Analysis of the CLP's Nutritional monitoring database

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1. Introduction

This report presents the results of the longitudinal and cross-sectional analyses of the nutritional status of the six CLP Phases. Nutritional status has been measured by maternal weight, Body Mass Index (BMI) and haemoglobin concentration and in children by height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) and haemoglobin concentration. HAZ is a measure of chronic undernutrition (stunting) WHZ is a measure of acute undernutrition (wasting) and WAZ is a combination of both acute and chronic undernutrition (underweight).

2. Data sources and statistical analyses

Data were available from a total of 7 surveys conducted between March 2008 and November 2011. As can be seen from Table 1 CLP1 mothers and children had their height and weight measured up to 7 times, those in CLP2.1, three times, CLP2.2 and CLP2.2. 2nd Tier twice, and CLP2.3 and the Control phase only once. Haemoglobin concentration was only measured from survey 5 onwards and so there were a maximum of 3 measurements for CLP1 and CLP2.1, two measurements for CLP2.2 and CLP2.2 2nd Tier and one measurement for CLP2.3 and the Control phase.

Table 1 History of CLP Nutrition Monitoring Surveys

Survey	CLP Phase						Date
	CLP1	CLP2.1	CLP2.2	CLP2.2 2nd Tier	CLP2.3	Control	
1	√						March-July 2008
2	√						October-November 2008
3	√						April 2009
4	√						October-November 2009
5	√	√					April 2010
6	√	√	√	√			October-November 2010
7	√	√	√	√	√	√	October-November 2011

Separate analyses were undertaken for mothers and children. Initially changes in maternal weight and BMI were analysed for CLP1 mothers only as they provided the clearest trends of changes over time. Repeated measures analysis of variance was the statistical tool used which tested whether there were significant within-mother changes over the 7 measurements. The second analysis focussed on a comparison of CLP1 and CLP2.1 mothers over surveys 5 to 7. Again repeated measurement analysis of variance was used but besides testing whether there was within mother heterogeneity the analyses also tested whether or not the trends over the three surveys were the same or not in the two CLP phases (i.e. the lines were parallel) as well as whether the overall means (the average of the three surveys) was homogeneous or not. The third analysis compared CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd Tier just for surveys 6 and 7 again using repeated measures analysis of

variance as described for the second analyses. The fourth analysis used oneway analysis of variance to compare the means of all six phases just at survey 7. Finally the results of all analyses were presented graphically so that the trends over time for all six phases could be compared. The analyses for children followed the same steps as for mothers.

3. Results

3.1 Maternal nutritional status

3.1.1 Changes in Maternal Weight in CLP1

CLP1 mothers were surveyed a maximum of 7 times between March 2008 and October 2011. Mothers were selected who were less than three months pregnant in any survey and for whom there was complete data for all 7 surveys.

Repeated measures analysis of variance revealed that there was a highly significant (p<0.001) within-mother gain in weight averaging 2.5kg between surveys 1 and 7 equivalent to a 6% increase in body weight. The changes in mean weight by survey are presented in Figure 1.

Figure 1 Changes in Mean Maternal Weight in CLP1 by Survey
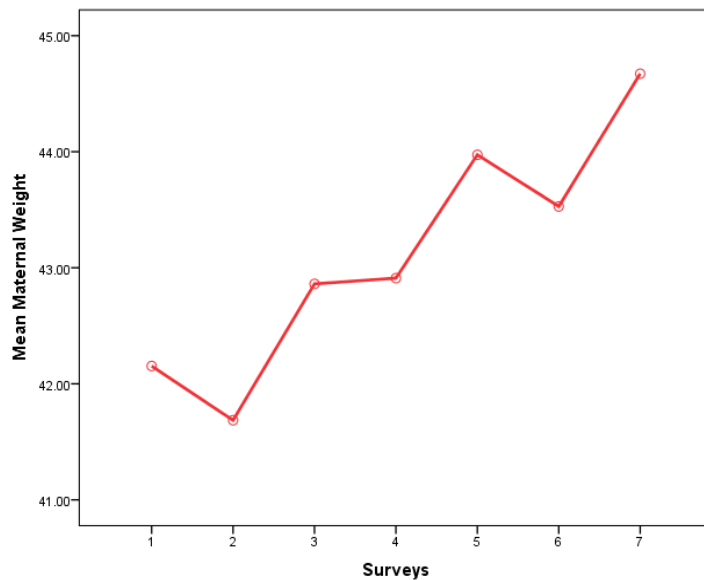
As can be seen there were small falls in mean weight in surveys 2 and 6. Part of the variation across surveys might be due to seasonal variation and so the data were reanalysed just for surveys 2, 4, 6 and 7 which were all conducted in October and November each year. The results are presented in Figure 2 and they show a near linear increase in maternal weight across the four surveys from 41.7kg in survey 2 to 44.7kg in survey 7 (p<0.001), an increase in 3kg (equivalent to a 7% increase in body weight).

Figure 2 Changes in Mean Maternal Weight in CLP1 by Survey (just for surveys 2, 4, 6 and 7)
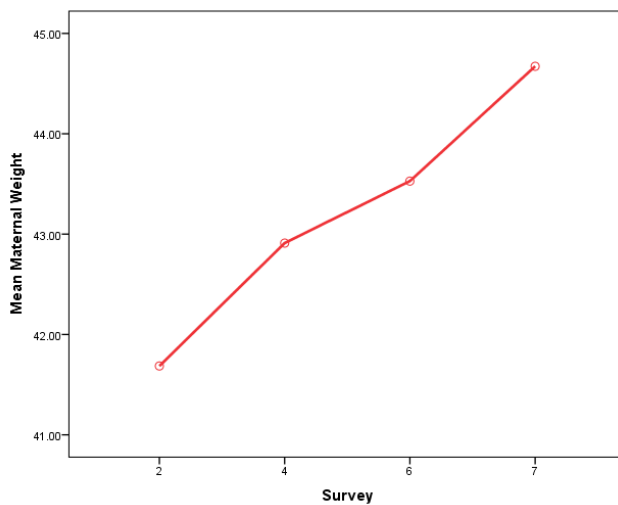
3.1.2 Changes in Maternal Body Mass Index in CLP1

The analyses were repeated for Body Mass Index. Mean BMI significantly increased from 18.6 in survey 1 to 19.7 in survey 7 (p<0.001, Figure 3) and the changes by survey mirrored the changes seen for maternal weight. When the analyses were repeated just for surveys 2, 4, 6 and 7 there was a near linear increase in mean BMI across the four surveys (p<0.001, Figure 4).

The percentage of mothers with BMI <18.5 (the cut-off for Chronic Energy Deficiency, CED) fell from 51.0% in survey 1 to 37.2% in survey 7 (p<0.001); CED III (BMI <16) fell from 8.7% in survey 1 to 4.6% in survey 7 and CED II (BMI 16-16.99) also fell from 12.2% to 7.1% between surveys 1 and 7, respectively (both p<0.001). Figure 5 presents the changes in BMI categories over the 7 surveys.

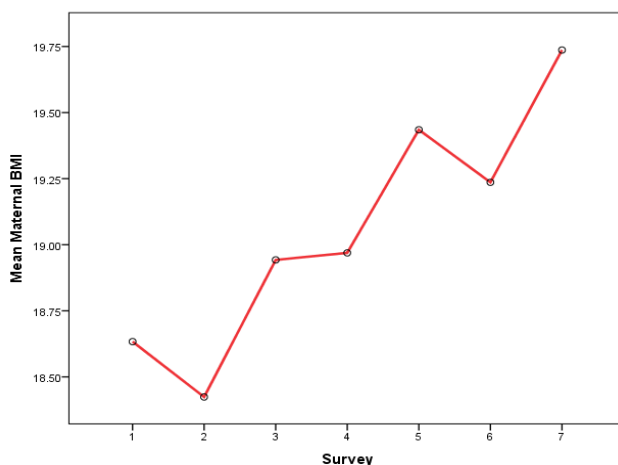Figure 3 Changes in Mean Maternal BMI in CLP1 by Survey

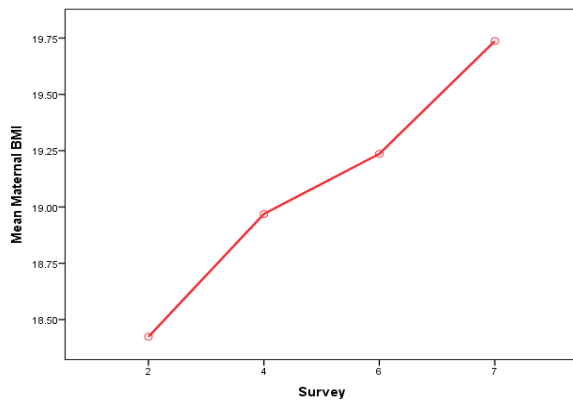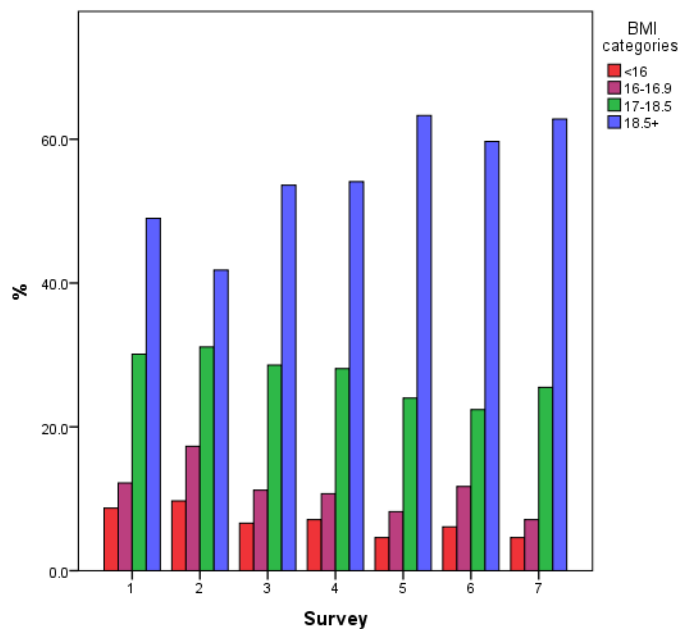Figure 4 Changes in Mean Maternal BMI in CLP1 by Survey (just for surveys 2, 4, 6 and 7)

Figure 5 Changes in Maternal BMI categories (%) in CLP1 by Survey


3.2 Comparison of CLP1 and CLP2.1 Phases

3.2.1 Changes in Maternal Weight

CLP1 and CLP2.1 phases were compared for surveys 5 to 7 in relation to maternal weight, BMI and haemoglobin concentration. Repeated measures analysis of variance showed that there were significant changes in within-mother's weight over the three surveys (p<0.001) and there was a consistent trend in both phases (p ns) with maternal weight falling between surveys 5 and 6 (means of 43.4kg and 42.9kg, respectively) and improving slightly in survey 7 (mean 43.2kg). Figure 6 shows that the lines for the two phases were essentially parallel (p ns) but overall the mean weight of mothers in CLP1 was significantly higher by 0.8kg than CLP2.1 mothers (43.6 kg versus 42.8kg, respectively, p<0.001).


Figure 6 Changes in Mean Maternal Weight in CLP1 and CLP2.1 Phases by Survey
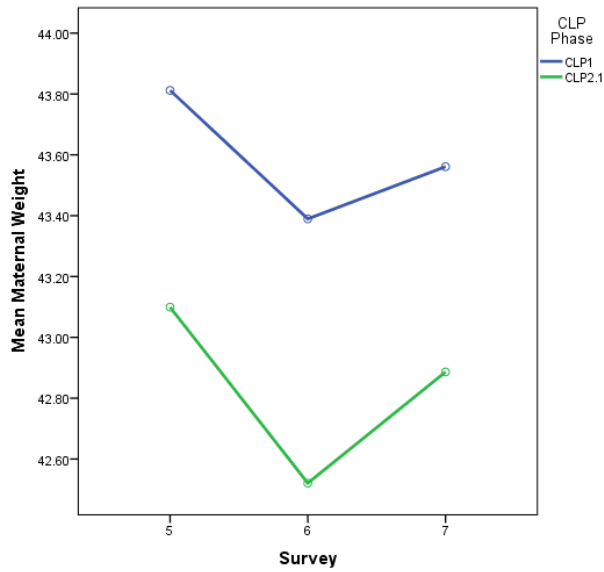
3.2.2 Changes in Maternal Body Mass Index

When the analyses were repeated for Maternal BMI, no significant within-mother differences in BMI were found across the three surveys (Figure 7) but the overall mean BMI was significantly higher in CLP1 phase than CLP2.1 by 0.4 kgm^{-2} (p<0.001).

Figure 7 Changes in Mean Maternal BMI in CLP1 and CLP2.1 Phases by Survey
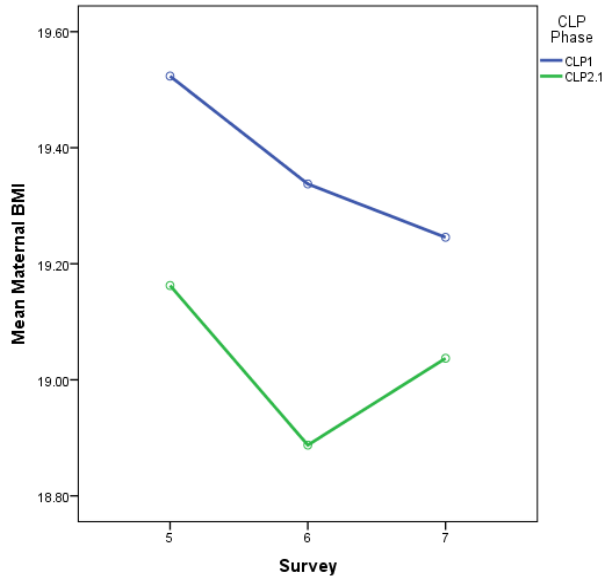
The percentage with BMIs in the normal range fell from 62.4% in survey 5, to 56.9% in survey 6 and increased back to 59.8% in survey 7.

3.2.3 Changes in Maternal Haemoglobin

There was significant within-mother change in haemoglobin concentration (Figure 8, p<0.001) and the mean maternal haemoglobin concentration fell consistently across the three surveys (p<0.001) but there was no significant difference in the trend between the two phases (p ns, i.e. the lines were parallel). However there was a significant difference in overall means with mothers in CLP1 having a just significantly higher mean than CLP2.1 mothers, (120.5 versus 118.7, respectively, p = 0.04).

Figure 8 Changes in Mean Maternal Haemoglobin in CLP1 and CLP2.1 Phases by Survey
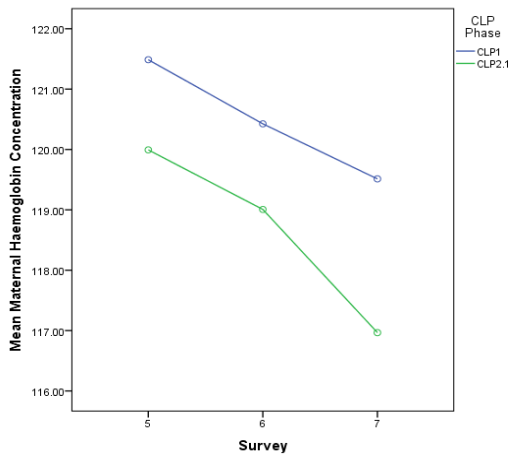
For the two phases combined the percentage of mothers who were anaemic increased from 44.1% in survey 5 to 47.9% and 53.6% in surveys 6 and 7, respectively. Most of the increase in anaemic prevalence was due to the sharp rise in CLP2.1 (Figure 9) between surveys 6 and 7 and there was a significant difference in anaemic prevalence only in survey 7 between CLP1 and CLP2.1 (45.6% and 58.9%, respectively, p=0.004).

Figure 9 Anaemia prevalence CLP1 and CLP2.1 Phases by Survey
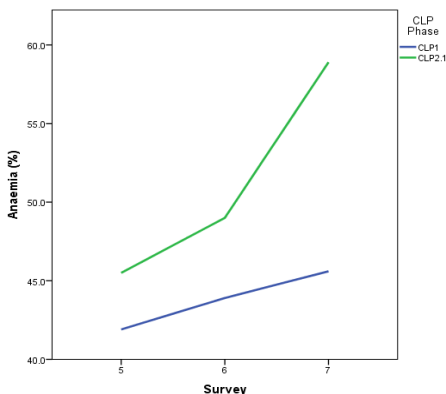
3.3 Comparison of CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd Tier Phases

As a significant difference in mean haemoglobin was found in survey 6 between CLP2.2 and CLP 2.2 2nd tier the analyses presented have not amalgamated the two CLP2.2 phases and comparisons have been undertaken between the four 'phases'.

3.3.1 Changes in Maternal Weight

As can be seen from Figure 10 there was very little change in mean weight between surveys 6 and 7 in each of the four phases and the changes in mean weights between surveys 6 and 7 were not significantly different between the four phases nor were there any significant differences in the overall means between the four phases.

Figure 10 Changes in Mean Maternal Weight in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
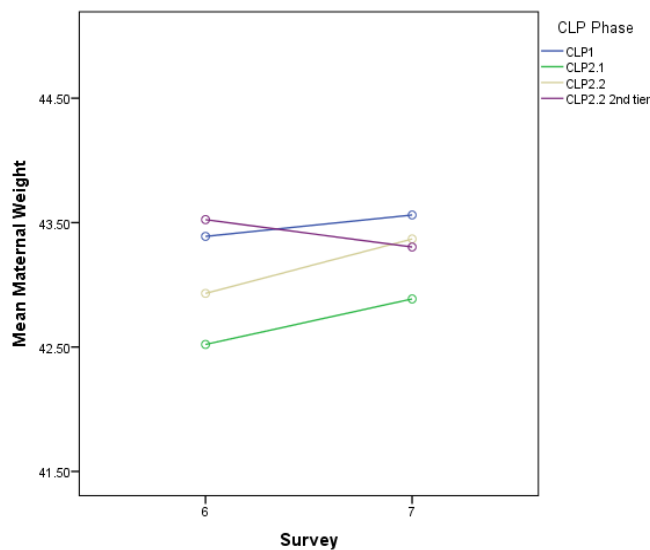
3.3.2 Changes in Maternal Body Mass Index

There was very little change in mean BMI between surveys 6 and 7 in each of the four phases nor were there any significant differences in the overall means between the four groups (Figure 11).

Figure 11 Changes in Mean Maternal BMI in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd Tier Phases by Survey
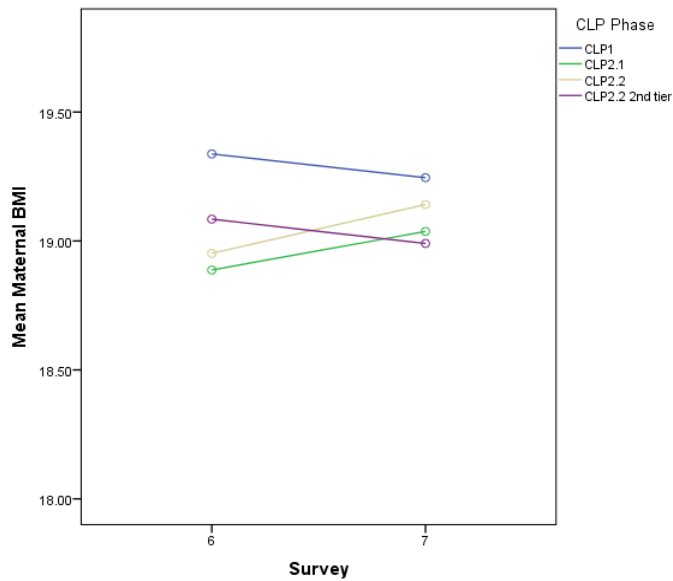
3.3.2 Changes in Maternal Haemoglobin

Repeated measures analysis of variance showed that the mean haemoglobin of all four phases fell between surveys 6 and 7 particularly so for CLP2.2 2nd tier which fell by over 5 g/dl (p>0.001, Figure 12). The overall means of CLP1 and CLP2.2 2nd tier were significantly higher than CLP2.1 and CLP2.2 (p<0.001).

Figure 12 Changes in Mean Maternal Haemoglobin Concentration in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
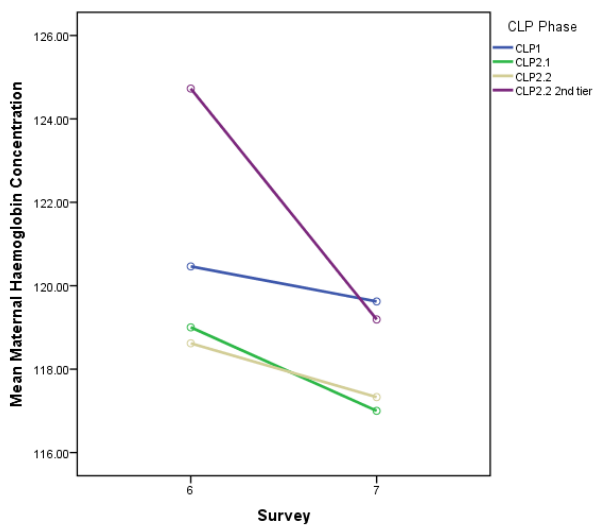
3.4 Comparison of CLP1, CLP2.1, CLP2.2, CLP2.2 2nd Tier, CLP2.3 and Control Phases at survey 7

3.4.1 Maternal Weight

Table 2 presents the mean maternal weights for the six different phases at survey 7. There was significant (p<0.001) heterogeneity between the six means mainly due to the lower mean maternal weight in the control phase. Post-hoc tests showed that the control phase had a significantly lower mean that CLP1 (p=0.04), CLP2.2 (p=0.025) and CLP2.3 (p<0001).

Table 2 Mean Maternal weight, BMI and haemoglobin concentration of the different phases at survey 7

Phase	Weight	BMI	% <18.5 BMI	Haemoglobin	% anaemic
CLP1	43.6	19.2	38.8	119.7	45.6
CLP2.1	42.9	19.0	41.6	117.0	58.9
CLP2.2	43.4	19.1	43.4	117.3	55.8
CLP2.2. 2nd tier	43.3	19.0	48.3	119.2	49.8
CLP2.3	44.0	19.5	42.2	121.0	47.4
Control	41.7	18.7	51.0	121.2	43.4

3.4.2 Maternal BMI

The mean maternal BMIs also varied significantly (p=0.004 and Table 2) with a lower mean in the control phase. Post-hoc tests showed that the only significant difference was between the higher mean in CLP2.3 compared with the control phase. The control phase had the highest percentage of mothers with Chronic Energy Deficiency (BMI <18.5) of 51% and CLP1 the least (38.8%, p=0.01).

3.4.3 Maternal Haemoglobin

There was significant heterogeneity between the six means (p<0.001) with the main differences being the lower means in CLP2.1 and CLP2.2 compared with CLP2.3 and the control phase (all p<0.001). The control phase had the lowest percentage with anaemia (43.4%) while CLP2.1 had the highest percentage (58.9%, p<0.001).

3.5 Comparison of Maternal weight, BMI and haemoglobin concentration over all six phases

Figures 13 to 15 present the mean weight, BMI and haemoglobin concentration for all six phases depending on how many surveys were conducted.

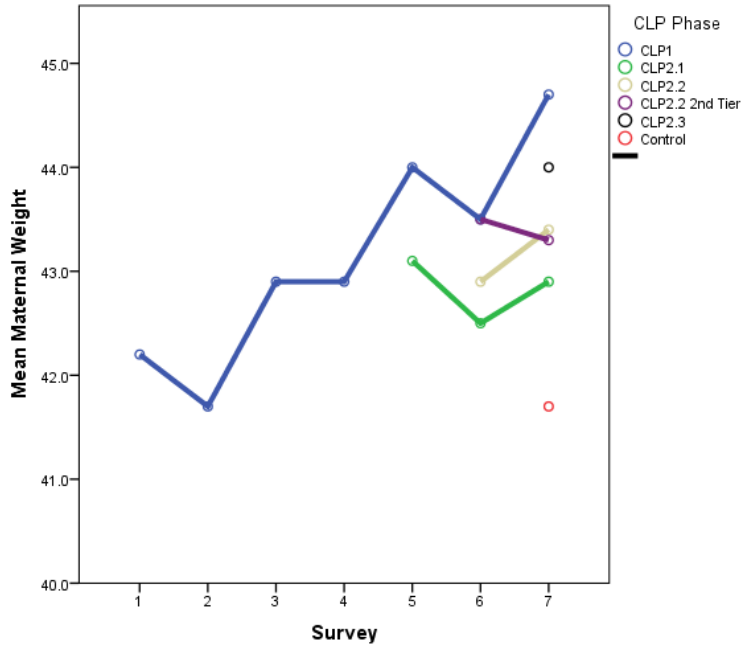Figure 13 Mean Maternal Weight by CLP Phase and Survey

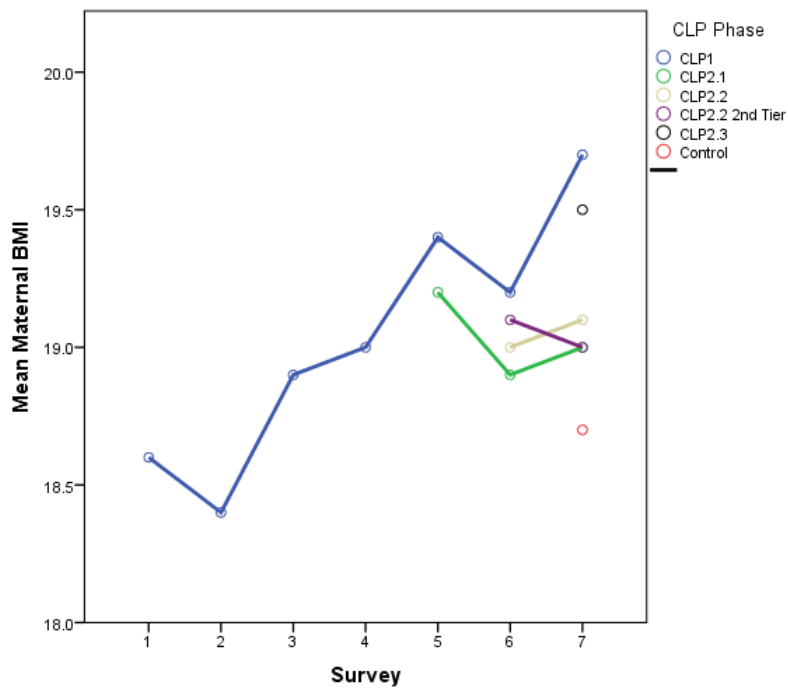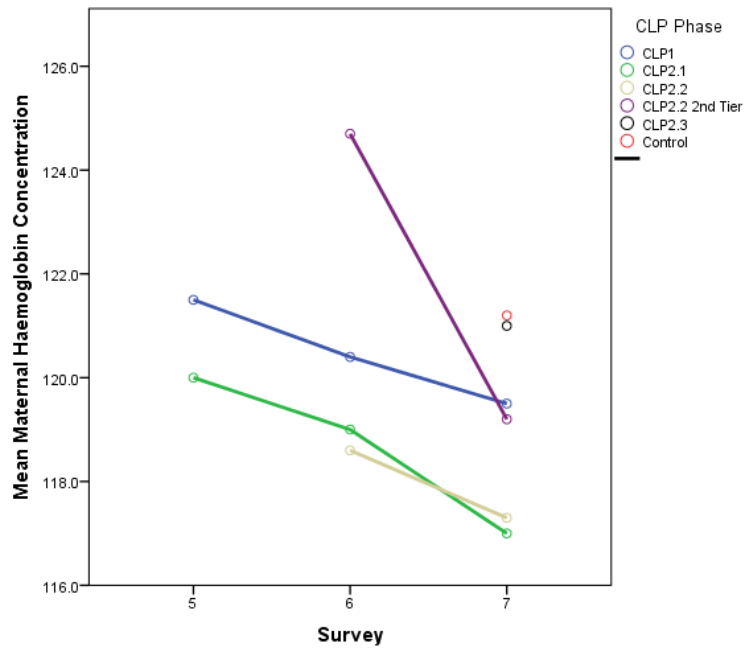Figure 14 Mean Maternal BMI by CLP Phase and Survey

Figure 15 Mean Maternal Haemoglobin Concentration by CLP Phase and Survey

For CLP1 there was evidence of an upward trend in both maternal weight and BMI i.e. an improvement in nutritional status over the 7 surveys. The other phases have much fewer surveys and drawing firm conclusions from 2 or 3 surveys must be made with caution. For CLP2.1 and CLP2.2 there was an upward trend in surveys 6 and 7 but CLP2.2 2nd Tier showed a downward trend so there was inconsistency in the trends between the two CLP2.2 phases. The Control phase had a much lower mean weight and BMI than the other phases in survey 7 and in particular CLP2.3.

For maternal haemoglobin there was consistent evidence for the four phases with data on more than one survey of a downward trend in mean haemoglobin and a concomitant increase in anaemia.

4.1 Child Nutritional Status

4.1.1 Changes in height-for-age Z-scores (HAZ) in CLP1

There was no significant difference in mean HAZ between boys and girls (means of the seven surveys, -1.47 and -1.49, respectively) nor was there any significant difference in the pattern of changes over the 7 surveys by sex of the child. Repeated measures analysis of variance revealed highly significant within-child variation in height-for-age Z-scores over the 7 surveys ($p<0.001$). As can be seen from Figure 16 there was a sharp worsening of mean HAZ between surveys 1 and 2, but from surveys 4 to 7 there was some improvement with mean HAZ rising -1.54 to -1.44.

Figure 16 Changes in mean HAZ over the 7 Surveys
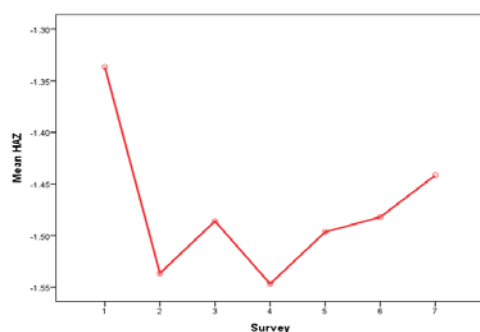
The percentage of children who were stunted increased from 34.9% in survey 1 to 48.0% in survey 7 and then improved back to 34.9% in survey 7.

4.1.2 Changes in weight-for-age Z-scores (WAZ) in CLP1

There was no significant difference in mean WAZ between boys and girls over the 7 surveys (-1.74 and -1.77, respectively). The analyses revealed a close to linear worsening ($p<0.001$) in mean WAZ from survey 1 to survey 7, and the mean fell from -1.58 to -1.91 (Figure 17). The percentage of children who were underweight increased from 34.3% in survey 1 to 45.7% in survey 7 (see Figure 19).

Figure 17 Changes in mean WAZ over the 7 Surveys
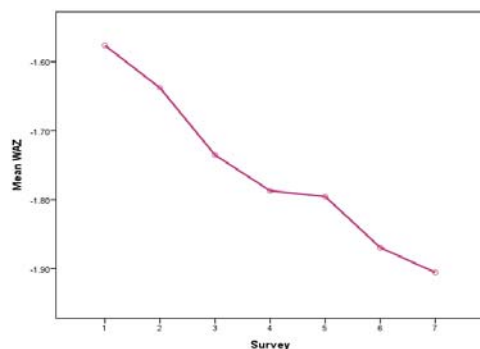
4.1.3 Changes in weight-for-height Z-scores (WHZ) in CLP1

There was no significant difference in mean WHZ between boys and girls over the 7 surveys (-1.23 and -1.18, respectively). Mean WHZ improved slightly between surveys 1 and 2 to -0.96 and then worsened and reached -1.46 by survey 7 (p<0001, Figure 18). The percentage of children who were wasted increased from 13.1% in survey 1 to 25.3% in survey 7 (Figure 19).

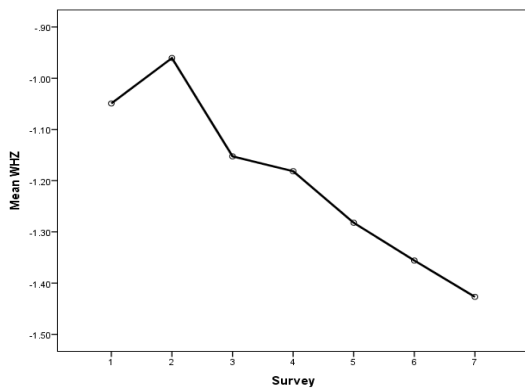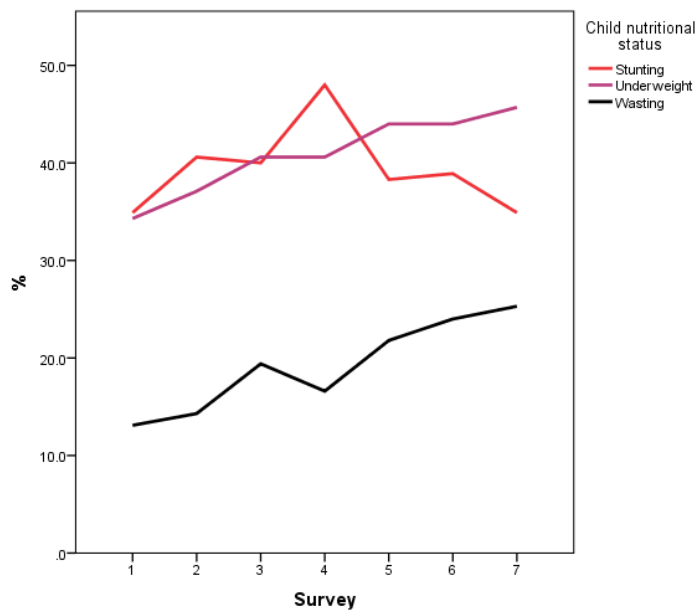Figure 18 Changes in mean WHZ over the 7 Surveys

Figure 19 Changes in the percentage of children stunted, underweight and wasted over the 7 surveys


4.2 Comparison of CLP1 and CLP2.1 Phases

CLP1 and CLP2.1 phases were compared for surveys 5 to 7 in relation to HAZ, WAZ, WHZ and haemoglobin.

4.2.1 Changes in Height-for-age Z-scores

Repeated measures analysis of variance showed that there were no significant within-child changes over the three surveys but the mean of CLP2.1 was consistently worse that CLP1 by 0.28 SDs (-2.02 and -1.74, respectively, Figure 20).

Figure 20 Changes in HAZ in CLP1 and CLP2.1 Phases by Survey
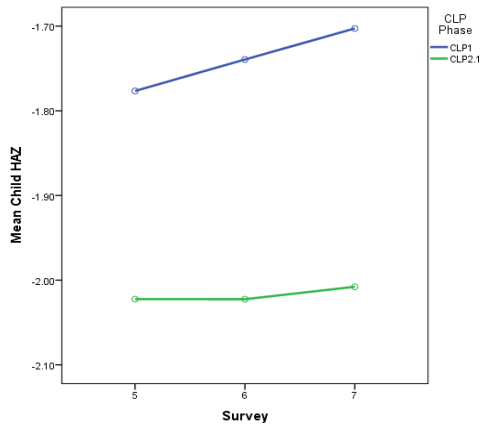
The percentage of children who were stunted fell from 44.6% in survey 5 to 40.1% in survey 7 in CLP1 and from 53.5% to 48.4% in CLP2.1.

4.2.2 Changes in Weight-for-age Z-scores

The changes in WAZ over the three surveys was very similar in CLP1 and CLP2.1 and in both phases children became significantly more underweight ($p < 0.001$) although there was no significant difference in the overall means between phases (Figure 21). The percentage of children who were underweight increased from 47.6% to 48.8% in CLP1 and from 45.8% to 49.7% in CLP2.1.

Figure 21 Changes in WAZ in CLP1 and CLP2.1 Phases by Survey
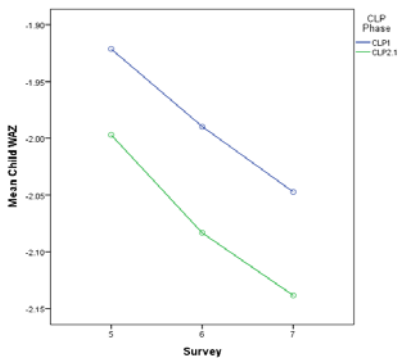
4.2.3 Changes in Weight-for-height Z-scores

In both CLP1 and CLP2.1 the mean WHZ worsened from surveys 5 to 7 and the downward trend was similar in both phases (Figure 22). There was a just significant difference in overall mean with CLP1 worse than CLP2.1 (-1.29 versus -1.13, respectively, p=0.03). The percentage of children who were wasted increased from 19.0% to 23.2% between surveys 5 and 7 in CLP1 and from 16.6% to 22.3% in CLP2.1.

Figure 22 Changes in WHZ in CLP1 and CLP2.1 Phases by Survey
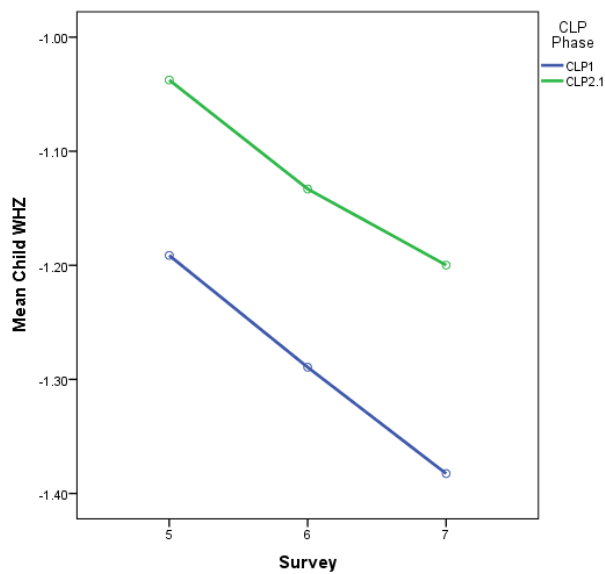
4.2.3 Changes in Haemoglobin

The changes in mean haemoglobin concentration are presented in Figure 23. There was a consistent upward trend in means across the surveys in both phases (p<0.001), with an overall improvement of about 2 g/dl between surveys 5 and 7. The CLP1 children had, on average, about 2 g/dl higher mean (111.9 g/dl versus 109.9 d/fl for CLP1 and CLP2.1, respectively). The percentage of children who were anaemic fell from 43.3% to 34.9% in CLP1 and from 51.1% to 41.0% in CLP2.1 between surveys 5 and 7.

Figure 23 Changes in Haemoglobin concentration in CLP1 and CLP2.1 Phases by Survey
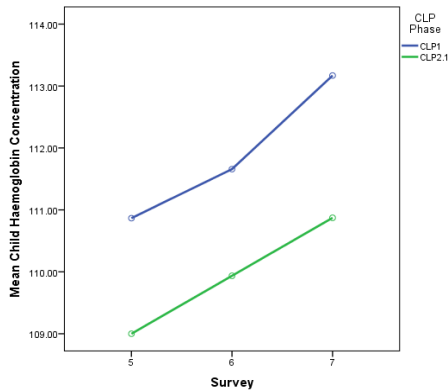
4.3 Comparison of CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd Tier Phases

As a significant difference in mean haemoglobin was found in survey 6 between CLP2.2 and CLP 2.2 2nd tier the analyses have compared the four phases.

4.3.1 Changes in Height-for-age Z-scores

There was no significant within-child change in HAZ between surveys 6 and 7 nor was there any significant heterogeneity in the trends across the four phases (Figure 24). There was however significant differences in overall means with CLP2.2 having the best mean (-1.67) followed by CLP1 (-1.71), CLP2.2 2nd tier (-1.83) and finally CLP2.1 (-2.03). Post-hoc tests revealed that the CLP2.1 mean was significantly worse that CLP2.2 (p=0.002) and CLP1 (p=0.003). Just over 50% of CLP2.1 children were stunted compared with between 40%-45% in the other three phases.

Figure 24 Changes in HAZ in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
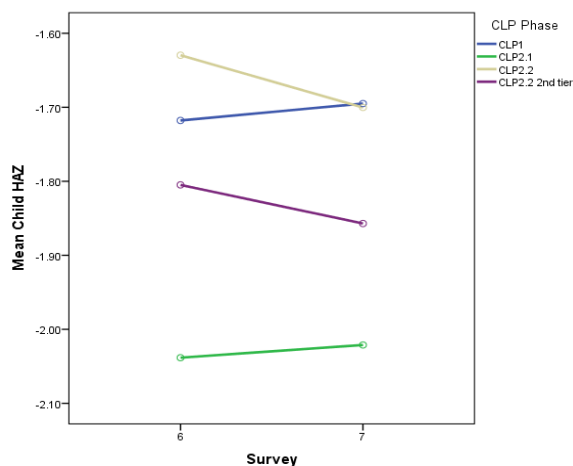
4.3.2 Changes in Weight-for-age Z-scores

There was a highly significant worsening of WAZ between surveys 6 and 7 (p<0.001 Figure 25), more so for CLP2.2 2nd tier than the other phases (p<0.001). In addition there were significant differences in overall means with CLP2.1 and CLP1 having the worst means (-2.11 and -2.01, respectively) and CLP2.2 and CLP 2.2 2nd tier significantly better means (p=0.03). The percentage underweight increased from 44% in survey 6 to over 48% in survey 7.

Figure 25 Changes in WAZ in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
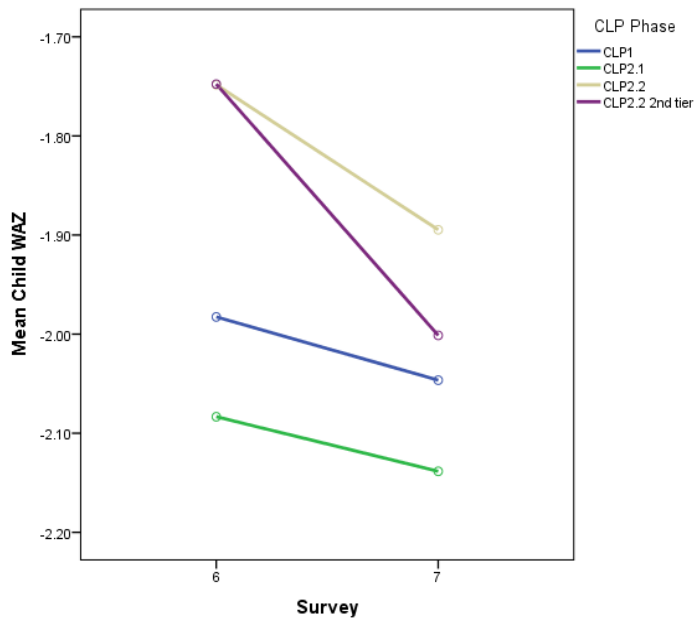
4.3.3 Changes in Weight-for-height Z-scores

As can be seen from Figure 26 there was significant worsening in WHZ from survey 6 to 7 (p<0.001) and the trend was not uniform across the phases with greater worsening in the CLP2.2 2nd tier phase. The overall means were also heterogeneous with worst mean in CLP1 (-1.32) followed by CLP2.1 (-1.17) and the best means in CLP2.2 and CLP2.2 2nd tier (-1.09 and -1.07, respectively). Post-hoc tests showed that the mean differences between CLP1 and CLP2.2 and CLP2.2 2nd tier were significant (p=0.004 and p=0.009, respectively). The percentage of wasted children increased from 18.7% in survey 6 to 20.4% in survey 7 but there were higher prevalences in CLP1 and CLP2.1 (both about 23%) compared with about 16% in CLP2.2 and CLP2.2 2nd tier.

Figure 26 Changes in WHZ in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
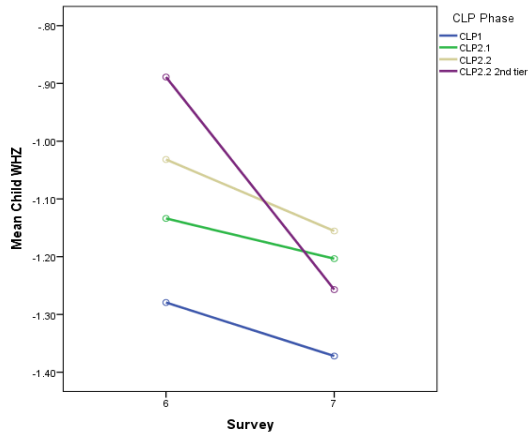
4.3.4 Changes in Haemoglobin (Hb) concentration

Between surveys 6 and 7 there was a consistent within-child improvement in haemoglobin concentration (Figure 27, p<0001) across the phases by, on average 1.3 g/dl (up from 110.9 to 112.2 g/dl). However overall mean haemoglobin concentration varied significantly between phases (p=0.014) with higher means in CLP2.2 2nd tier and CLP1 (112.9 and 112.2 g/dl, respectively) and lower means in CLP1 and CLP2.2 (110.2 and 110.6 g/dl). The percentage of anaemic children fell from 42.4% to 36.4% between surveys 6 and 7 and there were lower percentages in CLP2.2 2nd tier and CLP1 (both about 34%) and higher prevalences of above 40% in the other two phases.

Figure 27 Changes in Haemoglobin concentration in CLP1, CLP2.1, CLP2.2 and CLP2.2 2nd tier Phases by Survey
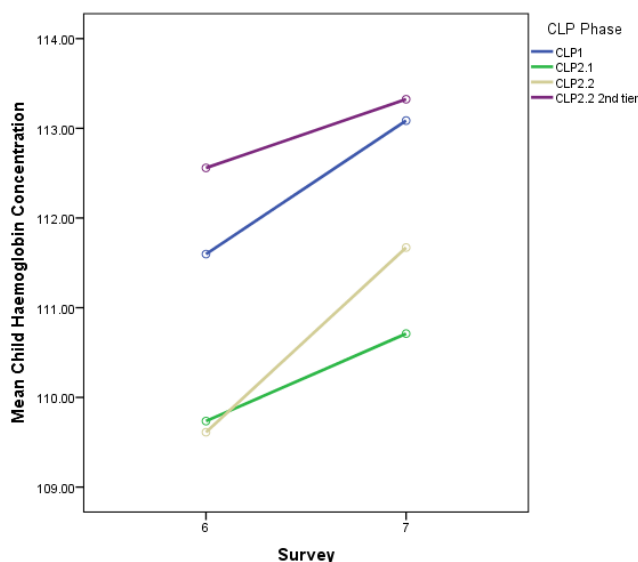
4.4 Comparison of CLP1, CLP2.1, CLP2.2, CLP2.2 2nd Tier, CLP2.3 and Control Phases at survey 7

4.4.1 Height-for-Age

Table 3 presents the means for the 6 phase as well as the prevalence of stunting. There was highly significant heterogeneity between phases with the worst means in the Control phase and CLP2.1 and the best in CLP2.2. There was significant heterogeneity in the prevalence of stunting across the 6 phases (p=0.002) with highest prevalences of over 50% in CLP2.3 and the Control phases and lowest prevalences in CLP1, CLP2.2 and CLP2.2 2nd tier.

Table 3 Means of HAZ, WAZ and WHZ and prevalences (%) of stunting, underweight and wasting

Phase	Mean HAZ	% stunted	Mean WAZ	% underweight	Mean WHZ	% wasted	Mean Hb	% anaemic
CLP1	-1.61	38.0	-2.00	48.8	-1.35	21.5	112.6	36.2
CLP2.1	-1.99	47.6	-2.11	49.7	-1.22	23.0	110.1	45.4
CLP2.2	-1.67	39.5	-1.82	40.6	-1.12	16.3	110.8	41.4
CLP2.2 2nd tier	-1.87	40.3	-2.00	46.7	-1.25	16.9	113.6	33.6
CLP2.3	-1.82	51.0	-1.78	43.8	-0.91	11.0	109.6	48.7
Control	-2.08	52.9	-1.93	43.9	-0.80	9.6	106.7	55.4

4.4.2 Weight-for-Age

WAZ showed just significant mean variation between phases (p=0.011) with the main difference being better means in CLP2.3 and CLP2.2 and a worse mean in CLP2.1. There was no significant heterogeneity in the prevalence of underweight in survey 7 across the 6 phases (Table 2)

4.4.3 Weight-for-height

WHZ means varied very significantly (p<0.001) between the six phases in survey 7 with lowest means in the Control and CLP2.3 phases and highest in CLP1. Wasting varied considerably between phases with double the rates of wasting in CLP1 and CLP2.1 than in the Control and CLP2.3 phases (Table 2).

4.4.4 Haemoglobin concentration

Mean haemoglobin concentration varied significantly between phases in survey 7 (p<0.001) with the Control phase having significantly lower mean than all the other phases except for CLP2.3. Anaemic rates were the highest in the Control phase and least in CLP2.2 2nd tier and CLP1 (Table 2).

4.5 Comparison of HAZ, WAZ, WHZ and haemoglobin concentration over all six phases

Figures 28 to 31 present the mean HAZ, WAZ and WHZ and haemoglobin concentration for all six phases depending on how many surveys were conducted.

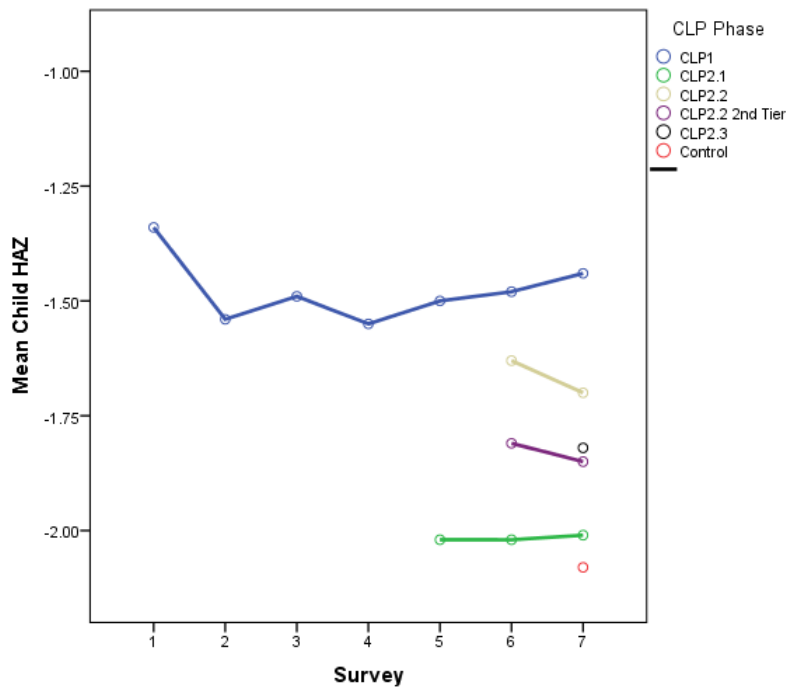Figure 28 Mean Child HAZ by CLP phase and Survey

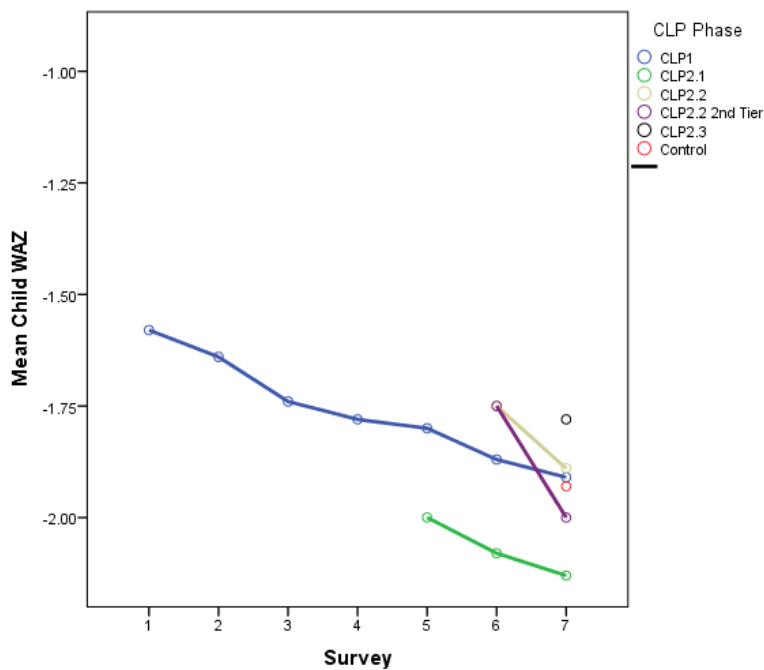Figure 29 Mean Child WAZ by CLP phase and Survey

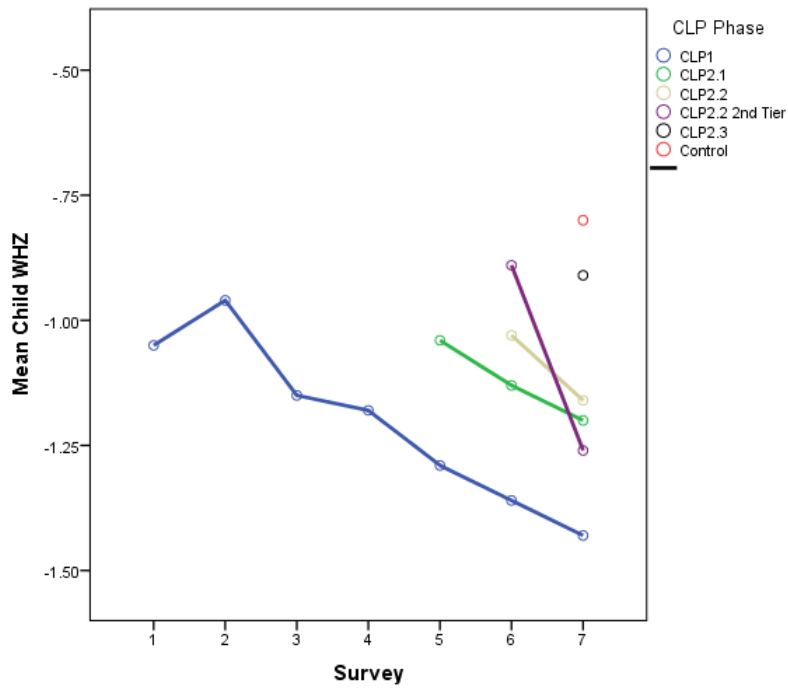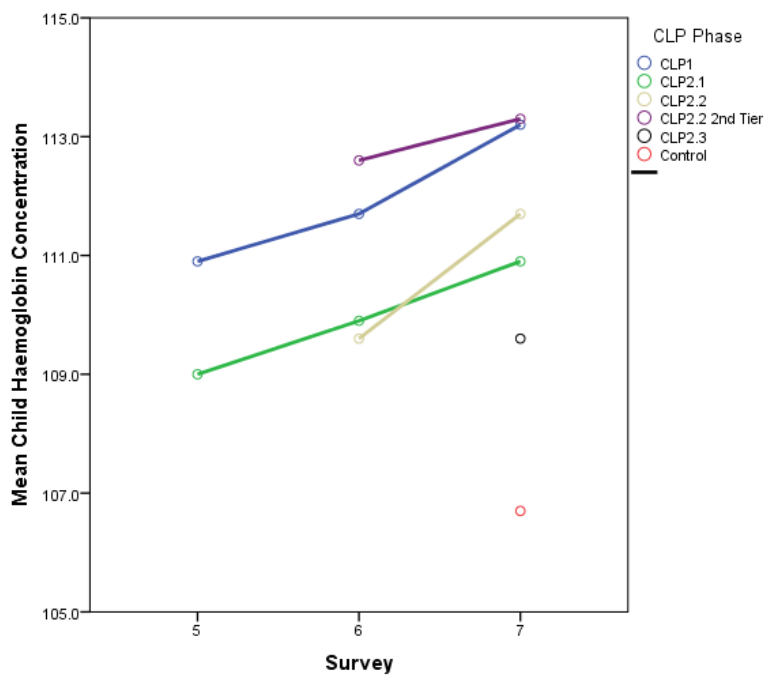Figure 30 Mean Child WHZ by CLP phase and Survey

Figure 31 Mean Child HAZ by CLP phase and Survey

The data on chronic nutritional status of the child (HAZ) were inconsistent with a slight improvement between surveys 4 and 7 in CLP1, but worsening in CLP2.2 and CLP2.2 2nd Tier and no change in CLP2.1. For acute nutritional status (WHZ) there was consistent worsening in mean Z-scores in all phases which had longitudinal data; underweight (WAZ) showed a similar worsening trend.

There was a consistent upward trend in mean haemoglobin concentration for the four phases with longitudinal data and the means of both CLP2.3 and Control phases were lower in survey 7 than the other phases.

5. Conclusions

There were inconsistent trends in nutritional status between mothers and children. Child haemoglobin means improved consistently over the surveys whereas mothers' means deteriorated. Maternal weight and BMI tended to improve over the surveys whereas child wasting and underweight worsened.