

Original Research Article

Statistical Analysis of Weight Gain of Children Under-five years in the Kintampo Municipality, Ghana

ABSTRACT

Aims/objectives: The main objective of the study was to use statistical models to assess the change in weight of children over time and to investigate whether some maternal and baby characteristics directly influence those changes. Also to determine if there is significant difference in weight gain between male and female children under-five years.

Place and Duration of Study: The data used in this study was a retrospective data on relevant variables of delivered mothers and infants or children less than five years, extracted from the weighing cards of the babies in the Kintampo Reproductive Health Care weighing center. Repeated measures of weights of babies under-five years of age for the period of July, 2014 to March, 2016, were used in this study.

Methodology: The data contains monthly repeated measurements of one hundred and fifteen (115) under-five years' children in the Kintampo municipality. Multivariate Analysis of Variance and Profile Analysis were employed to ascertain the significant factors that affect the weight of babies.

Results: The study revealed that the minimum weight (birth weight) for both male and female children were 1.8kg and 1.6kg respectively which falls below World Health Organization's standard birth weight of 2.5kg. The study further revealed that feeding type was significant ($p < 0.05$). Besides, child's age and parity were also significant ($p < 0.05$).

Conclusion: Generally, male and female children less than five years do not differ significantly in terms of weight gain. The study revealed that feeding type, age of the baby and parity plays significantly different roles or are importance in influencing weight gain in children less than five years.

Keywords: *Weight, Parity, Covariance, profile, Sex*

1.0 INTRODUCTION

Improving child health has been a key concern for many nations and this is evident from observations of numerous international summits and conferences including the Millennium Summit in 2000 [1]. Taking good care of newborn children is very important for their health and development.

In Ghana, the issue of weight-for-age of babies and factors influencing it has not received much needed attention. This should be an issue of public health concern as a nation because birth weight and it subsequent weights is a strong predictor of an individual baby's survival and a person's personality [2]. Many researches on weight-for-age of babies have reported varying causes. Some of the factors that influence weight change at birth are maternal age, maternal weight gain, parity, marital status, smoking, heredity, gender of baby, and various socio-economic factors [3]. [4] in a study conducted among adolescents and older mothers in New York reported maternal age as a significant predictor of birth weight. Also a study by [5] discovered a U-shaped relationship between age and low birth weight. [6] found that maternal and paternal education levels were the best overall predictors of reproductive outcomes like birth weight. Low socio economic status (SES) as seen to be significantly related to low

birth weight in a study by [7], conducted in an urban area in India. However a study in Thailand by [8] observed that among the SES indicators, only family income correlated with birth weight. [9] used profile Analysis to examine the Determinants of Baby Weights in Bolgatanga Municipality of Ghana. Their results showed that breastfeeding was not a significant determinant of baby weight at 5% significance level. [10] studied the relationship between sport, nationality, gender, and psychological skills. A multivariate analysis of variance (MANOVA) resulted in significant main effects for nationality, sport, gender and for the interactions between nationality, sport, and between sport and gender. Weight-for-age of babies has been found to play a vital role in early childhood development and have profound effect on later lives of children. The weight-for-age of babies, as a measure of child's growth, was found in several literatures as one of the key determinants of under-five mortality. Though monthly records have been taken in the Kintampo municipality, the ability to model it and communicate to the people is one thing that is lacking. With this observation much attention need to be paid on weight-for-age of babies, hence the need for this study.

2.0 MATERIAL AND METHODS

2.1 Source of Data and Variables

The research considered data obtained from the Reproductive Health Care (RHC) weighing center in the Kintampo Municipality of Ghana, the only but large center that served the whole Kintampo Township. The data consist of monthly repeated measurements of 115 under five year children observed over the period of seven months. The following prognostic factors were considered in the data: sex, baby's age, mother's age, mother's educational level, parity, religion, occupation, marital status and baby's feeding type.

2.2 Manova Model

The model is expressed as:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij} \quad (2.1)$$

$$= \mu_i + \varepsilon_{ij}, i = 1, 2, \dots, k; j = 1, 2, \dots, n$$

Where k is the groups of multivariate observations with n_i observations in group i , Y_{ij} is the vector of p responses observed on the experimental unit j of level k , μ_i is the population mean for population i , α_i is the effect due to factor at level i and ε_{ij} is the error term.

2.3 Model Accuracy

Normal distribution:- The Kolmogorov - smirnov and Shapiro - wilk tests were used to test the assumption that the dependent variables are normally distributed within groups.

Linearity:- Scatter plots were used to test for linearity.

Homogeneity of variances: Levene's Test of equality of variance was used to tests the assumption that the variances are equal across the groups.

Multicollinearity: - We run correlation test to test the strength and correlations among the dependent variables.

Homogeneity of variance-covariance matrix: Box's M Test was used to checks the assumption of homogeneity of covariance matrices across the groups.

2.4 Manova Inferential Procedures

The purpose of MANOVA is to use several responses simultaneously to discern significant differences among controlled experimental treatments. The MANOVA tests for all multivariate main effects and interactions and assumes the residual to be the error term. The MANOVA procedure identifies (inferentially) whether:

Different levels of the independent variables (IVs) have a significant effect on a linear combination of each of the dependent variables (DVs).

There are interactions between the IVs and a linear combination of the DVs.

There are significant univariate effects for each of the DVs separately.

Dependent variables (DV): Weight with Time points 'Month1, Month2, Month3,..., Month7'.

Independent variables (IV): Feeding practice, mother's age, mother's educational level, marital status and so on.

A MANOVA is a way to test the hypothesis that one or more independent variables, or factors, have an effect on a set of two or more dependent variables. In MANOVA, we usually test the null hypothesis to see if the vector of means of the dependent variables is equal for multiple independent groups, and the model is given as:

$$H_0 = \begin{bmatrix} X'_{11} \\ X'_{21} \\ \vdots \\ X'_{p1} \end{bmatrix} = \begin{bmatrix} X'_{12} \\ X'_{22} \\ \vdots \\ X'_{p2} \end{bmatrix} = \dots = \begin{bmatrix} X'_{1k} \\ X'_{2k} \\ \vdots \\ X'_{pk} \end{bmatrix} \quad (2.2)$$

2.5 Profile Analysis

Profile analysis is the multivariate equivalent of repeated measures or mixed ANOVA. Profile analysis uses plots of the data to visually compare across groups. The pattern of mean change in baby weight was portrayed through the profile analysis. [11] reported that profile analysis was more informative than repeated ANOVA. Profiles for the means of baby's weight were plotted against the time points for the various groups.

3.0 RESULTS AND DISCUSSION

3.1 Descriptive Analysis

The study revealed that out of a total of 115 mothers, 42 of them practice exclusive breastfeeding, indicating an estimated percentage of 36.5 whiles mothers who practice complementary feeding were 60 with an estimated percentage of 52.2% and those who used breast milk substitute were 13 indicating 11.3%. Mothers who belong to the age group of 26 – 35 years were 67 representing approximately 56.5% and those between 36 – 45 years had the least value of 18 with approximately 15.7%.

On the category of education, mothers who attained basic school level was the highest with a value of 45 approximately representing 39.1%, those who completed senior high school as well as those who had tertiary education were 27 and 12 respectively. Meanwhile mothers who did not receive any formal level of education emerged the second highest with a value of 31, which indicated an approximate percentage of 27. Mothers who had given birth for the first time were 45 corresponding to 39.1% and those who delivered 7 and 8 times recorded the same figure indicating an estimated percentage of 0.9 each.

On employment type, 90 out of 115 mothers were self - employed, those who were unemployed had an approximate percentage of 12.2. Meanwhile only 9.6% of the mothers were government employees. That can be attributed to the fact that majority of the people in the municipality are traders and farmers. Out of the 115 babies measured, 56 were male whilst 59 were females. Eighty (80) mothers were married whilst 35 of them were singles (Table 3.1).

Table 3.1 Descriptive Statistics of Mother's Characteristics and Baby

Variable		Frequency	Percent
Gender	Male	56	48.7
	Female	59	51.3
Mother's Education	Nil	31	27
	Basic	45	39.1

	Secondary	27	23.5
	Tertiary	12	10.4
Mother's Religion	Christianity	73	63.5
	Islamic	42	36.5
Marital Status	Married	80	69.6
	Single	35	30.4
Employment Type	Formal	11	9.6
	Non-formal	90	78.3
	Unemployed	14	12.2
Feeding Type	EBF	42	36.5
	CF	60	52.5
	BS	12	11.3
Mother's Age Group	16 - 25	32	27.8
	26 - 35	65	56.5
	36 - 45	18	15.7
Parity	1	45	39.1
	2	26	22.6
	3	24	20.9
	4	11	9.6
	5	5	4.3
	6	2	1.7
	7	1	0.9
	8	1	0.9

117 **EBF=Exclusive Breast Feeding, CF=Complementary Feeding, Breast milk Substitute**

118 An investigation of the result of the data showed that the least mean weight (3.0 kg) was recorded in the
 119 first month whilst 7.8kg was the highest mean weight recorded in the seventh month. The minimum and
 120 maximum weight at month one were 1.6kg and 4.9 kg respectively whereas the minimum and maximum
 121 weight values at the seventh month (half a year) were 5.2kg and 10.0kg respectively with an approximate
 122 standard deviation of 0.9481. Furthermore, it was observed that the weights of the babies recorded was
 123 found to be fairly negatively skewed and leptokurtic in nature. Thus, the fifth and seventh months were

platykurtic in nature, indicating that the weights of the babies were widely distributed around their mean value whilst the rest of the months were leptokurtic in nature, showing the weight were closely distributed around the means value as shown in table 3.2 below.

Table 3.2 Descriptive Statistics of Baby's Weight Over Time (Months)

Time (months)	Min	Max	Mean	Sd	Skewness	Kurtosis
1	1.6	4.9	3.011	0.6545	0.2010	0.121
2	1.6	6.4	4.364	0.7901	-0.0440	1.111
3	3.0	7.6	5.257	0.8563	0.1840	0.327
4	3.7	8.7	6.045	0.8759	0.0044	0.341
5	4.5	8.8	6.748	0.8716	-0.1280	-0.176
6	4.8	9.6	7.269	0.9410	-0.1830	0.066
7	5.2	10.0	7.803	0.9481	-0.2760	-0.026

The descriptive statistics of baby weights over time grouped by sex is shown in table 3.3 below. The minimum weights at the first month, males and females were 1.8kg and 1.6kg respectively with female babies recording the lower minimum weight compared to their counterpart male babies. However, at the end of the seventh month period the female babies recorded the higher minimum weight than the male babies. The standard deviations of the male and female babies at the same month one were 0.6053 kg and 0.6995 kg respectively with the male babies recording the higher mean weight of 3.064kg than their counterpart female of 2.961kg. Meanwhile the female babies recorded the greater standard deviation compared to the male babies. It was also realized that the mean change in weight of babies for the seven months period (half a year) generally exhibited nonlinear growth over time. This followed that the weight of a baby does not necessarily depend on the time the individual baby was born.

Table 3.3 Descriptive Statistics of Baby Weight Over Time (in Months) by Sex

Time (months)	Minimum		Maximum		Mean		Std. Deviation	
	Male	Female	male	Female	Male	Female	Male	Female
1	1.8	1.6	4.5	4.9	3.064	2.961	0.6053	0.6995
2	1.6	2.9	6.4	6.0	4.448	4.285	0.9189	0.6427
3	3.0	3.4	7.6	6.8	5.343	5.176	0.9605	0.7433
4	3.7	4.5	8.7	7.5	6.134	5.961	0.9649	0.7812
5	4.5	5.0	8.8	8.0	6.857	6.644	0.9115	0.8263

6	4.8	5.2	9.6	9.2	7.329	7.212	0.9682	0.9192
7	5.2	5.6	10.0	9.7	7.895	7.717	0.9651	0.9317

140 3.2 Model Adequacy

141 3.2.1 Test of Linearity

142 The hypothesis of the linearity assumption is that there are linear relationships of all pairs of dependent
 143 variables. From the Scatter plots (figure 3.1 in appendix), there appeared to be a positive correlation
 144 between the variables. The scatter plots do not show any evidence of nonlinearity, hence the assumption
 145 of linearity is satisfied.

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147 3.2.2 Test of Normality of the Dependent Variables

148 The Kolmogorov - smirnov and Shapiro - wilk tests were used to test the assumption that the dependent
 149 variables are normally distributed within groups. From the Kolmogorov-smirnov and Shapiro-wilk's table
 150 below, it is clear that both tests have p - values greater than 0.05, which indicates normality of the data.

151 **Table 3.4 Kolmogorov – Smirnov and Shapiro – Wilk Tests of Normality**

	Kolmogorov-Smirnov			Shapiro - Wilk		
	Statistic	DF	Sig.	Statistic	DF	Sig.
Weight 1	0.065	115	0.2000	0.983	115	0.166
Weight 2	0.063	115	0.2000	0.983	115	0.143
Weight 3	0.062	115	0.2000	0.991	115	0.619
Weight 4	0.06	115	0.2000	0.994	115	0.904
Weight 5	0.065	115	0.2000	0.991	115	0.645
Weight 6	0.075	115	0.0159	0.988	115	0.402
Weight 7	0.081	115	0.0600	0.989	115	0.513

152 3.2.3 Homogeneity of Variances

153 The Levene's Test of equality of variance tests the assumption of the MANOVA that the variances are
 154 equal across the groups. From the levene's test output (Table 3.5), the assumption is satisfied since all
 155 the dependent variables are not significant ($p > 0.05$).

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Table 3.5 Levene's Test of Equality of Error Variances

	F	DF 1	DF 2	Sig.
Weight 1	1.063	1	113	0.305
Weight 2	4.668	1	113	0.033
Weight 3	2.154	1	113	0.145
Weight 4	0.318	1	113	0.157
Weight 5	0.000	1	113	0.998
Weight 6	0.000	1	113	0.928
Weight 7	0.283	1	113	0.596

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Significant at 5%

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3.2.4 Homogeneity of Variance Covariance Matrices

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Box's M Test checks the assumption of homogeneity of covariance matrices across the groups. Box's M is a highly sensitive test and tends to pick up tiny differences, so it can often be ignored unless it is highly significant ($p < 0.001$) and the group sizes are very unequal [12]. The hypothesis of this assumption is that the observe covariance matrices of the dependent variables are equal across groups. From table 3.6, the output of Box's M (50.371) is not significant ($p > 0.001$), indicating the covariance matrices of the dependent variables are equal across groups.

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Table 3.6 Box's M Test of Equality of Covariance Matrices

Box's M	50.371
F	1.68
DF 1	28
DF 2	44237.233
Sig.	0.014

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Significant at 1%

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3.3 Multivariate Test

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3.3.1 Test for Group Effect

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In order to determine the factors that have significant impact on weight gain, MANOVA was carried out, making use of the following factors and covariances; baby's gender, baby's age, mother's educational level, marital status, feeding type given to babies, mother's employment type and the age of the mother. The tests show the effects of the factors on weight gain tested at 5% significance level. The MANOVA

results in Table 3.7 below revealed that feeding type is statistically significant with $F(14, 208) = 47.427$, $p = 0.000$ and Wilk's Lamda = 0.056. Wilk's Lamda is a measure of the percent of variance in the dependent variables that is "not explained" by differences in the level of the independent variable. Also, child age is statistically significant with all multivariate tests having significant values less than 0.05, wilk's lamda = 0.067, F-value = 198.302 and its associated significant value ($p < 0.05$). For parity, only Roy's Largest Root was significant whilst the rest (Pillai's Trace, Wilk's Lamda and Hotelling's Trace) were not significant at 5% significance level. Roy's largest's Root = 0.392 and has associated $F(7, 80) = 0.392$, which is significant at $p = 0.000$. This shows that feeding type given to children at their infant level, baby's age and party have significant impact on weight gain, and hence, are influential factors in determining the weight gain of children under five years whilst the other factors such as mother's age, marital status, mothers' religious affiliation and so on have no direct influence on weight gain of children less than five years (Table 3.7).

Table 3.7: Multivariate Analysis of Variance Test of Factors (Groups)

Effect		Value	F	Hyp. DF	Error DF	Sig.
Intercept	Pillai's Trace	0.975	350.389	7.000	62.000	0.000*
	Wilks' Lamda	0.025	350.389	7.000	62.000	0.000*
	Hostelling's Trace	39.56	350.389	7.000	62.000	0.000*
	Roy's Largest					
	Root	39.56	350.389	7.000	62.000	0.000*
Child Sex	Pillai's Trace	0.100	0.980	7.000	62.000	0.454
	Wilks' Lamda	0.900	0.980	7.000	62.000	0.454
	Hostelling's Trace	0.111	0.980	7.000	62.000	0.454
	Roy's Largest					
	Root	0.111	0.980	7.000	62.000	0.454
Mother's Education	Pillai's Trace	0.240	0.796	21.000	192.000	0.722
	Wilks' Lamda	0.776	0.785	21.000	178.581	0.735
	Hostelling's Trace	0.268	0.774	21.000	182.000	0.749
	Roy's Largest					
	Root	0.147	1.340	21.000	64.000	0.246
Marital Status	Pillai's Trace	0.240	0.219	7.000	62.000	0.980
	Wilks' Lamda	0.976	0.219	7.000	62.000	0.980
	Hostelling's Trace	0.025	0.219	7.000	62.000	0.980
	Roy's Largest	0.025	0.219	7.000	62.000	0.980

	Root					
Feeding Type	Pillai's Trace	1.252	24.864	14.000	208.000	0.000*
	Wilks' Lamda	0.560	47.427	14.000	208.000	0.000*
	Hostelling's Trace	11.342	82.635	14.000	208.000	0.000*
	Roy's Largest					
Occupation	Root	10.835	160.979	14.000	104.000	0.000*
	Pillai's Trace	0.185	0.919	14.000	126.000	0.541
	Wilks' Lamda	0.822	0.913	14.000	124.000	0.547
	Hostelling's Trace	0.208	0.906	14.000	122.000	0.554
	Roy's Largest					
Mother's Age	Root	0.150	1.349	14.000	63.000	0.243
	Pillai's Trace	0.079	0.442	14.000	150.000	0.958
	Wilks' Lamda	0.922	0.439	14.000	148.000	0.959
	Hostelling's Trace	0.084	0.437	14.000	146.000	0.960
	Roy's Largest					
Parity	Root	0.068	0.729	7.000	75.000	0.648
	Pillai's Trace	0.496	0.871	49.000	560.000	0.720
	Wilks' Lamda	0.575	0.893	49.000	148.000	0.678
	Hostelling's Trace	0.623	0.920	49.000	506.000	0.630
	Roy's Largest					
Mother's Religion	Root	0.392	4.480	7.000	80.000	0.000*
	Pillai's Trace	0.048	0.446	7.000	62.000	0.869
	Wilks' Lamda	0.952	0.446	7.000	62.000	0.869
	Hostelling's Trace	0.050	0.446	7.000	62.000	0.869
	Roy's Largest					
Child Age	Root	0.050	0.446	7.000	62.000	0.869
	Pillai's Trace	0.933	198.302	7.000	100.000	0.000*

Wilks' Lamda	0.067	198.302	7.000	100.000	0.000*
Hostelling's Trace	13.881	198.302	7.000	100.000	0.000*
Roy's Largest Root					
Root	13.881	198.302	7.000	100.000	0.000*

* =Significant at 5%.

3.3.2 Weight Gain by Feeding Type between Males and Females

From the MANOVA result, it has been revealed that, feeding type was an influential factor in determining weight gain among children. At this stage, we examined the effect of feeding type on weight gain between male and female children with respect to the interactive effect of gender and feeding type. Table 3.8 revealed that there were statistically significant main effects for both gender and feeding type. However, the interaction effect is not significant ($p > 0.05$). This means that the effect of feeding on weight gain is the same for both male and female children less than five years.

Table 3.8 Multivariate Test for Weight Gain by Feeding Type With Respect to Child Sex

Multivariate Tests

Effect		Value	F	Hyp. DF	Error DF	Sig.
Intercept	Pillai's Trace	0.991	1654.186	7	103	0.000*
	Wilks' Lamda	0.009	1654.186	7	103	0.000*
	Hotelling's Trace	112.42	1654.186	7	103	0.000*
	Roy's Largest Root	112.42	1654.186	7	103	0.000*
Child Sex	Pillai's Trace	0.141	2.420	7	103	0.025*
	Wilks' Lamda	0.859	2.420	7	103	0.025*
	Hotelling's Trace	0.164	2.420	7	103	0.025*
	Roy's Largest Root	0.164	2.420	7	103	0.025*
Feeding Type	Pillai's Trace	1.319	28.776	14	208	0.000*
	Wilks' Lamda	0.042	56.779	14	206	0.000*
	Hotelling's Trace	14.077	102.56	14	204	0.000*
	Roy's Largest Root	13.442	199.714	7	104	0.000*
Child Sex*Feeding Type	Pillai's Trace	0.102	0.799	14	208	0.670

Multivariate Tests

Effect	Value	F	Hyp. DF	Error DF	Sig.
Wilks' Lamda	0.900	0.796	14	206	0.673
Hotelling's Trace	0.109	0.794	14	204	0.675
Roy's Largest Root	0.082	1.219	7	104	0.299

* =Significant at 5%

3.4 Discussion

The birth weight for both males and females (1.8kg and 1.6kg respectively), could be considered as low birth weights which were not good enough because they are lower than the recommended standard for normal birth weights of 2.5kg by the World Health Organization (WHO). Among the three main feeding types, complementary feeding has the highest percentage of 52.2 whilst breast milk substitute recorded the least with only 11.3%. The high percentage of complementary feeding may be due to the campaign and intervention, that complementary feeding should be introduced into a child's diet starting around the age of six months [13].

The leptokurtic nature of the data shown in the descriptive statistics revealed how the weights were distributed around their mean value. The close distribution of weights around their mean value indicates statistical power. For the category of occupation or employment types, mothers who were self-employed (78.3%) were almost three times as mothers who were government employees together with those who were not employed (12.2%). The very high number of self-employed mothers may be due to the fact that Kintampo municipality is predominated with major farming activities and trading and hence, many women involved in these activities rather than being employed by government or other Non-Governmental Organizations (NGOs). The male and female babies slightly differed in their mean weights as well as minimum and maximum weights. The males recorded the higher minimum weight (1.8kg) and mean weight (3.064kg) at the initial month than their female counterpart of minimum weight and mean weight of 1.6kg and 2.961kg respectively, and they (males) consistently led throughout the period of observation where both male and female children recorded a mean weight of 7.895kg and 7.717kg respectively at the seventh month, suggesting that the change in weight for both males and females do not differ but seem to follow the same pattern of growth during the infant stage (Table 3.3).

The MANOVA results confirmed that feeding type is important in infant growth as reported by [14] that deprivation of colostrum and improper complementary feeding were found to be significant risk factors for underweight among children less than five years. It however, disagrees with [15] assertion that breastfeeding type was not significantly different at 5% significant level for average weight change. Moreover, socio economic status (SES) such as mother's education and occupation were not statistically significant ($p > 0.05$), confirming a study in Thailand by [16] that among the SES indicators, only family income correlated with birth weight.

Obviously, the results proved that factors such as baby's age, parity and feeding type practice by the nursing mothers were statistically significant at 5% significance level. This implies that, the mean weight of a baby can significantly be predicted by baby's age, parity and feeding type. Therefore, baby's age, parity and feeding type are significant predictors of weight of children less than five years in the Kintampo municipality.

4. Conclusion and Recommendations

In this study, it was found generally that, male and female children less than five years do not differ significantly in terms of weight gain. The MANOVA interaction results indicated that, the main effects for both feeding and sex were significant ($p < 0.05$) but their interaction effect was insignificant ($p > 0.05$). Also, the results revealed that child's age, parity and feeding type were statistically significant ($p < 0.05$). Hence, feeding type, age of the baby and parity plays significantly different roles or are importance in influencing weight gain in children less than five years.

According to the study findings, both significant and insignificant factors were identified. Hence, the health professionals, stakeholders and policy makers can make use of these findings to tailor their health care education strategies and health service provisions with potential risk children's health care needs.

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Appendix

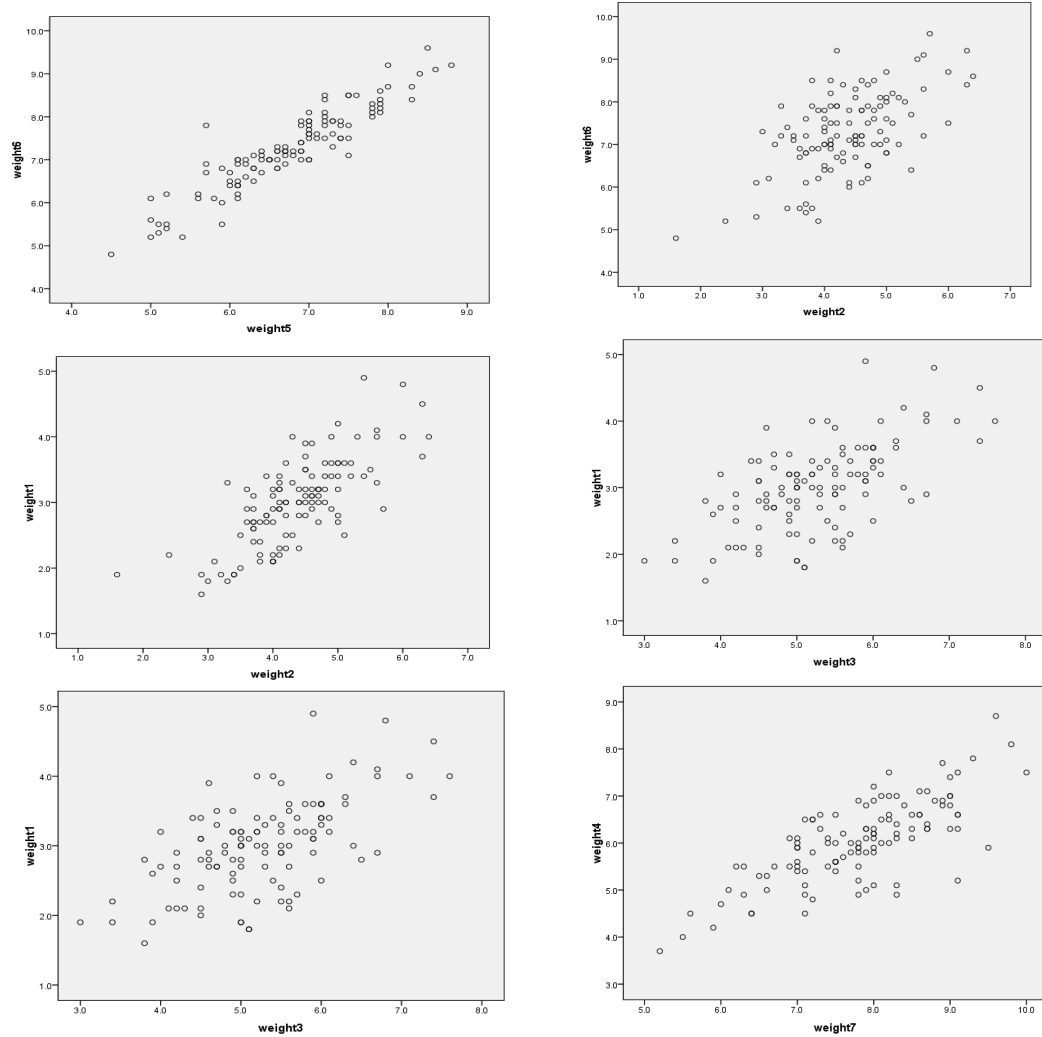


Figure 3.1: Scatter Plots of Test of Linearity