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

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Authors' contributions

This work was carried out in collaboration between all authors. Author IZ designed the study, wrote the introduction, materials and methods as well as the analysis and recommendations of the study. Author AA managed the literature searches and edited the work thoroughly. Author JD edited the methodology and the analysis of the manuscript. All authors read and approved the final manuscript.

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Abstract

Aims/Objectives: The study aims at using statistical models to assess the change in weight of children over time and to investigate whether some maternal and baby's characteristics directly influence those changes. Also to determine if there is significant difference in weight gain between male and female children under-five years.
Study Design: The study design is a repeated measures case study.
Place and Duration of Study: The key area of the study involved Ghana Health Service, Department of Public Health, (Child Health Unit), in the Kintampo municipality, between July 2014 to March 2016.
Methodology: The monthly repeated measurement data was collected from one hundred and fifteen (115) children less than five years (56 male and 59 female), in the Kintampo municipality. Multivariate Analysis of Variance and Profile Analysis were employed to ascertain the significant factors influencing weight gain.
Results: The study revealed that, the mean birth weight for both male and female children were 3.06kg and 2.96kg respectively, which were higher than the World Health Organization standard birth weight of

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2.5kg. The multivariate analysis of variance disclosed that feeding type and parity were statistically significant, (P <0.05), in determining weight gain of children less than five years. The test of main effects of feeding and sex were significant. However, their interaction effect was not significant (P >0.05), suggesting that male and female children do not differ significantly in terms of weight gain.
Conclusion: The effect of feeding on weight gain follows the same pattern for both male and female children. Moreover, feeding type and parity are important factors influencing weight gain.

Keywords: Weight; parity; covariance; profile; sex.

1 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].

Helen et al. [4] performed a secondary analysis on the Indonesia Family Life Survey (IFLS), height and weight measurements, information regarding parental education, maternal employment and household income were collected from children under five years old. Their results indicated that parental weight change is an independent predictor of child weight change. [5] 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 [6] discovered a U-shaped relationship between age and low birth weight. [7] 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 [8], conducted in an urban area in India. However a study in Thailand by [9] observed that among the SES indicators, only family income correlated with birth weight.

Akansuke et al. [10] 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. However, in a study by [11], factors that might influence weight gain (e.g. birth weight, parental body mass index, breastfeeding, hours of sleep and maternal education) were examined using linear regression to best explain differences in weight gain. Their findings reveal that birth weight and breast feeding were most importantly related to weight gain in the first six months.

Yi et al. [12] investigated the possible risk factors related to macrosomia using Logistic regression models to assess the independent association between these potential predictors and macrosomia. Their findings indicate that weight gain in pregnancy, maternal age and gestational age should be considered as independent risk factors for macrosomia. [13] 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 needs to be paid on weight-for-age of babies, hence the need for this study.

1.1 Objectives

i. To determine if there is significant difference in weight gain between male and female children under five (5) years.
ii. To identify significant factors on weight gain of children under-five years.

2 Materials and Methods

2.1 Source of data and variables

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

2.2 Study duration

One and half years data, containing detailed information on repeated measures of weights of babies under-five years of age for the period of July 2014 to March 2016, was used in this study. The data contains monthly repeated measurements of one hundred and fifteen (115) under-five years' children in the Kintampo municipality.

2.3 Study design/methods of data collection

The study design is a repeated measures case study. The data used in this study was secondary data extracted from the weighing cards of children whose mothers accessed the weighing services at the center during the study period. The extracted data obtained from the Kintampo Reproductive and Child Health weighing center covers records of delivered women, who accessed weighing services from July 2014 to March 2016.

2.4 Data variables

Key variables on delivered mothers and their respective children less than five years were captured in the extracted data. All subjects in the study were measured at the same set of time point. Thus, no missing data were involved in this study. The following variables were collected; child's age, child's gender, marital status of the mother, occupation of the mother, mother's religion, mother's educational level, mother's age, feeding type and parity. Also, repeated measurements of individual children weight was recorded at seven specific time points (monthly); weight1, weight2, weight3,… …, weightt7.

2.5 Data analysis techniques

The study employed multivariate analysis of variance (MANOVA) and profile analysis to obtain the determinant factors influencing weight gain.

The MANOVA model is expressed as:

$$\begin{aligned} Y_{ij} &= \mu + \alpha_i + \varepsilon_{ij} \\ &= \mu_i + \varepsilon_{ij}, i = 1, 2, \dots \dots \dots k; j = 1, 2, \dots \dots \dots n \end{aligned} \tag{2.1}$$

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_i is the error term.

2.6 Model accuracy

In statistical analysis, all parametric tests assume certain characteristic about the data, also known as assumptions (model accuracy). The validity of inferences drawn from statistical results depends on how well data meet associated assumptions. Therefore, this research follows these assumptions for accurate interpretation.

2.6.1 Normal distribution

The dependent variables should be normally distributed within groups. The data tested by Kolmogorov-smirnov and Shapiro-wilk's tests were found to be normally distributed, (P>0.05).

2.6.2 Linearity

MANOVA assumes that there are linear relationships among all pairs of dependent variables. The data tested using scatter plots do not show any evidence of nonlinearity.

2.6.3 Homogeneity of variances

Homogeneity of variances assumes that the dependent variables exhibit equal level of variance across the range of predictor variables. Levene's Test of equality of variance satisfied this assumption, (P>0.05).

2.6.4 Homogeneity of variance-covariance matrix

Since there are multiple dependent variables, it is also required that their inter-correlations (covariance) are homogeneous across the cell of the design. Box's M test was used to check 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 [14]. The results of Box M was not significant, (P> 0.001), indicating the covariance matrices of the dependent variables are equal across groups.

2.7 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:

a) Different levels of the independent variables (IVs) have a significant effect on a linear combination of each of the dependent variables (DVs).
b) There are interactions between the IVs and a linear combination of the DVs.
c) 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:

$$H_O = \begin{bmatrix} X_{11}' \\ X_{21}' \\ \vdots \\ X_{p1}' \end{bmatrix} = \begin{bmatrix} X_{12}' \\ X_{22}' \\ \vdots \\ X_{p2}' \end{bmatrix} = \cdots = \begin{bmatrix} X_{1k}' \\ X_{2k}' \\ \vdots \\ X_{pk}' \end{bmatrix} \tag{2.2}$$

2.8 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 babies' weight was portrayed through the profile analysis. [15] 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 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. Out of the 115 babies measured, 56 were male whilst 59 were females. Eighty (80) mothers were married whilst 35 of them were single (Table 1).

The study showed that, the least mean weight (3.0 kg) was recorded in the first month whilst 7.8 kg was the highest mean weight recorded in the seventh month. The minimum and maximum weights at month1 were 1.6 kg and 4.9 kg respectively whereas the minimum and maximum weight values at the seventh month were 5.2 kg and 10.0 kg respectively, with an approximate standard deviation of 0.9481. Furthermore, it was observed that the weights of the babies recorded was found to be fairly negatively skewed and leptokurtic in nature. Thus, the fifth and seventh months were platykurctic in nature, implying 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 2.

The descriptive statistics of baby weights over time classified by sex is shown in Table 3. Comparatively, at month1, the mean birth weight of males is higher than the mean birth weight of female babies. Averagely, male children have consistently gained weight over the seven month period as compared to that of female babies at the same period. Nevertheless, both sexes recorded higher mean weights compared to the World Health Organization standard for normal baby's weight at birth (2.50 kg).

Table 1. Descriptive statistics of mother and baby's characteristics

Variable		Percent
Sex	Male	48.7
	Female	51.3
Mother's education	Nil	27.0
	Basic	39.1
	Secondary	23.5
	Tertiary	10.4
Mother's religion	Christianity	63.5
	Islamic	36.5
Marital status	Married	69.6
	Single	30.4
Employment type	Formal	9.6
	Non-formal	78.3
	Unemployed	12.2
Feeding type	EBF	36.5
	CF	52.5
	BS	11.3
Mother's age group	16 - 25	27.8
	26 - 35	56.5
	36 - 45	15.7
Parity	1	39.1
	2	22.6
	3	20.9
	4	9.6
	5	4.3
	6	1.7
	7	0.9
	8	0.9

EBF=Exclusive Breast Feeding, CF=Complementary Feeding, BS=Breast milk Substitute

Table 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	0.201	0.121
2	1.6	6.4	4.364	0.7901	-0.044	1.111
3	3.0	7.6	5.257	0.8563	0.184	0.327
4	3.7	8.7	6.045	0.8759	0.0044	0.341
5	4.5	8.8	6.748	0.8716	-0.128	-0.176
6	4.8	9.6	7.269	0.941	-0.183	0.066
7	5.2	10	7.803	0.9481	-0.276	-0.026

Table 3. Descriptive statistics of baby weight over time (in months) by sex

Time (months)	Minimum		Maximum		Mean		SD	
	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	9.7	7.895	7.717	0.9651	0.9317

3.2 Model adequacy

3.2.1 Homogeneity of variance covariance matrices

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. The hypothesis of this assumption is that the observe covariance matrices of the dependent variables are equal across groups. 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.

3.3 Profile plot of mean weight babies by mother's educational level

The profiles by maternal educational level shows that the mean changes in weights of babies among the different levels of maternal education were changing over time, with tertiary consistently leading up to the fifth month and then falling behind secondary. However, they all follow similar pattern of growth.

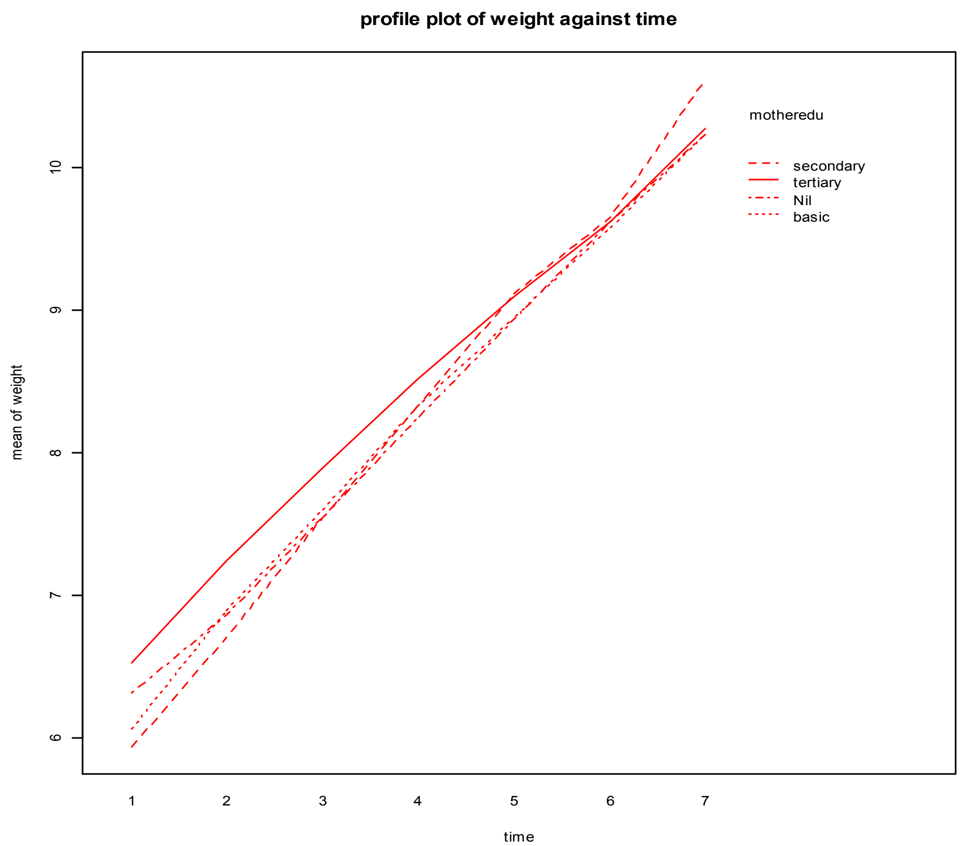

Fig. 1 profile plot of mean weight babies by mother's educational level

3.4 Multivariate test

3.4.1 Test for group effect

In order to determine the factors that have significant impact on weight gain, MANOVA was carried out, making use of the following factors or covariances; child sex, mother's educational level, marital status, feeding type given to babies, mother's employment type and the age of the mother. The MANOVA results in Table 4 revealed that, feeding type is statistically significant with $F(14, 208) = 47.427$, $P = 0\ .000$ and Wilk's Lamda = 0.056. For parity, only Roy's Largest Root was significant. These indicate that feeding type given to children at their infant stage and parity 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, mother's occupation and child's sex have no direct influence on weight gain of children less than five years (Table 4).

Table 4. Multivariate analysis of variance test of factors

Variable	Statistic	Value	F value	Sig.
Child Sex	Pillai's Trace	0.100	0.980	0.454
	Wilks' Lamda	0.900	0.980	0.454
	Hostelling's Trace	0.111	0.980	0.454
	Roy's Largest Root	0.111	0.980	0.454
Mother's education	Pillai's Trace	0.24	0.796	0.722
	Wilks' Lamda	0.776	0.785	0.735
	Hostelling's Trace	0.268	0.774	0.749
	Roy's Largest Root	0.147	1.340	0.246
Marital status	Pillai's Trace	0.240	0.219	0.980
	Wilks' Lamda	0.976	0.219	0.980
	Hostelling's Trace	0.025	0.219	0.980
	Roy's Largest Root	0.025	0.219	0.980
Feeding type	Pillai's Trace	1.252	24.864	0.000*
	Wilks' Lamda	0.560	47.427	0.000*
	Hostelling's Trace	11.342	82.635	0.000*
	Roy's Largest Root	10.835	160.979	0.000*
Occupation	Pillai's Trace	0.185	0.919	0.541
	Wilks' Lamda	0.822	0.913	0.547
	Hostelling's Trace	0.208	0.906	0.554
	Roy's Largest Root	0.150	1.349	0.243
Mother's age	Pillai's Trace	0.079	0.442	0.958
	Wilks' Lamda	0.922	0.439	0.959
	Hostelling's Trace	0.084	0.437	0.960
	Roy's Largest Root	0.068	0.729	0.648
Parity	Pillai's Trace	0.496	0.871	0.720
	Wilks' Lamda	0.575	0.893	0.678
	Hostelling's Trace	0.623	0.920	0.630
	Roy's Largest Root	0.392	4.480	0.000*
Mother's religion	Pillai's Trace	0.048	0.446	0.869
	Wilks' Lamda	0.952	0.446	0.869
	Hostelling's Trace	0.050	0.446	0.869
	Roy's Largest Root	0.050	0.446	0.869

** =Significant at 5%.*

3.4.2 Weight gain by feeding type between males and females

From the MANOVA result in Table 5, feeding type was an influential factor in determining weight gain among children. At this stage, we examined the interactive effect of gender and feeding type. The results in Table 5 revealed that, there were statistically significant main effects for both child's sex and feeding type ($P< 0.05$). However, their interaction effect was 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 in the Kintampo municipality.

Table 5. Multivariate test for weight gain by feeding type with respect to child sex

Variable	Statistic	Value	F value	Sig
Child sex	Pillai's Trace	0.141	2.420	0.025*
	Wilks' Lamda	0.859	2.420	0.025*
	Hotelling's Trace	0.164	2.420	0.025*
	Roy's Largest Root	0.164	2.420	0.025*
Feeding type	Pillai's Trace	1.319	28.776	0.000*
	Wilks' Lamda	0.042	56.779	0.000*
	Hotelling's Trace	14.077	102.560	0.000*
	Roy's Largest Root	13.442	199.714	0.000*
Child Sex*feeding type	Pillai's Trace	0.102	0.799	0.670
	Wilks' Lamda	0.900	0.796	0.673
	Hotelling's Trace	0.109	0.794	0.675
	Roy's Largest Root	0.082	1.219	0.299

** =Significant at 5%.*

3.5 Discussion

Several studies identified multiple factors that explain weight gain [3,5,7,8]. This study specifically investigated the weight change of children, identified significant factors that influence those changes, and further examined the children weights stratified by sex. The records of one hundred and fifteen (115) weights of babies were taken from the medical record files of the babies from the Reproductive and Child Health weighing center in the Kintampo municipality.

We observed in the study that, feeding type and parity were most importantly associated with weight gain of children less than five years. The link between feeding and weight gain had been reported by [11] that type of feeding was most importantly related to weight gain in the first six months from birth. The study however, disagrees with [10] assertion that breastfeeding type was not significantly different at 5% significant level for average weight change.

Averagely, male children seemed to have slightly higher weight than their counterpart female children. However, the pattern of weight change showed no significant difference between male and female children less than five years.

The birth weights for both males and females were observed to be higher than the recommended standard for normal birth weights of 2.50kg by the World Health Organization.

The high percentage of complementary feeding in the descriptive statistics may be due to the campaign and intervention that, complementary feeding should be introduced into a child’s diet starting from the age of six months [16]. Moreover, the very high number of self-employed mothers may be as a result of the fact that, Kintampo municipality is predominated by farming and trading activities. Hence, many women are involved in these activities rather than to be employed by government or other Non-Governmental Organizations. The leptokurtic nature of the data shown in the study revealed how the weights were distributed around their mean value. The close distribution of weights around their mean value indicates statistical power.

The analysis in this study focused on the most important determinants that influence weight gain. However, there are some identified factors that were not significantly related to weight gain, but had an interesting and consistent effect on the profiles over time. An example is the mother’s educational level. The profiles revealed that, mothers who attained tertiary education slightly lead compared with the other educational levels. The educational pattern of profiles with consistent lagging nature of weight change, with mothers who had no education, basic education and secondary education may suggest that their understanding of maternal and child health care educations is low compared with those who attained tertiary education. That is to say high educated mothers feed well and take good care of their children, probably due to the fact that, they were able to understand better and adhere to maternal and child health care educations offered by the midwives and other service providers. This is in agreement with [17]. The general pattern however, appeared to be approximately the same among the educational profiles. The socio economic status (SES) such as mother's education and occupation were not statistically significant (P > 0.05), confirming a study in Thailand by [9] that among the SES indicators, only family income correlated with birth weight.

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, parity as well as feeding type were statistically significant (P <0.05). Hence, feeding type and parity play significantly different roles or are important 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.

5 Study Limitations

Most facilities with data bases covering their weighing services do not collect uniform variables across-board. This makes it difficult to undertake any appropriate joint study involving all weighing facilities in the country.

Ethical Consideration

The data collected was secondary data, and the collection procedures did not involve direct contact with subjects. Also, the analysis was free from any personal identifiable information. Hence, no ethical consideration was needed. However, approval was obtained from the municipal health directorate and the management unit of the weighing center.

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Competing Interests

Authors have declared that no competing interests exist.

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