

Title Page

Title: Maternal nutritional status, food intake and pregnancy weight gain in Nepal

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Author contributions

Conceived and designed the study: OA, PA and ZBF. Reviewed methodology and analysis: PA, FBZ. Performed the data collection OA. Interpreted the findings: OA, BE, FBZ, PA. Wrote the paper: OA, FBZ, BE. Edited the paper: OA, FBZ, BE, PC.

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Abstract and Keywords

Poor maternal nutrition during pregnancy may predispose to intrauterine growth restriction (IUGR), immunological and metabolic adaptations which manifest as low birth weight and increase the risk of adult non-communicable disease. This study examined the relationships between maternal nutritional status, food intake and pregnancy weight gain (PWG) which may account for risk of low birth weight (LBW) in Nepal.

A prospective cross-sectional study was undertaken in rural and urban Nepalese population using simple random sampling to select eligible subjects. A questionnaire designed for data collection including retrospective data from records and dietary intake were assessed using Food Frequency Questionnaire and 24 Hour Dietary Recall.

Three hundred and seventy six women were recruited. A high prevalence of LBW (27.9%) and pre-term (14%) delivery were observed. LBW was higher in rural than urban subjects ($p<0.05$). Birth weight was related to period of gestation ($r=0.609$, $p<0.05$) ($r=0.49$, $p<0.001$), energy intake ($r=0.061$, $p<0.001$) and maternal protein intake ($r=0.501$, $p<0.001$). Low PWG (8.11 kg) was also observed and was associated with protein ($r=0.499$, $p<0.01$) and energy intake ($r=0.396$, $p<0.01$) and were lower among mothers in rural areas ($p<0.05$). Calcium intake was related to crown heel length ($r=.399$, $p<0.001$). Lipid, zinc and folate intake were significantly different in rural and urban subjects although the latter was adequate in both.

Findings demonstrate the impact of maternal nutrition on birth outcomes in relation to specific nutrients and components of the diet. Targeted interventions are supported by the findings of this study in both rural and urban areas of Nepal.

Keywords: maternal nutrition, pregnancy weight gain, food intake, Nepal, rural and urban

Introduction

Almost 99% of the maternal deaths occur in developing countries (WHO, 2014), which include one-third from South Asia (UNICEF, 1996). Nepal has the highest maternal deaths in South Asia. This coupled with alarming statistics such as 41% stunting, 11% wasting and 29% underweight children (0-5 years) in Nepal, (Population Division, 2012); makes maternal and child nutrition become a global priority for researchers and clinicians to understand and resolve the nutritional issues in this population.

Maternal nutritional status at conception and during pregnancy has been linked as one of the key factors related to poor foetal outcomes. Birth weight is dependent on maternal health and nutrition during pregnancy. The weight of the infant at birth is important to infant growth and survival. It is now well established that a stunted, undernourished woman is more likely to give birth to a baby who, due to inadequate foetal nutrition, is diminutive in length (below minus 2 SD from median length for age of reference population) and low in birth weight (≤ 2.5 kg) even though the child is born at full term (≥ 38 weeks of gestation) (ACC/SCN, 2000). Low birth weight is an important secondary factor in 40%–80% of neonatal deaths, 98% of which occur in developing countries (Bhutta, Darmstadt, Hasan, & Haws, 2005)

The period of intrauterine growth and development is one of the most vulnerable periods in the human life cycle. Mothers who were exposed to a nutritiously poor diet during pregnancy delivered babies with altered functioning of the hypothalamic–pituitary–adrenal axis (HPAA) in childhood and adulthood (Jones et al., 2006; Phillips et al., 2000; Reynolds, Godfrey, Barker, Osmond, & Phillips, 2007) In Gambia women who conceive during the rainy season, when the average weight loss due to sparse food supply is 2.6 kg or 5% of body weight, equating to a daily energy deficit of 10–15%, have significantly shorter gestation lengths than those who conceive during the harvest season (Rayco-Solon, Fulford, & Prentice, 2005a) Women with the lowest body weight at the time of conception were most at risk (Rayco-Solon, Fulford, & Prentice, 2005b).

On average females in developing countries weigh 28% less and are shorter by 10% compared to the adult females in developed countries (Adhikari, 1989). It has been estimated (Ramalingaswami, Jonsson, & Rohde, 1996) that most women in South Asia gain little more than 5 kg rather than the 10-15 kg gain by women in developed countries and thus pregnancy weight gains of women in Asia tends to be low. A woman's low weight for height or

anaemia during pregnancy can lead to low birth weight and continued undernutrition in her children (Brabin, Hakimi, & Pelletier, 2001; El Guindi et al., 2004; Levy, Fraser, Katz, Mazor, & Sheiner, 2005; Peña, Comunián, & Marti-Peña, 2000) At the same time, maternal undernutrition increases the risk of maternal death during childbirth ((WHO). World Health Organisation, 2011) .

Furthermore, it has been estimated that women in developing countries, who weigh 44-55 kg would deliver an infant with birth weight >3 kg if they gained 10.5 kg during pregnancy ((WHO). World Health Organisation, 1995a). This would be a much higher weight gain than the 5-9 kg range that usually occurs. Low birth weight leads an impaired growth of the infant with a risk of higher mortality rate and increased morbidity (Ashworth, 1998), impaired mental development (Grantham-McGregor, 1998), and the risk of chronic adult disease (Barker, 1998). Maternal nutrition therefore contributes greatly towards pregnancy weight gain (PWG).

A study in Nepal reported a positive correlation between PWG and foetal outcomes (Shrestha, Sunuwar, Bhandary, & Sharma, 2010). Therefore, the focus of the present study is to examine specific dietary factors (maternal macro and micro nutrient intake) which influence the course of pregnancy, with an emphasis on the outcome of pregnancy weight gain and also to examine current maternal dietary and lifestyle factors which characterise the Nepalese community. The findings from this study will help inform frontline health care workers of practical targeted actions that could help decrease poor pregnancy outcomes in the future.

Methods and Materials

A cross sectional retrospective and prospective study using trained field researchers was carried out to examine the maternal nutritional status, food intake and pregnancy weight gain in rural and urban Nepalese population. Urban and rural populations are explored to enable comparison of findings as these regions differ in relation to diet and food availability and access. The rural area was further divided into two; namely the hills and plains according to geographic location. These two locations have been known to differ in culture, attitude and food related practice.

Field worker recruitment and training

Field workers in rural areas were recruited from a cohort of health workers working within the government health structure (nurse and midwives) in Sarlahi district and Kavre district, of Nepal, who had previous experience of field work, sufficient background and local (indigenous) knowledge. Two experienced field supervisors (one from each district) were appointed (who had knowledge of the use of Microsoft excel). In the urban area, two intern doctors working in obstetrics and gynaecology were recruited. Inclusion and exclusion criteria applied in the recruitment of field workers. A three day intensive training programme was delivered for the field workers before commencement of the study.

Participants eligible for inclusion in the study were recruited using simple random sampling procedure. Survey design was informed by the published formula (Odeh & Fox, 1991) which estimated a calculated sample size of 400 pregnant women (200 each in urban and rural setting) bearing in mind design effect, contingency and distribution. In the urban setting, every third eligible woman attending antenatal clinic and later admitted into hospital for delivery was recruited for the study. In the rural setting due to a smaller possible cohort size, every second eligible woman was recruited. Collection of data was undertaken after screening for inclusion and exclusion criteria, recruitment and enrolment. Informed consent procedures were used.

Data collection

A questionnaire was designed for data collection enabling both qualitative and quantitative data to be collected. Retrospective data was collected from records. Dietary intake was assessed by two methods namely the Quantitative Food Frequency Questionnaire (QFFQ) and the 24 Hour Dietary Recall. Trained field workers (Health Centre Staff) were involved in the study completed both questionnaires in the health centre during a face-to-face interactive interview.

Anthropometric measurements were taken using standardized procedures as recommended in the Anthropometric Standardization Reference Manual (Lohman, Roche, & Martorell, 1991) Circumference (girth) measurements were recorded with the help of flexible tape with an accuracy of 0.2cm. Similarly, maternal height (stature) was measured with a previously calibrated stadiometer which measured to within 0.1 cm. The measurements taken included:

a. Maternal measurements

Weight: standard mechanical weighing balance to the nearest 100 grams

Standing height (stature): calibrated, vertical stadiometer fixed to the wall measured to the nearest 0.1 cm

b. Neonatal measurements

Birth weight: Birth weight of newborn was measured soon after birth and within the first hour of life. Birth weight of the newborn was recorded using a standard beam balance provided in the labour wards of health centres. Weight was measured to the nearest 0.1kg with no clothes on the body of the baby.

Head circumference: Measured by anthropometric tape over the occipital protuberance on the back of the head and above the ears on the sides and supra orbital ridges in front across the frontal aspects of the scalp.

Crown heel length: Measured by placing the baby on a flat couch with the head supported with the help of an assistant and the knees pressed down firmly and the heels fixed and held by hand. A firm anthropometric tape measuring to the nearest 0.2 cm was used by trained individuals.

All measurements were taken three times and the average of two concordant readings taken as the final value.

Ethical approval

Approval for the study was obtained from two sources: the National Health Research Council (NHRC) and Paropakar Maternity and Women's Hospital, Government of Nepal, Kathmandu. Anonymity was ensured by using subject numbers instead of names during the study although these numbered codes could be used to identify subject's medical records for reference purpose only. Only researchers had access to patient information and all data collected was kept secure in folders and transferred shortly thereafter onto an Excel database created for data collation. The latter was kept by the principal investigator throughout (OA). All subjects recruited to the study were well informed about the details of the study and provided written informed consent prior to inclusion in the study. (NHRC ref no: 78. Paropakar Maternity and Women's Hospital : 50-11Ka-1374)

Statistical Analysis

All data was collected and collated in an Excel database, including qualitative and quantitative data. Results of quantitative measurements were presented as means, standard deviations or standard error of mean with 95% confidence intervals. Correlations between maternal weight variables and various outcome measures of pregnancy including e.g. birth size were compared using correlation coefficient and significance tested using independent t-test. Mann-Whitney U test and chi-square test were employed to examine impact of several factors singly or together and to compare regional differences and mean differences between subjects from rural and urban regions. Appropriate regression analyses were employed where necessary.

Results

Maternal nutritional status

A total of 400 women were recruited in the study out of which 376 women completed the study (189 women in urban area and 187 in rural area). 91% compliance was observed and is high compared to other studies due to Nepalese Government programmes in place to encourage mothers to give birth at health centres due to incentives (Ref). The dietary intake of pregnant women from urban and rural groups was compared. There was no statistically significant difference ($p>0.05$) in consumption of energy, protein and calcium. A significant difference ($p<0.05$) was seen in lipid, zinc and folate consumption between the two groups and in relation to recommended intakes (recommended daily allowances, RDAs) for this population group. Since no dietary reference values for Nepalese population exists, the Indian RDA values are used as an appropriate reference point (ICMR, 1993). Data is presented in **Table 1**.

Energy Intake: The average energy intake was 1920.5 (SD=424.22) Kcal/day i.e. 8.04 (SD=1.77) MJ/day. This is equivalent to 76% of the recommended daily allowance (RDA) of 2525 Kcal/10.57 MJ/day recommended energy intake for pregnant women within this population (Table 1).

The results, presented in **Table 1**, show participants were consuming below their recommended daily dietary requirements. The energy intake was significantly correlated to birth weight ($r=.061$, $p<0.001$). There was significant association between pregnancy weight gain and total energy intake ($r=.396$, $p<0.01$)

Table 1: Nutrient intake of the subjects compared to the dietary reference intake values (n=376).

Nutrients	Mean	SD	Median	*RDA Value	% of RDA value
Energy Kcal	1920.53	424.22	1877.20	2525	76%
Protein g/dl	48.66	14.28	47.89	75	64%
Lipid g/dl	37.42	11.32	34.67	30	124%
Calcium mg/dl	353.44	129.20	322.85	1000	35%
Zinc mg/dl	7.20	2.58	6.93	11	65%
Folate mcg/dl	978.74	283.14	967.00	600	163%

*RDA Source: ICMR, 1993

Protein Intake: The average protein intake of the study population was 48.66 (SD=14.28) grams/day. This is equivalent to 64% of RDA recommended value for pregnant women within this population. The result shows variation in intakes among subjects as indicated by the large standard deviation observed. A statistically significant relationship between protein intake and birth weight is observed ($r=.501$, $p<0.001$). The maternal protein intake in this study group also showed statistical association with pregnancy weight gain ($r=.499$, $p<0.01$).

Lipid Intake: The average lipid intake among the study group was 37.42 (SD=11.32) grams/day. This is equivalent to 124% of the dietary reference intake (DRI) for pregnant women for this population. The average lipid consumption in urban group was 36.05 (SD=9.50) gram/day and in rural group was 38.79 (SD=12.78) grams/day. This difference was statistically significant ($p<0.05$).

Table 2 presents the nutrient composition of diets of subjects in the urban group compared to the rural group.

Table 2: Nutrient Composition ion of Urban versus Rural diets

Nutrients	Urban Group		Rural Group		P value
	Mean	SD	Mean	SD	
	N=189		N=187		
Energy	1885.69	414.05	1955.7	432.53	0.109
Protein	48.72	14.00	48.61	14.60	0.940
Lipid	36.05	9.50	38.79	12.78	0.019
Calcium	347.75	110.55	359.1	145.71	0.392
Zinc	6.71	2.18	7.68	2.86	0.00
Folate	1032.8	271.2	924.03	285.06	0.00

Calcium Intake: The average calcium intake was 353.44(SD=129.20) mg/day among the subjects. This is low and is equivalent to 35.34% of the RDA for pregnant women within this population (Table 2). Dietary calcium intake was compared with crown heel length (CHL) of the new born. The data was moderately correlated and was statistically significant ($r=.399$, $p<0.001$)

Zinc Intake: The average zinc intake was 7.20 (SD=2.58) mg/day, which is low compared to the DRI value of 11mg/day (equivalent to 65.45% of RDA for pregnant women within this population). There was a moderate correlation of maternal zinc intake with crown heel length (CHL) ($r=.449$). This correlation was statistically significant ($p<0.001$). Similarly, the average zinc consumption in the urban group was 6.71 (SD=2.18) mg/day and in rural was 7.68 (SD=2.86) mg/day. The significantly high ($p<0.05$) level of zinc consumption in the rural group compared to the urban group is noteworthy, ie pregnant mothers residing in the city consumed only 61% of daily requirement whereas the rural mothers consumed more (around 70%) of the RDA ($p<0.00$).

Folate Intake: Average maternal folate intake was 978.74 (SD=283.14) mcg/day, which is equivalent to 163.12% of the RDA value for pregnant women (600mcg/day) within this population. Folate intake was higher in urban dwelling mothers (mean=1032.8, SD=271)

mcg/day in comparison to rural mothers (mean=924, SD=285.06) mcg/day with statistically significant difference ($p<0.00$). This shows wide variation in intakes among the groups as indicated by the outcome of a large standard deviation. Comparison between the two areas showed the total folate was significantly different in these two populations ($p<0.000$).

Food Intake

The distribution of food sources of foods consumed by the sample population are presented in **Figure 1**. Sixty four percent of the foods consumed were cereal and cereal-based products; 8% pulses and legumes, 7% vegetables, 4% was from meat, 3% milk, 3% fruits, 2% sugars, 4% oil; and 3% from miscellaneous food items including tea, carbonated drinks and coffee. Fish and eggs only contributed 2% of food sources in this population.

Differences in urban and rural food intakes were largely in the consumption of higher amounts of wheat, corn and barley in the diet of rural mothers than the urban mothers who base their 90% of diet on rice. This may account for the observed differences in zinc intake between the two groups. Consumption of fruit and vegetables is very low and will affect the nutritional status in relation to micronutrients presented earlier.

Figure 1 shows the distribution of food sources by food group consumed for the sample population of pregnant women in rural and urban Nepal combined ($n=376$).

Insert Figure 1 and legend.

Period of gestation and pregnancy weight gain

Table 3 presents anthropometric data for 376 subjects enrolled in the study. The average gestational age was 37.95 (SD=2.15) weeks (median: 38 weeks). The average pre-pregnancy weight in this study was 47.42 (SD=6.29) kg (range: 34-90 kg) and average height was 1.52 (SD=0.06) meters, approx. 5 feet (4.98 feet). This gives a pre-pregnancy body mass index (BMI) of 20.65 (SD=3.08) kg/m^2 for the entire group (median value: 20.34 kg/m^2). The average gestation weeks of the mothers at delivery was 37.95(SD=2.15) weeks (median: 38 weeks).

The subjects' average total weight gain in the first trimester was 8.11(SD=2.04) kg (median: 8 kg). This study's pregnancy weight gain ranged from 4 kg to 16 kg and also showed

significant difference in weight gain among rural mothers (mean=7.85, SD=1.69 kg) and urban mothers (mean=8.36, SD=2.32 kg) ($p<0.05$).

Figure 2 shows the weight gain increased with the rise in gestation period and compares urban and rural subjects.

Insert Figure 2 and legend.

This findings show 69.4% births occurred between 37-39 weeks; 16.8% births after 40 weeks (post-term); 9% between 24-36 weeks; 3.2% between 31-33 weeks and 1.6% between 28-30 weeks. Of these births,13.8% of births were pre-term.

Table 3: BMI measurements of healthy pregnant women enrolled in the study (n=376).

	Mean	SD*	Median
Pre-pregnancy weight (kg)	47.42	6.29	47
Weight at term (kg)	55.71	6.96	55.25
Height (meter)	1.52	0.063	1.52
Gestation week (Total)	37.95	2.15	38.00
Gestation week (Urban)	38.25	1.90	38.00
Gestation week (Rural)	37.66	2.30	38.00
Pre-pregnancy BMI (Total) (kg/m ²)	20.65	3.08	20.34
Pre-pregnancy BMI (Urban) (kg/m ²)	20.81	3.22	20.69
Pre-pregnancy BMI (Rural) (kg/m ²)	20.50	2.94	20.30
BMI at term (Total) (kg/m ²)	24.24	3.44	23.94
BMI at term (Urban) (kg/m ²)	24.59	3.63	24.23
BMI at term (Rural) (kg/m ²)	23.89	3.21	23.81

*Standard Deviation

Placental Weight, Ponderal Index and Gestational week:

The average ponderal index was 27.08 (SD=3.9) kgm⁻³. Pearson correlation coefficient was

applied between the ponderal index and gestation week, which showed no significant relation between each other ($r=0.058$, $p>0.05$), whereas, there was a moderately positive but highly significant relationship between placental weight and the ponderal index ($r=.49$, $p<0.001$).

The average placental weight in the study population ($n=188$) was 543.03 (SD=85.39) gm (median - 550gm). There was a significant ($p<0.001$) but moderate relationship ($r=0.49$) between birth weight and placental weight among the urban study population. The unavailability of placental weight among rural population was one of the drawback of the study.

Discussion

Evidence from this study indicates low intake of energy, protein, calcium and zinc in maternal diets of both rural and urban dwelling women in Nepal. Maternal protein intake was related to pregnancy weight gain in this study. ($r=.499$, $p<0.01$). The association between birth weight of the baby and protein intake of mother during pregnancy was reinforced by the findings. Low birth weight has been associated with poor maternal nutritional status including stunting, micronutrient deficiency e.g. zinc (King, 2000; McKeigue, Lamm, Linn, & Kutcher, 1994; Osendarp et al., 2001) and iron (Allen, 2000) (Haidar & Pobocik, 2009) and poor PWG. Thus the significant relationship between energy and protein intake in relation to birth outcome is one of the major causes for low birth weight and pre-term delivery in Nepal.

A significant difference ($p<0.05$) was seen in lipid, zinc and folate consumption between the urban and rural groups. The consumption of lipid was seen higher in rural than in urban. The reason for this may be due to the use of clarified butter (ghee) in the diet of rural mothers during pregnancy.

Zinc food sources from the diet are wheat, corn and barley. The consumption of these foods were higher in the diet of rural mothers than the urban mothers who base 90% of their diet on rice.

In a normal Nepalese diet lentils are consumed twice almost every day. It is a good source of folate. Other folate rich foods commonly consumed by pregnant women in Nepal are barley, pearl millet, bengal gram (whole), Sesame seeds, and cluster beans. The folate consumption as seen in this study might not be the same throughout the year. Seasonal variation in the diet of these women should be considered when interpreting the findings. During the period of study most of the pregnant women's diet included seasonal foods rich in folate for example spinach, lentils, bengal gram, cluster beans and barley. Almost 30% of the urban study group and only 5% of rural group took folic acid supplementation in this study.

Zinc plays an important role in the growth and development of the foetus. The action of zinc can be characterised in three areas. Firstly it is important for action on taste and smell acuity, appetite regulation, and food consumption and regulation; secondly it is central to DNA and RNA synthesis; and thirdly it is an important hormonal mediator. The combination of these mechanisms contributes to the physiological function of bone. Linear growth is believed to be restricted because of the zinc deficiency (Brandão-Neto, Stefan, Mendonça, Bloise, & Castro, 1995) (Ploysangam, Falciglia, & Brehm, 1997). In this study a moderate correlation ($r=0.449$, $p<0.001$) was seen between zinc intake and crown heel length. This could be a contributing factor for stunting in the geographical area of study. The average zinc intake of the sample population was 7.2 mg/day providing nearly 65.45% of the daily requirements for pregnant women, based on Indian reference data (ICMR, 1993). Therefore it is important to increase zinc intake in pregnancy in this population due to its functional roles and its importance in preventing stunting, LBW and perinatal morbidity and mortality (Osendarp et al., 2000; Osendarp et al., 2001).

Comparing between the rural and urban group showed that intakes of zinc for pregnant mothers residing in city was significantly lower than for rural areas ($p<0.00$), but still lower than the reference amounts. This is most likely due to differences in food sources.

Pregnancy weight gain of 13.6 kg is normal in healthy pregnant women (Institute of Medicine, 2009). Evidence shows the associations of pregnancy weight gain with birth weight (Abrams et al., 1989; Abrams et al., 1995; (Abrams, Altman, & Pickett, 2000). Adequate nutrition during pregnancy not only ensures the birth of a healthy baby but also prepares the mother to withstand the stress and strain of labour and prevents its complication.

This in turn reduces this high prevalence of low birth weight along with decrease in maternal mortality.

First attendance at antenatal clinic (first booking) varies but pregnant women in some developing countries, particularly those from poor communities may not start to attend an antenatal clinic until much later in the pregnancy (Lavender, Downe, Finnlayson, & Walsh, 2007; Myer & Harrison, 2003) by which time the effects of low pregnancy weight e.g. intrauterine growth restriction (IUGR) may have already started. Therefore knowledge of pre-pregnancy /maternal BMI at an early stage might be useful for interventions involving weight gain strategies as part of pregnancy management.

This study thus highlights the importance of upgrading the maternal health services to incorporate a compulsory and effective nutrition component in Nepal especially as a target to lower the alarming statistics of maternal and child health. It is hopeful that such studies not only help in increasing the access of maternal and child healthcare but also look into optimising the utilisation of the available service. Resolving the maternal and child outcomes in countries like Nepal forms strong evidence for effective global healthcare management. Further studies are mandated to understand the root of this concern affecting Nepal.

Author contributions

Conceived and designed the study: OA, PA and ZBF. Reviewed methodology and analysis: PA, FBZ. Performed the data collection OA. Interpreted the findings: OA, BE, FBZ, PA. Wrote the paper: OA, FBZ, BE. Edited the paper: OA, FBZ, BE, PC.

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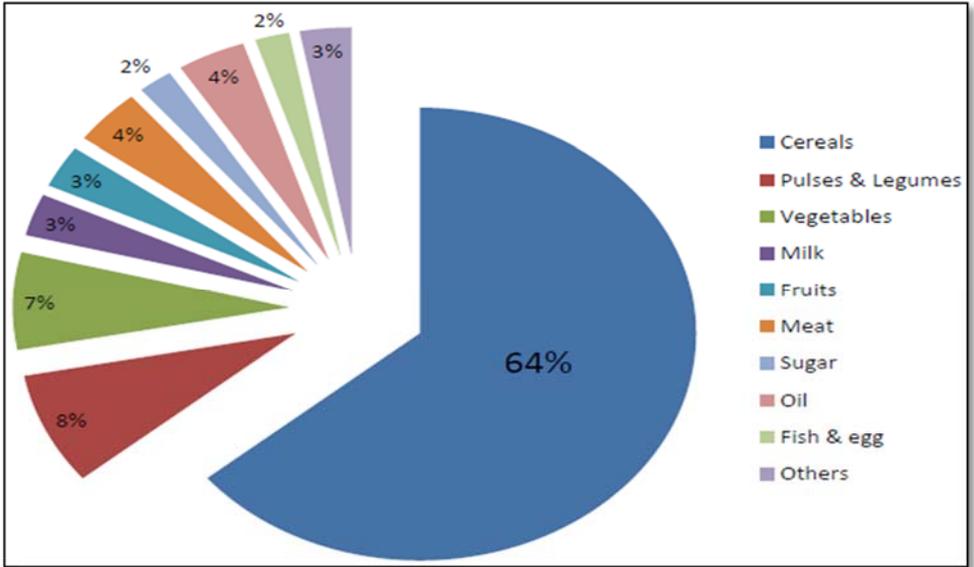


Figure 1: The distribution of food sources by food group consumed for the sample population of pregnant women in rural and urban Nepal combined (n=376).

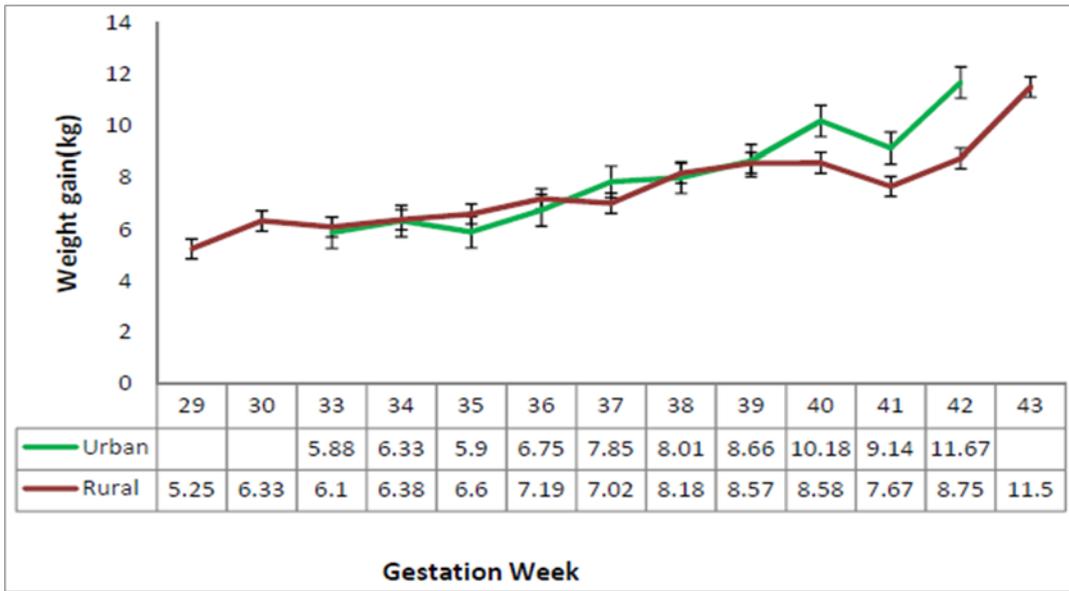


Figure 2: Weight Gain Pattern against Gestation Weeks