during pregnancy may consequently result to deficiency in the neonates. In addition, it is important to indicate that socioeconomic variables do not markedly affect the hematologic and mineral status of women of reproductive age in Northern Nigeria. These findings may be due to the similarity in the nature of foods mostly consumed by the subjects evaluated as the population groups resident in Northern Nigeria subsist predominantly on Cereal-based Diets.

4.18. Suggestions:

In light of the present study the author hereby advocates that

i. more definitive studies be conducted to confirm the findings from the present study;

ii. the sample size be increased in such studies to reflect the status of several population groups;

iii. a comparative and extensive study be carried out to evaluate the mineral status of women resident in Northern and Southern Nigeria;

vi. comparative studies be conducted to assess the mineral status of women with abnormal deliveries

v. the mineral content of the regular diets of the Nigerian populace especially parturient mothers should be a subject for further investigation.

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APPENDIX I. PERASON'S CORRELATION COEFFICIENT BETWEEN THE VARIOUS PARAMETERS IN CONTROLS.

	Age(yrs)	Parity	Hb	PCV(%)	Fe	Cu	Zn	Mn	Cr	Ca	Mg
Age		0.714*	-0.411	-0.280	-0.125	-0.163	-0.264	0.123		0.004	-0.359
Parity			-0.112	-0.065	-0.151	-0.347	-0.355	-0.029		-0.335	0.206
Hb				0.969	0.100	0.216	0.443	-0.010		-0.116	-0.113
PCV					-0.098	0.253					
Fe							0.177	-0.475		-0.037	-0.388
Cu							0.713*	-0.488		0.570*	-0.021
Zn								-0.522*		0.263	0.023
Mn										0.079	-0.033
Cr											-0.054
Ca											
Mg											

* = Significant difference
Mineral concentrations were expressed Uç/100ml.

APPENDIX II. PEARSON'S CORRELATION COEFFICIENT RELATIONSHIP BETWEEN THE VARIOUS FETAL PARAMETERS

	B.weight	Sex	Hb	PCV(%)	Fe	Cu	Zn	Mn	Cr	Ca	Mg
B.weight			-0.082	-0.081	-0.031	-0.097	-0.004				
sex	0.135		-0.198	-0.155	0.162	-0.148	-0.245				
Hb	-0.029	-0.198									
PCV	-0.019	-0.155	0.965*								
Fe	-0.014	0.162	0.242	0.276*							
Cu	-0.139	-0.142	-0.209	-0.126	-0.105						
Zn	-0.013	-0.211	-0.037	-0.019	-0.002	0.159					
Mn	0.107	0.092	0.156	0.160	0.256	-0.213	-0.002				
Cr											
Ca	-0.066	0.137	-0.097	0.117	-0.095	-0.003	0.172	0.244			
Mg	-0.006	0.184	0.107	0.148	0.209	-0.031	0.105	0.140		0.362*	

* = Significant difference
Mineral concentrations were expressed Ug/100ml.

APPENDIX III. PERASON'S CORRELATION COEFFICIENT BETWEEN THE VARIOUS MATERNAL PARAMETERS ASSESSED.

	Age(yrs)	Parity	S.Class	Hb	PCV(%)	Fe	Cu	Zn	Mn	Cr	Ca	Mg
Age		0.800	-0.028	-0.163	-0.150	-0.067	0.101	-0.044	-0.042		-0.194	-0.332
Parity	0.800*		0.175	0.147	0.129	-0.064	-0.051	-0.026	0.149		-0.158	-0.262
S.class	-0.026	0.195		0.128	0.064	-0.087	0.022	-0.180	-0.037		-0.035	-0.112
Hb	-0.163	0.147	0.128		0.906*	-0.082	-0.004	0.181	-0.062		-0.116	-0.218
PCV	-0.150	0.129	0.064	0.906*		0.021	-0.080	0.107	0.029		-0.202	-0.273
*Fe	-0.067	-0.064	-0.087	-0.082	-0.021							
Cu						-0.176		0.162	-0.371		-0.089	
Zn						-0.020					0.100	-0.065
*Mn						0.354*					-0.077	-0.031
Cr												
Ca						-0.206						0.615*
Mg						-0.124						

* = Significant difference
Mineral concentrations were expressed Ug/100ml.

APPENDIX IV. PERASON'S CORRELATION COEFFICIENT BETWEEN MATERNAL & FETAL PARAMETERS STUDIED.

	Age(yrs)	Parity	S.Class	Hb	PCV(%)	Fe	Cu	Zn	Mn	Cr	Ca	Mg
B.weight	0.110	0.172	0.125	-0.060	-0.004	-0.083	-0.140	-0.048	0.225		0.106	-0.064
Sex	-0.007	-0.082	0.042	-0.165	-0.203	0.138	-0.140	-0.128	0.367		-0.100	
Hb	-0.006	0.014	-0.043	0.343*	0.404*	0.199	-0.187	-0.070	0.020		-0.080	-0.115
PCV	0.044	-0.069	-0.015	0.328*	0.398*	0.196	-0.121	-0.021	-0.005		-0.082	-0.103
Fe	-0.064	-0.096	-0.211	-0.012	-0.078	0.355*	-0.145	-0.021	0.087*		-0.119	-0.046
Cu	-0.065	-0.010	-0.071	-0.055	0.128	-0.222	0.637	0.239	-0.288*		-0.016	-0.032
Zn	-0.084	-0.016	0.230	0.144	0.119	-0.020	0.227	0.800*	-0.068		-0.079	-0.160
Mn	-0.030	0.181	-0.005	0.111	-0.058	-0.00004	-0.408*	0.111	0.888*		-0.085	-0.015
Ca	0.101	0.141	-0.052	0.192	0.191	-0.215	-0.046	0.174	0.296*		-0.526	0.214
Mg	-0.075	-0.019	-0.062	0.118	0.103	-0.068	0.490	-0.060	-0.018		-0.053	0.274

* = Significant difference

Mineral concentrations were expressed Ug/100ml.