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The Effects of Breast Milk Versus Formula Feeding on Infant Growth: A Quantile Regression Approach

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ABSTRACT: The foods that the baby receives during early life impact on the health and physical growth of the newborn. This study aims to employ statistical methods such as quantile regression (QR) to examine the effect of breast milk (BF) versus formula feeding (FF) and mixed feeding (MF) on infant growth outcomes, especially weight and height. We used 207 infants of 48 months in Sulaimani City with general information about their parents as sample data, and the mode of delivery is between 38 and 40 weeks, classified by gender and feeding types. Growth metrics were measured against the World Health Organization (WHO) growth standards for children from 0 to 48 months. The QR revealed that BF supports steady and balanced growth across percentiles, with minimal gender-based differences. FF and MF were associated with increased growth outcomes at certain ages but demonstrated greater variability, particularly among female infants. Furthermore, multinomial logistic regression (MLR) indicated a significant link between Caesarean delivery and a reduced likelihood of exclusive breastfeeding, and no associations were found between parental information and choosing feedings. The body mass index (BMI) for infants compared to WHO-BMI Z-scores is normal and healthy growth, which suggests that the infants across different ages and feeding types are in normal growth, except for the FF boys at 15 months being above the median and in +1 SD, which suggests an overweight risk. These findings emphasize the nutritional and developmental advantages of BF and highlight the importance of encouraging breastfeeding practices through evidence-based health policies.
Keywords: Breast Milk , Formula, Feeding , Mix Feeding , Quantile Regression , WHO growth standards

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تأثير الرضاعة الطبيعية مقابل الرضاعة الصناعية على نمو الرضع: طريقة الانحدار الكمي

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المستخلص
تؤثر الأطعمة التي يتلقاها الطفل في مرحلة مبكرة من حياته على صحته ونموه البدني. هدف هذه الدراسة هو استخدام أساليب إحصائية مثل الانحدار الكمي (QR) لتحليل تأثير حليب الأم (BF) مقابل الرضاعة الصناعية (FF) والرضاعة المختلطة (MF) على نمو الرضع، وخاصة الوزن والطول. استخدمنا 207 رضيعًا يبلغ عمرهم 48 شهرًا في مدينة السليمانية مع معلومات عامة عن والديهم كبيانات مدروسة، و أن وقت الولادة بين 38 الى40 أسبوعًا، و تم تصنيفهم حسب الجنس و نوعالتغذيية. تم قياس مقاييس النمو مقابل معايير نمو منظمة الصحة العالمية (WHO) للأطفال من 0 إلى 48 شهرًا. ظهر نتائج الانحدار الكمي أن الرضاعة

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الطبيعية (حليب الأم) تدعم نموًا ثابتًا ومتوازنًا عبر النسب المئوية، مع وجود فروق ضئيلة بين الجنسين. ارتبطت الرضاعة الصناعية والتغذية المختلطة بزيادة نتائج النمو في أعمار معينة ولكنها أظهرت تباينًا أكبر، لا سيما بين الإناث. كما أظهر الانحدار اللوجستي المتعدد (MLR) علاقة كبيرة بين الولادة القيصرية وانخفاض احتمالية الرضاعة الطبيعية الحصرية، ولم يُعثر على أي ارتباط بين معلومات الوالدين واختيار الرضاعة. يُظهر مؤشر كتلة الجسم (BMI) للرضع مقارنةً بالدرجات المعيارية لمؤشر كتلة الجسم لمنظمة الصحة العالمية (WHO-BMI) نموًا طبيعيًا وصحيًا، مما يشير إلى أن الرضع في مختلف الأعمار وأنواع الرضاعة يتمتعون بنمو طبيعي، باستثناء ذكور الرضاعة الصناعية (FF) عند عمر 15 شهرًا، حيث تجاوزت قيمتهم المتوسط وانحرافهم المعياري +1، مما يشير إلى خطر زيادة الوزن. تُؤكد هذه النتائج على المزايا الغذائية والتنموية للرضاعة الطبيعية، وتُبرز أهمية تشجيع الرضاعة الطبيعية ودعمها من خلال سياسات صحية مبنية على الأدلة.

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Introduction

The type of early-life nutrition has a critical impact on the health and physical growth of the baby. Human milk is recommended by health organizations such as the WHO as the only source of nutrition during the early period of life to fulfil the nutritional needs of a growing and developing newborn. Infant milk companies have increased recently, becoming an effective source of income for many companies that offer a practical alternative for mothers who are not able or choose not to breastfeed. Many studies have examined the effect of feeding type on infant growth; most have focused on average outcomes using traditional mean-based statistical methods. However, these methodologies may not be able to catch significant disparities within the distribution of infant growth metrics, including weight and height. To address this limitation, our study focused on advanced statistical models such as quantile regression. It uses the conditional quantile function to model nonlinear and asymmetric relationships. Additionally, this approach is not predicated on any distributional assumptions, which makes it particularly useful for analysing cases with asymmetric conditional distributions, as is often the case in health-related research involving feeding practices and allows for a deeper comprehension of how feeding types of influence infant growth across different percentiles of the growth spectrum.

We parted our study into four sections. The methodological framework presented in the first section, the second one is the theoretical framework, and the third section is concerned with presenting the Applications and Limitations. The research concluded with the fourth section, which dealt with the conclusions and recommendations.

Section One: Methodological Framework

1.1. Research Problem

Increasing the problems in children's growth, decreased breastfeeding, and lack of attention to the benefits of breast milk for children by mothers, communities, and families, due to various reasons. From this standpoint, the research problem is determined by two questions:

1. Is there a relationship in growth outcomes between breast milk and formula feeding?
2. Is there a significant difference between infants who were breastfed and infants not breastfed?

1.2. Research Motivation

As a woman, understanding the variation between breast milk and formula feed in infant growth outcomes is a personal issue and scientific interest. From an academic perspective, this study aims to explore how health science and statistical methods, such as quantile regression, can be integrated to compare the effects of these two types of milk or both together. The main goal is to contribute to humanity's well-being and support the protection of women’s health and future generations.

1.3 Research Objective

The study aims to employ statistical methods such as quantile regression to examine data on the impact of breast milk versus formula feeding on infant growth outcomes and provide trustworthy scientific conclusions regarding infant growth outcomes by comparing the effects of breastfeeding and formula feeding.

1.4 Social and Economic Impacts of the Project

This study offers critical evidence to help parents make informed choices between feeding types (breast milk or formula). The findings support improvements in public health policies in Iraq, encouraging breastfeeding through supportive programs and women's awareness. The study helps families reduce unnecessary spending on formula milk and raises awareness about the risks of artificial feeding. At the same time, the findings can inspire positive change in the formula industry by encouraging manufacturers to increase the nutritional content of their products to look like breast milk.

1.5 Research Contribution

The study emphasises the practical application of statistical methods to health data, enhancing the understanding of complex health research models for students and statisticians. It provides evidence-based information beneficial for parents and the community, with findings that could influence public health policies. It inspires innovation in the formula industry, prompting manufacturers to improve nutritional content.

1.6 Research Hypothesis

To answer the research problem, the following hypotheses were formulated:

1. Feeding types do not significantly affect growth outcomes at specific quantiles(H_0).
2. Feeding types have a significant effect on growth outcomes at specific quantiles(H_1).

1.7 Statistical methods

To analyse our data and reach accurate and scientific results, we used statistical methods such as the Quantile Regression to investigate how the impact of breast milk and formula feeding differs across the distribution of growth outcomes, such as weight, height, and body mass index (BMI).and statistical analyses were performed using Python 3.11.5, packaged by Anaconda, Inc.

1.8 Methods of collecting data and sample size

This project was implemented in Sulaimani, in coordination with the Sulaimani General Directorate of Health, health centers, and child development consultation clinics. Data collection was conducted after receiving approval from the relevant health authorities, and all procedures were carried out in a manner that ensured the confidentiality and privacy of the children's information. The children's age is 48 months, and their information is from birth to 48 months, and the time of delivery is between 38 and 40 weeks. The sample size is as follows:

Table 1: Sample distribution by Gender and Feeding Type

Type Of Milk	Boy	Girl	Total
Breast Feeding	40	24	64
Formula Feeding	29	17	46
Mix Feeding	48	49	97
Total	117	90	207

1.9 Literature Review

In 2008, Beyerlein, A., et al. studied the association between breastfeeding and overweight in preschool children by comparing outcomes from statistical models, including logistic, linear, and quantile regression, using a dataset of 9,368 children in Germany and Bavaria. Organised during school-entry studies from 1999 to 2002, the analysis concentrated on BMI, fat, and obesity while possessing variables like breastfeeding group, gender, parental education, and maternal BMI. They discovered that logistic regression showed a defensive impact of breastfeeding against obesity, but linear regression showed no significant associations, and the results of quantile regression showed that breastfeeding decreased BMI at the 90th and 97th percentiles but was also linked with higher BMI values at lower percentiles. The contrasts in outcomes may be linked with the coding of response variables and statistical methods used, suggesting that quantile regression should be merged into future research. **(Beyerlein et al., 2008)**

After that, In 2014, Jing Yan. et al. conducted a meta-analysis to understand this association better. They analysed 25 studies involving 226,508 individuals from 12 different countries, conducted between 1997 and 2014. Their findings concluded that there is an important link between obesity and breastfeeding in children. highlighting breastfeeding as a safeguard against excessive increases in weight in children. **(Yan et al., 2014)**

Additionally, in 2017, Wang, L. et al. conducted a study of 1,234 children in the United States aged 2 to 12 who were born from 1991 to 2007 in different years. Their study emphasised that the rate of obesity increased with age, and their findings showed that the longer the duration of breastfeeding between 1 and 6 months, the lower the risk of obesity in children is lower to children who are not breastfed. These findings suggest that the low rates of breastfeeding in the 1990s may have long-term effects on children's obesity-related health outcomes. **(Wang et al., 2017)**

In 2020, Takele et al. used quantile regression to determine the factors of children's malnutrition. Utilising pieces of information from Ethiopia's Demographic and Health Survey in 2016, which includes 8743 children, the study focused on the 10th to 90th percentiles to determine the risk factors linked with undernourishment across different locations of the distribution. The results showed that a number of variables significantly impacted child malnutrition at different quantiles, including the child's old and gender, the time between pregnancies, the order of birth, nursing practices, the mother's BMI, the mother's educational attainment, the availability of sanitary facilities, and geographical variations. Positively, the impacts of these factors differed depending on the distribution, highlighting the importance of targeted interventions addressing specific segments of the child population to combat malnutrition effectively. **(Takele et al., 2020)**

After that, in 2022, Bhusal and Sapkota examined a study in Nepal of how different socioeconomic and demographic elements affected the nutritional status of children under 60 months. The study analysed information on 6,288 children from the 2019 Nepal Multiple Indicator Cluster Survey (MICS). They emphasised the factors that influence children's height for age z-scores (HAZ). they applied quantile regression to look at different points along the growth spectrum, from the most undernourished children to those doing relatively well. They found that a child’s age, sex, the province they lived in, and household wealth played a consistent role in shaping nutritional outcomes across all groups. The findings indicated that mothers with more education tended to have children with better growth outcomes, though this effect was less visible among the most inadequately nourished. Other factors, like the mother’s age and the size or number of the family members, had effects on HAZ at different quantiles. Quantile regression approach demonstrated that the impact of many parameters varied throughout the HAZ conditional distribution. **(Bhusal and Sapkota, 2022)**

Section Two: Theoretical Framework

2.1 Quantile Regression Model (QR)

The QR model was presented by the two American professors Koenker and Bassett in 1978. It is a statistical method that enhances the least absolute deviation (LAD) regression, offering a more exhaustive knowledge of the relationship between response and predictor variables compared to ordinary least squares (OLS). Quantile regression uses the conditional quantile function to model nonlinear and asymmetric relationships. Additionally, this approach is not predicated on any distributional assumptions, which makes it particularly useful for analyzing cases with asymmetric conditional distributions, as is often the case in health-related research involving feeding practices. Quantile Regression offers to investigate how the distribution of growth outcomes differs when using different feeding types. Unlike traditional mean-based analyses, the quantile regression model provides insights into how these feeding methods influence infants at different quantile levels of the growth distribution. This approach allows a deeper insight into the heterogeneous impacts of feeding practices on infant growth and is also robust to outliers. Usually, infants' growth data contain outliers or extreme values. QR is more robust to these outliers in contrast to ordinary least squares (OLS), ensuring that our results are not unduly influenced by a few extreme cases. **(Koenker and Bassett 1978; Kramer et al., 2001; Li: 2010; Haung et al., 2017)**

2.1.1 Properties of the QR Model

A. Models any conditional quantile (e.g., median, 25th percentile, 90th percentile).
B. Less sensitive to outliers than mean regression (especially at lower and higher quantiles), making it ideal for skewed or non-normal data.
C. It does not require the residuals to follow a normal distribution.
D. It is more flexible than OLS. because it does not just depend on the homoscedasticity of the errors.
E. The coefficients reflect differences across the entire distribution of the response variable, not just the average.

2.1.2. Assumptions of the QR Model

A. The model assumes that the association between the explanatory variables and the conditional quantile of the responses for parametric quantile regression is linear.
B. It assumes that observations should be independent from each other.
C. No assumption of normality.
D. No assumption of constant variance (homoscedasticity).

2.1.3. Quantile Regression Formula:

The QR model calculates specific conditional percentiles of the outcome variable (y) according to the values provided of the explanatory variables(x). The standard form of a QR model is:

$$Q_\theta(y|X) = X\beta(\theta) + e \qquad (1)$$

where:

X: The vector of explanatory variables (independent variable).
y: The response or outcome variable (dependent variable).
$Q_\theta(y/X)$: The conditional θ^{th} percentile of the variables (Y /X).
θ: **T**he specific quantile of interest, such as ($\theta = 0.25$, $\theta = 0.5$, and $\theta = 0.75$,...).
$\beta(\theta)$: The coefficients, which represent the impact of each independent variable(x) on the θ^{th} percentile of the dependent variable(y).

Quantile regression minimizes an asymmetric, special loss function called the "check or pinball" function. This loss function penalizes overestimation and underestimation differently, depending on the quantile θ. **(Koenker & Bassett, 1978; Koenker, 2005; Hao & Naiman, 2007)**

$$\min_{\beta} \sum_{i=1}^{n} \rho_\theta(y_i - x_i^T\beta) \qquad (2)$$

$$\rho_\theta(u) = u\,.(\theta - II_{u<0}) \qquad (3)$$

$$\rho_\theta(u) = \begin{cases} u\theta & if\ u \geq 0 \\ u(\theta - 1) & if\ u < 0 \end{cases} \qquad (4)$$

$$u = y_i - x_i^T\beta \qquad (5)$$

where:

$\rho_\theta(u)$: Quantile loss function.
u: The residual.
n: The total number of observations.
i: The index for each observation from 1 to n.
$II_{u<0}$: An indicator functions. It equals 1 if u < 0 and 0 otherwise.

2.2 Kruskal- Wallis Test

The Kruskal- Wallis test, or the Kruskal-Wallis H test, is non-parametric. Comparable to the one-way analysis of variance (ANOVA), used to ascertain whether the medians between three independent groups or more significantly differ. When the variances are not equal (homogeneity), the assumptions of normality are not valid, and the observations are small or unequal, the Kruskal- H test is a useful test to use. It ranks the data and compares the total of these ranks of the groups (**Kruskal, Wallis, 1952).**

2.3 Multinomial logistic regression (MLR)

We employed Multinomial logistic regression to examine the association between type of birth or mode of delivery and infant feeding Types (breastfeeding, formula feeding, and mixed feeding). This method was selected because the outcome variable (feeding type) was nominal and had more than two categories, and it does not require the predictors or outcome to be normally distributed, nor does it assume homoscedasticity or linear relationships between variables **(Hosmer et al., 2013).** It assumes the following:

a. The predictor variable is categorical with mutually exclusive groups.
b. Observations are independent.
c. No multicollinearity among predictors.
d. The independence of irrelevant alternatives (IIA) holds.

Section Three: Practical Framework

This section contains a statistical method and WHO growth standards for babies from one day to 48 months for comparing them with our variables' growth outcomes, and to analyse our data, we used a powerful programming language such as Python 3.11.5, packaged by Anaconda, Inc. our sample data were collected from the government health clinics in Sulaimani city. using child health card records produced by the WHO growth standards **(WHO, 2023)**, We focused on standard measurements for children, including height and weight from birth to 48 months. focusing on only those with complete records from birth to four years, and the time of delivery was after 38 weeks. The study sample contains 207 infants from both genders; 64 infants were breastfed, 46 infants were formula-fed, and 97 infants were fed both types of milk and named Mixed feeding.

3.1 Breastfeeding (BF)

The foods that the baby receives at the beginning of his life play a significant role in staying healthy and physical growth. The World Health Organization suggests that for the first 6 months, newborns be fed breast milk only to aid the best growth, health, and development. Following this, breastfeeding and supplementary feeding should then continue up to or more than 24 months of age. **(WHO, 2023**. Breast milk has the most useful factors for protecting against pathogens and infection, stimulating inflammatory responses, promoting cell growth and bacterial colonization, regulating appetite and energy conversion, and inhibiting adipogenesis. These factors are nutrients and bioactive. **(Eidelman et al., 2012)**. These advantages can help to improve growth patterns and reduce the risks of infections and chronic diseases later in life. **(Kramer et al., 2001, Victora et al., 2016)**

3.2 Formula Feeding (FF)

In the past, when an infant was not breastfed, families relied on nursing from another woman or animal milk, which often lacked enough nutrition for newborns. In the mid-19th century, the chemist Justus Von Liebig created the initial commercial newborn formula in 1867. It was designed to replace human milk, alongside advancements in nutritional science and pasteurization that enhanced safety and formulation. **(Lyon, 2007; Kolotzko, 2016)**

To protect human health, the organizations FAO and WHO created a commission named the Codex Alimentarius (CAC). They developed international standards for infant formulas in 1976, ensuring safety and nutritional quality. These recommendations provide a framework for the composition, labelling, and marketing of newborn formulas and encourage health for non-breastfed infants. The Codex standards have since evolved to incorporate ongoing nutritional advancements, supporting the development of safe and nutritious breast milk alternatives. But they emphasize that for the early period of life, breast milk is still the only source of dietary requirements for a growing and developing newborn. **(Codex Alimentarius Commission, 1976; WHO, 2018)**

3.3 Mix Feeding (MF)

Some infants use both feeding methods together during the early period of life for many reasons, like the mother's mood or work, the infant's health, etc. In these situations, parents and families tend to use both feeding methods together to gain a better-growing and developing baby. Also, some mothers think that formula feeding alongside their milk can improve their baby's growth and get more sleep, so they decide to use both feeding methods together. **(Brown and Lee, 2013)**

Practical Steps

1. **Variables of interest**

Table 2: Study Variables: Infant Height, Feeding Methods, and Demographics

Dependent Variables (response variable)					
Height at different ages in centimetres			Height at different ages in centimetres		
Yi			Yi		
Independent Variables (explanatory variable)					
Breastfeeding (BF)	Formula feeding (FF)	Mix feeding (MF)	Ages	Gender	Mode of Delivery
X1	X2	X3	Xi	Xi	Xi

2. **Testing the Normality**

For assurance, we tested our response variables by using the two statistical methods, such as the Anderson-Darling test and the Shapiro-Wilk test for checking normality, combining all age growth outcomes from birth to 48 months.

Table 3: The Normality test for the Weight of children combining all ages

Test	Test Statistic	p-value / Critical Values
Shapiro–Wilk Test	0.9521	$p < 0.0001$
Anderson–Darling Test	17.8813	Critical value at 15 % = 0.575
		Critical value at 10 % = 0.654
		Critical value at 5.0 % = 0.785
		Critical value at 2.5 % = 0.916
		Critical value at 1.0 % = 1.089

Table 4: The Normality test for the Height of children combining all ages

Test	Test Statistic	p-value / Critical Values
Shapiro–Wilk Test	0.9465	$p < 0.0001$

Anderson–Darling Test	21.6042	Critical value at 15 % = 0.575
		Critical value at 10 % = 0.654
		Critical value at 5.0 % = 0.785
		Critical value at 2.5 % = 0.916
		Critical value at 1.0 % = 1.089

The results of the normality tests for weight and height of children from birth date to 48 months showed that the distributions did not follow a normal distribution. Consequently, the Quantile Regression (QR) model is one of the suitable models for analyzing our dataset after the assumptions of no multicollinearity are met.

3. **The assumption of testing Multicollinearity**

Table 5: Testing Multicollinearity for Independent Variables

Variable	VIF (Variance inflation factor)
Feeding Types	1.014531
Age in months	1.000000
Gender	1.014531

- Since the VIF tests are close to 1 and less than 5 or 10, we can conclude that no multicollinearity is present. Without a doubt, we can use our approach, Quantile Regression and apply it to gain reliable results.

4. **Parental Demographics and General Information: A Kruskal-Wallis Test**

For Parental Demographics, we also checked the distribution, and they are freely distributed and not normally distributed. Since our data set is not normally distributed, we used a statistical test Kruskal-Wallis Test, to compare the median across three types of food.

Table 6: Parental Demographics and General Information: A Kruskal-Wallis Test

Parental Demographics	Type of food						Kruskal-Wally's test	
	Breastfeed		Formula Feed		Mix feed			
	Median	MAD	Median	MAD	Median	MAD	H statistic	p-value
Father's job	4	0.0	4	0.0	4	0.0	2.291	0.3181
Mother's job	1	0.0	1	0.0	1	0.0	0.092	0.9547
Father's education	3	2.0	4	1.0	4	1.0	0.467	0.7917
Mother's education	4	1.0	4	1.0	4	1.0	0.989	0.6096
Father's age(year)	39	4.0	38.5	4.5	39	4.0	0.176	0.9157
Mother's age(year)	34	3.5	35.5	4.5	36	3.0	2.978	0.2255
Time of birth(weeks)	39	0.5	39	0.0	39	1.0	2.9476	0.229
Type of birth	2	0.0	2	0.0	2	0.0	5.531	0.063

- We coded the variables as:
  Jobs: 1 = No work, 4= Free work
  Education: 3= High school, 4 = Diploma
  Type of birth or mode of delivery: number 2 refers to surgery)
- All p-values > 0.05 suggest that the parental demographic factors, type and time of birthdate of infants are not statistically associated with differences in feeding type. But there is a little association noted between the type of birth and feeding type (p = 0.063), suggesting a potential trend that warrants further investigation, and later we will examine this.
- MAD: Median Absolute Deviation.
- Median and MAD values for groups are very close to each other, suggesting little variability across groups.

5. **Effect of Mode of Delivery on Infant Feeding Type by utilizing MLR method**

We employed multinomial logistic regression (MLR) to examine the association between mode of delivery (Caesarean vs. natural birth) and infant feeding type (BF, FF, MF), as the outcome variable was nominal with two or more categories. All key assumptions of MLR were checked and met (not shown).

Table 7: Effect of Mode of Delivery on Infant Feeding Type

Comparison	Coefficient (Birth Type)	p-value	Odds Ratio	Interpretation
MF vs BF	0.733	0.034	2.08	Significant ↓ likelihood
FF vs BF	0.778	0.070	2.18	Marginal ↓ likelihood

The results showed that, compared to children born naturally, those born via Caesarean section had more than twice the odds ratio of receiving mixed feeding versus exclusive breastfeeding (odds ratio = 2.08, p = 0.034). Similarly, the odds ratio of formula feeding versus breastfeeding was also higher for Caesarean births (odds ratio = 2.18), although this result was marginally non-significant (p = 0.070). These findings suggest there is a significant link between Caesarean delivery and reduced likelihood of exclusive breastfeeding in early infancy, potentially due to medical, physiological, or hospital-related factors following surgical delivery.

6. **Growth outcomes of infants and type of food:**

   a. **Weight of infants in kilograms (kg) and type of food**

Table 8: Weight of infants and type of food (Boy in kg)

Ages	Type of food					
	Breastfeed		Formula Feed		Mix feed	
	Median	MAD	Median	MAD	Median	MAD
At birth	3.475	0.3	3.300	0.2	3.400	0.3
2 months	5.500	0.5	5.400	0.4	5.500	0.3
4 months	7.000	0.5	7.200	0.7	7.100	0.5
6 months	8.100	0.8	8.700	0.8	8.250	0.6
9 months	9.050	0.7	9.400	0.9	9.500	0.7
15 months	10.500	0.8	10.800	0.8	10.700	0.8
18 months	11.500	0.8	11.500	1.1	11.800	1.1
48 months	17.000	1.0	17.300	1.3	17.000	1.5

Table 9: Weight of infants and type of food (Girls in kg)

Ages	Type of food					
	Breastfeed		Formula Feed		Mix feed	
	Median	MAD	Median	MAD	Median	MAD
At birth	3.200	0.2	3.200	0.2	3.300	0.3
2 months	5.300	0.3	5.000	0.5	5.000	0.5
4 months	6.750	0.4	6.500	0.8	6.700	0.5
6 months	7.800	0.7	7.500	0.9	7.700	0.7
9 months	8.850	0.95	8.300	0.8	9.000	0.9
15 months	10.000	1.05	9.600	0.7	10.000	0.8
18 months	11.000	1.0	10.600	0.8	11.000	0.8
48 months	16.600	1.2	16.000	1.0	16.500	1.5

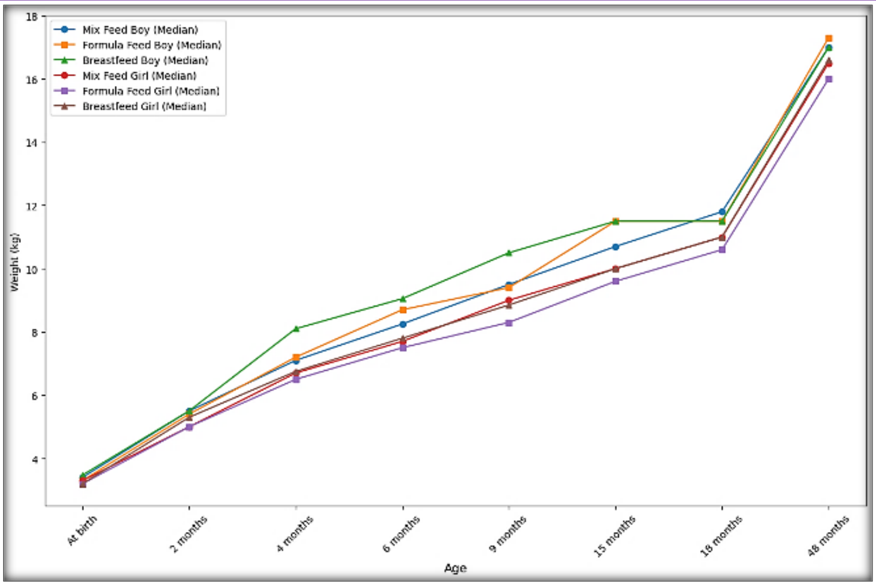

Figure 1: Weight Trends by Feeding Type and Gender

From tables and figure 1, we can conclude that while mixed and formula feeding tend to promote faster weight increases, breastfed children still achieve healthy growth, with variability in boys' weight measurements in contrast to girls' weight measurements, and BF girls tended to have slightly higher median weights at some ages compared to FF and MF girls.

b. **Height of infants in centimetres(cm) and type of food**

Table 10: Height of infants and type of food (Boys in cm)

Ages	Type of food					
	Breastfeed		Formula Feed		Mix feed	
	Median	MAD	Median	MAD	Median	MAD
At birth	49	0.0	49	0.0	49	0.0
2 months	57	1.0	57	1.0	57.5	0.5
4 months	64	1.0	64	3.0	64	2.0
6 months	68	2.0	69	2.0	68.5	1.5
9 months	72	2.0	73	2.0	74	2.0
15 months	77	2.5	77	3.0	79	3.0
18 months	84	1.0	83	3.0	84	1.0
48 months	105	2.0	105	2.0	105	2.0

Table 11: Height of infants and type of food (Girls in cm)

Ages	Type of food					
	Breastfeed		Formula Feed		Mix feed	
	Median	MAD	Median	MAD	Median	MAD
At birth	49	1.0	49	0.0	49	1.0
2 months	57	1.0	55	1.0	57.5	0.5
4 months	63	1.0	62	1.0	64	2.0
6 months	67	2.0	67	1.0	68	2.0
9 months	70.5	1.5	71	1.0	73	3.0
15 months	75	1.0	76	1.0	78	3.0
18 months	81.5	2.5	81	2.0	84	2.0
48 months	103.5	2.5	103	2.0	103	2.0

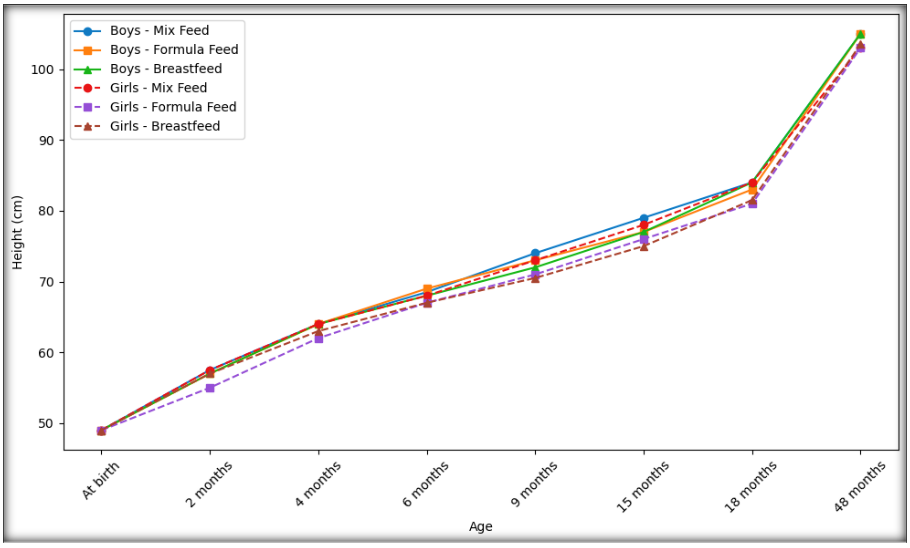

Figure 2: Median Height infants by Feeding Type (Boys and Girls)

Based on figures and tables above for height children Feeding types may slightly influence early height growth, but long-term height outcomes are similar across all groups.

7. **WHO Z-score standards**

The World Health Organization prepared the standards of children's growth to determine children's growth and nutritional rank from one day to 60 months of age. These standards are built on healthy, breastfed children from various countries and yield a reference for optimal growth patterns. The WHO used the Z-score, also known as the standard deviation score, using a statistical technique LMS method normalize growth data by calculating Z-scores that express a child's anthropometric measurement**. (WHO, 2023)**

$$Z = \frac{\left(\frac{X}{M}\right)^L - 1}{L\,.\,S} \tag{6}$$

$$Z = \frac{\left(\frac{BMI}{M}\right)^L - 1}{L\,.\,S} \tag{7}$$

$$BMI = \frac{Weight(kg)}{Height(m)^2} \tag{8}$$

Where:

$L \neq 0$
X: Observed value.
BMI: Body Mass Index.
M: Median.
S: Standard deviation.
L: Power to remove skewness using a Box-Cox transformation (Lambda).

Z-scores enable the identification of deviations from normal growth. The zero Z-score indicates that the measurement is precisely at the median of the group references. In contrast, scores below or above 0 indicate how far the child's measurement deviates from the reference group's median value. **(WHO 2006)**. In Table 12, We calculated the BMI of boys and girls across feeding types and compared them to WHO standards to understand our growth of individuals.

Table 12: The BMI infants with the kind of food (The boy infants)

Ages	Breastfeed	Formula feed	Mix feed	WHO - BMI standards	
				Median BMI	+1 SD
At birth	14.3	13.6	14.1	13.4	14.8
2 months	16.9	16.9	16.6	16.3	17.8
4 months	17.7	17.5	17.6	17.2	18.7
6 months	17.6	17.9	17.6	17.3	18.8
9 months	17.7	17.6	17.4	17.2	18.6
15 months	17.1	17.9	16.9	16.4	17.8
18 months	16.7	16.7	16.8	16.1	17.5
48 months	15.4	15.7	15.4	15.3	16.7

Based on WHO standards **(WHO, 2023)**, our BMI for infant's boy is all in the range and healthy, which suggests that the infants across different ages and different feeding types are in normal growth, without the boys at 15 months for FF being above the median and in +1 SD based on WHO BMI standards that suggest overweight risk.

Table 13: BMI infants with the kind of food (The girl infants)

Ages	Breastfeed	Formula feed	Mix feed	WHO - BMI standards	
				Median BMI	+1 SD
At birth	14.02	13.3	14.0	13.3	14.6
2 months	16.5	15.9	15.4	15.8	17.3
4 months	16.9	16.9	16.4	16.7	18.3
6 months	17.2	17.8	16.8	16.9	18.5
9 months	17.7	16.8	16.5	16.7	18.3
15 months	17.2	17.3	16.5	16.0	17.5
18 months	16.1	16.5	16.2	15.7	17.2
48 months	15.4	15.7	15.7	15.3	16.8

Based on WHO standards, our results of BMI infants with the kind of foods are all between the median and 1 SD for infant girls, and this suggests that the infants across different ages are in normal growth and healthy.

8. **Applying the Quantile Regression approach**
   A. Effect of Feeding Types on Infant Weight at Different Quantiles (BF- Boy (2 months) as a reference group)

Table 14: The interaction between Feeding Types and Gender on Infant Weight at Different Quantiles

Type of food	Coefficient	Std. Error	P-value	Pseudo R²
$\theta = 0.25$				
Intercept (Bf – Boy)	5.200	0.116	0.000	0.63
FF (Boy)	-0.100	0.119	0.400	
MF(Boy)	0.100	0.105	0.340	
BF(Girl)	- 0.6000	0.053	0.000	
FF* Girl	0.0000018	0.19	1.000	
MF* Girl	-0.000000046	0.16	1.000	
BF- Boy (4 to 48 months)	1.400 to 10.400	0.129	0.000	
$\theta = 0.50$				
Intercept (Bf – Boy)	5.500	0.109	0.000	0.67
FF (Boy)	0.100	0.115	0.383	
MF(Boy)	0.100	0.101	0.320	
BF(Girl)	-0.400	0.121	0.001	
FF* Girl	-0.400	0.188	0.033	
MF* Girl	-0.200	0.154	0.195	

BF- Boy (4 to 48 months)	1.600 to 11.400	0.122	0.000	
$\theta = 0.75$				
Intercept (Bf – Boy)	5.900	0.132	0.000	
FF (Boy)	0.100	0.137	0.464	
MF(Boy)	0.100	0.120	0.405	
BF(Girl)	-0.500	0.146	0.001	0.71
FF* Girl	-0.200	0.226	0.377	
MF* Girl	-0.200	0.185	0.590	
BF- Boy (4 to 48 months)	1.700 to 12.200	0.146	0.000	

In Table 14, we analysed the interaction effects of feeding type and gender on infant weight across different quantiles. BF boys at 2 months were used as the reference group. There was no statistically significant weight differences among boys based on feeding type (FF and MF) across all quantiles. BF girls consistently showed significantly lower weights than BF boys at all percentiles, with the strongest impact shown at the 25th percentile (coefficient = -0.600, $p < 0.001$). At the 50th percentile, FF girls also weigh significantly less than BF boys (coefficient = -0.400, $p = 0.033$), but MF girls did not show significant differences at any quantile. As expected, age showed a strong and positive relationship with weight across all feeding types and genders (all age-related p-values < 0.001). This indicates natural growth from 4 to 48 months. The model shows a good fit across quantiles, with pseudo R^2 values ranging from 0.63 to 0.71, suggesting a solid explanatory capacity for variation in infant weight based on feeding type, age, and gender. In general, while feeding type did not significantly affect boys' weight, girls, particularly those who were BF or FF, tended to weigh less than BF boys. These results highlight consistent gender differences in early growth patterns.

- Pseudo R^2 indicates how much variance in infant weight or height is explained by the model at a given quantile. A value closer to 1 means a stronger model fit.

After that, we analyse the interactions between (Feeding Type, Age and Gender) to understand and obtain which variables interact with others, and we concisely summarize the results below:

Table 15: The interactions between Feeding Types, Age and Gender at Different Quantiles on the weight of infants

Interactions	**Coefficient**	**Std. Error**	**P-value**	**Pseudo R^2**
$\theta = 0.25$				
Intercept (BF– Boy)	5.2000	0.199	0.000	
FF- Boy	-0.200	0.31	0.518	
MF- Boy	0.00000022	0.266	1.000	
BF- Girl	-0.2003	0.313	0.523	
BF- Boy from (4 to 48 months)	1.400 to 10.800	0.3	0.000	0.64
(FF, MF) * Ages	-0.200 to 0.3	0.4	0.4 to 1.00	
(FF, MF) * Girl	-0.2997	0.496, 0.4	0.546, 0.45	
Age (15) * Girl	-0.8974	0.452	0.047	
FF, MF * Ages * Girl	-0.100 to 0.900	0.5 to 0.7	0.1 to 0.9	
$\theta = 0.50$				
Intercept (BF– Boy)	5.5000	0.193	0.000	
FF- Boy	-0.150	0.297	0.736	
MF- Boy	-0.00000066	0.261	1.000	
BF- Girl	-0.200	0.314	0.525	
BF- Boy from (4 to 48 months)	1.500 to 11.500	0.27	0.000	0.68
(MF, FF) * Ages	0.0000 to 0.700	0.4	0.3 to 1.000	
(FF, MF) * Girl	-0.2, -0.3	0.5, 0.4	0.681, 0.454	
Ages * BF- Girl	-0.02 to -0.3	0.4	0.5 to 1.000	

FF, MF * Ages * Girl	-0.2 to 0.3	0.7, 0.6	0.3 to 1.000	
		$\theta = 0.75$		
Intercept (BF– Boy)	6.000	0.217	0.000	0.71
FF- Boy	-0.100	0.328	0.761	
MF- Boy	-0.200	0.292	0.493	
BF- Girl	-0.400	0.362	0.27	
BF- Boy from (4 to 48 months)	1.5022 to 12.00	0.30	0.000	
FF- Boy* Age (48)	1.1	0.45	0.01	
(FF, MF) * Girl	-0.200, 0.100	0.534, 0.45	0.71, 0.82	
Age* BF- Girl	-0.1 to 0.09	0.5	0.07 to 0.99	
FF, MF * Ages * Girl	-0.01 to 0.4	0.7, 0.6	0.2 to 0.99	

In Table 15, quantile regression analysis was used to explore interaction effects between feeding type, age, and gender on infant weight across different quantiles. The BF boys at 2 months served as the reference group. Across all quantiles, breastfed infants showed consistent weight gain, particularly at the 25th percentile and median weight levels, with age-based coefficients increasing steadily from 4 to 48 months (e.g., 1.4 to 12.0, all $p < 0.001$). This supports the notion that breastfeeding promotes healthy growth over time. While FF and MF boys did not show statistically significant weight differences compared to BF boys at any quantile ($p > 0.45$), an outlier was noticed at the 75th percentile, where FF boys had significantly higher weight at 48 months (Coeff = 1.1, p = 0.01). For girls, results indicated that they were generally lighter than boys across age and feeding types, though these differences were mostly statistically nonsignificant. Breastfed girls had significantly lower weights at age 15 at the 25th percentile (Coeff = -0.8974, p-value = 0.047), indicating a slower weight gain among girls at that age The three-way interaction terms (FF/MF, age, and gender) did not show significant results across quantiles, implying that the combined effects of age, gender, and feeding type on weight were not strong or consistent. The age effects for females in each feeding group had little statistical significance, The Pseudo R^2 values, ranging from 0.64 to 0.71, indicate that the model has a moderate explanatory power, explaining a fair proportion of the variation in infant weight across quantiles. According to these results, nursing promotes a healthy weight development, especially for infants who are lighter or medium in weight. While FF indicated a little tendency toward larger weight at later ages in heavier boys, MF caused weight trends comparable to breastfeeding. There were gender differences, but they were not always significant, and interaction effects were not very strong.

Table 16: Effect of gender on weight across Feeding Types (Boys as reference group)

Ages	Breastfeed		Formula feed		Mix feed	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
			$\theta = 0.25$			
2 months	-0.200	0.501	-0.500	0.271	-0.500	0.06
4 months	-0.201	0.634	0.00	1.00	-0.100	0.789
6 months	-0.100	0.816	0.100	0.877	-0.200	0.594
9 months	-0.500	0.238	-0.300	0.635	-0.300	0.418
15 months	-0.897	0.037	-0.500	0.433	-0.100	0.79
18 months	-0.802	0.063	-0.200	0.746	-0.100	0.787

48 months	-0.800	0.068	-0.300	0.636	0.100	0.787
			$\theta = 0.5$			
2 months	-0.200	0.535	-0.400	0.37	-0.500	0.045
4 months	-0.062	0.891	-0.300	0.635	0.001	0.998
6 months	-0.100	0.827	-0.800	0.205	-0.095	0.786
9 months	-0.021	0.964	-0.700	0.268	0.00	1.00
15 months	-0.300	0.511	-0.800	0.205	-0.296	0.4
18 months	-0.300	0.511	-0.500	0.428	-0.300	0.394
48 months	-0.295	0.518	-0.900	0.154	0.00	1.00
			$\theta = 0.75$			
2 months	-0.400	0.298	-0.600	0.181	-0.300	0.288
4 months	-0.102	0.853	0.00	1.00	-0.400	0.31
6 months	-0.099	0.85	-0.200	0.758	-0.101	0.798
9 months	0.001	0.999	-0.500	0.438	-0.600	0.128
15 months	0.100	0.851	-0.500	0.438	-0.300	0.452
18 months	-0.901	0.095	-0.600	0.34	-0.800	0.042
48 months	-0.500	0.335	-1.400	0.03	-0.001	0.999

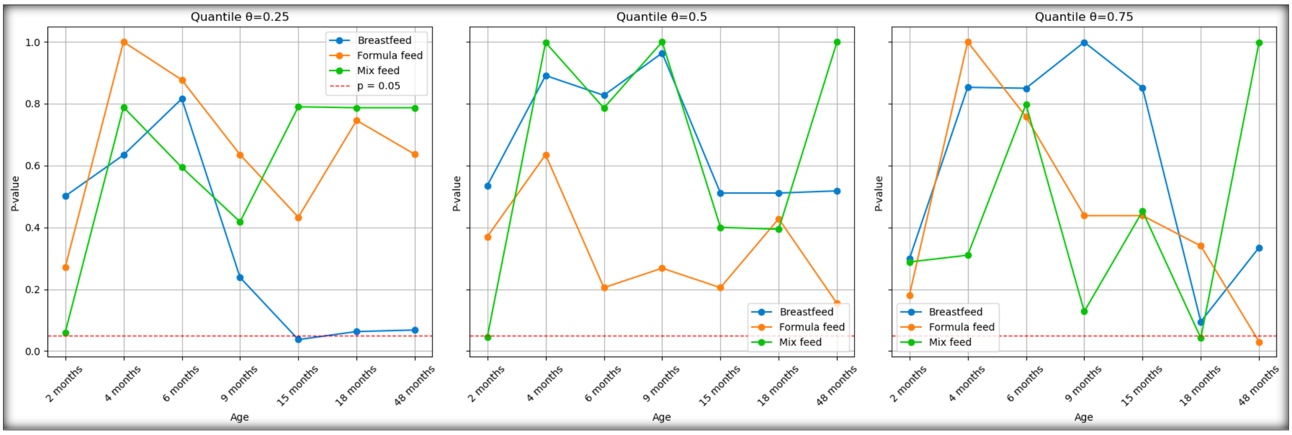

Figure 3: Effect of gender on Weight across Feeding Types (Boys as reference group)

In Table 16, we analyzed the differences in weight between genders by feeding types and boy infants were used as the reference group. The QR results at the 25th, 50th, and 75th percentiles revealed important patterns regarding the effect of feeding type on weight differences between genders in the same feeding groups. BF groups appeared to produce the most stable weight across feeding types, and boys were heavier than girls at many ages, a statistically significant difference emerging only at 15 months in the 50th percentile between genders in the BF group. In contrast, FF groups suggest greater variability in growth patterns between genders and boys were heavier than girls at many ages, and a statistically significant difference was seen at the 75th percentile between FF groups only at 48 months. MF groups consistently exhibited the most frequent gender differences across multiple ages and quantiles, especially during 2 and 18 months, where statistically significant differences emerged at the 50th and 75th percentiles. These findings suggest that BF may contribute to more uniform growth between boys and girls compared to FF or MF, which tend to amplify gender-based differences during early life. Thus, we can investigate that for girl infants, BF is likely to be the best option for weight gain compared to FF and MF.

B. Effect of Feeding Types on Infant Height in centimetres:

Table 17: Effect of Feeding Types, Age and Gender on Infant Height at Different Quantiles

Effects	Coefficient	Std. Error	P-value	Pseudo R^2
$\theta = 0.25$				
Intercept (Bf – Boy)	56.00	0.318	0.000	0.78
FF(Boy)	-0.0000435	0.328	1.000	
MF(Boy)	1.00	0.29	0.001	
BF(Girl)	-1.00	0.355	0.005	
FF * Girl	0.0000427	0.545	1.000	
MF * Girl	-0.9999	0.449	0.026	
BF- Boy (4 to 48 months)	6.00 to 46.00	0.36	0.000	
$\theta = 0.50$				
Intercept (Bf – Boy)	57.5	0.255	0.000	0.81
FF(Boy)	0.0000005591	0.267	1.000	
MF(Boy)	0.000001671	0.235	1.000	
BF(Girl)	-1.5	0.283	0.000	
FF * Girl	-0.5	0.438	0.254	
MF * Girl	1.5	0.36	0.00	
BF- Boy (4 to 48 months)	6.5 to 47.5	0.29	0.000	
$\theta = 0.75$				
Intercept (Bf – Boy)	58.00	0.301	0.000	0.83
FF(Boy)	0.000001528	0.293	1.000	
MF(Boy)	0.00001522	0.257	1.000	
BF(Girl)	-1.00	0.314	0.001	
FF * Girl	-1.00	0.49	0.042	
MF * Girl	1.00	0.398	0.012	
BF- Boy (4 to 48 months)	7.00 to 48.00	0.26	0.000	

Quantile regression results indicated that there was no statistically significant difference in height between BF and FF boys across any of the quantiles. However, MF boys were significantly taller than BF boys at the 25th percentile (coefficient = 1.00, p = 0.001), suggesting that mixed feeding may help height in shorter children. Breastfed girls consistently had shorter heights than BF boys across all percentiles (25th, 50th, and 75th), with statistically significant differences. MF girls at the median ($\theta = 0.50$) had a positive and significant coefficient (1.5, p = 0.00), and at the 75th percentile, they also showed superior growth compared to both FF and BF infants. FF girls showed significantly lower height than BF boys at the 75th percentile (coefficient = -1.00, p = 0.042). Pseudo R^2 values ranging from 0.78 to 0.83 suggest that the model explains a substantial proportion of the variability in height outcomes across quantiles. These findings indicate that feeding type and gender interactively influence height development across different growth distributions. MF appears especially beneficial for supporting height growth at the 75th percentile, particularly among girls. However, further study is needed to explore additional influencing variables, such as parental height, socioeconomic status, or nutrition quality.

Table 18: The interactions between Feeding Types, Age and Gender at Different Quantiles on the height of infants

Interactions	Coefficient	Std. Error	P-value	Pseudo R^2
$\theta = 0.25$				
Intercept (BF– Boy)	57.0	0.479	0.000	0.79
FF(Boy)	-1.00	0.79	0.206	
MF(Boy)	0.000000697	0.725	1.000	

BF(Girl)	-1.00	0.771	0.195	
BF- Boy (2 months to 48 months)	6.00 to 45.99	0.7	0.000	
FF* Ages	-1.00 to 2.00	1.1	0.07 to 0.3	
MF* Ages	-1.00 to 1.00	1.00	0.3 to 0.99	
FF* Girl	-0.00000084	1.414	1.000	
MF* Girl	0.00000017	1.054	1.000	
BF- Girl * Ages (4 to 48)	-0.00 to -1.00	1.1	0.3 to 1.00	
(FF, MF) * Ages * Girl	-0.000 to 1.00	1.5 to 1.9	0.4 to 1.00	
$\boldsymbol{\theta = 0.50}$				
Intercept (BF– Boy)	57.00	0.443	0.000	0.81
FF(Boy)	-0.00000073	0.683	1.000	
MF(Boy)	0.5	0.599	0.404	
BF(Girl)	-0.000001333	0.723	1.000	
BF- Boy (2 months to 48 months)	7.00 to 48.00	0.6	0.000	
FF* Ages	0.000 to 1.00	0.9	0.3, 1.00	
MF* Ages	-0.1 to 1.5	0.8	0.07 to 0.8	
FF* Girl	-2.00	1.12	0.074	
MF* Girl	0.00000075	0.92	1.000	
BF- Girl * Age (15)	-2.00	1.022	0.051	
BF- Girl * Age (18)	-2.2917	1.022	0.025	
(FF, MF) * Ages * Girl	-0.7 to 2.2	1.3, 1.5	0.07 to 0.9	
$\boldsymbol{\theta = 0.75}$				
Intercept (BF– Boy)	58	0.517	0.00	0.83
FF(Boy)	-0.5	0.763	0.512	
MF(Boy)	0.00000011	0.71	1.000	
BF(Girl)	-0.00000056	0.778	1.000	
BF- Boy (2 months to 48 months)	7.00 to 47.03	0.7	0.000	
FF* Age (9)	2.5	1.034	0.016	
MF* Age (15)	2.0	0.937	0.033	
FF * Girl	-1.5	1.154	0.194	
MF * Girl	0.00000047	1.034	1.000	
Ages (4 to 48) * BF- Girl	-0.01 to -2.00	1.1	0.06 to 1.00	
(FF, MF) * Ages * Girl	-0.5 to 2.0	1.3 to 1.6	0.2 to 1.00	

Breastfed boys at two months were the reference group at all three quantiles. There were no significant main effects for formula or mixed feeding alone. And no interaction was found between gender, age, and feeding types. However, the main effects indicated that formula-fed boys were shorter than breastfed boys at all percentiles, but the effects were not statistically significant and small. Across instructions of feeding type, Gender, and ages, BF girls tended to be shorter than BF boys, especially at 15, 18 months at the median quantiles, but it's statistically significant only at 18 months. The interactions of MF at age 15 months and FF at age 9 months showed a positive effect and indicated that infants in groups MF and FF at these ages are taller than BF boys at the same age. Based on the results of Pseudo R^2 (0.79 to 0.83) the model fits well at all percentiles.

Table 19: Effect of gender on Height across Feeding Types (Boys as reference group)

Ages	**Breastfeed**		**Formula feed**		**Mix feed**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
$\boldsymbol{\theta = 0.25}$						
2 months	-0.2	0.501	-0.5	0.271	-0.5	0.06
4 months	-0.201	0.634	0.0	1.00	-0.1	0.789
6 months	-0.1	0.816	0.1	0.877	-0.2	0.594

9 months	-0.5	0.238	-0.3	0.635	-0.3	0.418
15 months	-0.897	0.037	-0.5	0.433	-0.1	0.79
18 months	-0.802	0.063	-0.2	0.746	-0.1	0.787
48 months	-0.8	0.068	-0.3	0.636	0.1	0.787
$\theta = 0.5$						
2 months	-0.2	0.535	-0.4	0.37	-0.5	0.045
4 months	-0.062	0.891	-0.3	0.635	0.001	0.998
6 months	-0.1	0.827	-0.8	0.205	-0.095	0.786
9 months	-0.021	0.964	-0.7	0.268	0.00	1.00
15 months	-0.3	0.511	-0.8	0.205	-0.296	0.4
18 months	-0.3	0.511	-0.5	0.428	-0.3	0.394
48 months	-0.295	0.518	-0.9	0.154	0.00	1.00
$\theta = 0.75$						
2 months	-0.4	0.298	-0.6	0.181	-0.3	0.288
4 months	-0.102	0.853	0.0	1.00	-0.4	0.31
6 months	-0.099	0.85	-0.2	0.758	-0.101	0.798
9 months	0.001	0.999	-0.5	0.438	-0.6	0.128
15 months	0.1	0.851	-0.5	0.438	-0.3	0.452
18 months	-0.901	0.095	-0.6	0.34	-0.8	0.042
48 months	-0.5	0.335	-1.4	0.03	-0.001	0.999

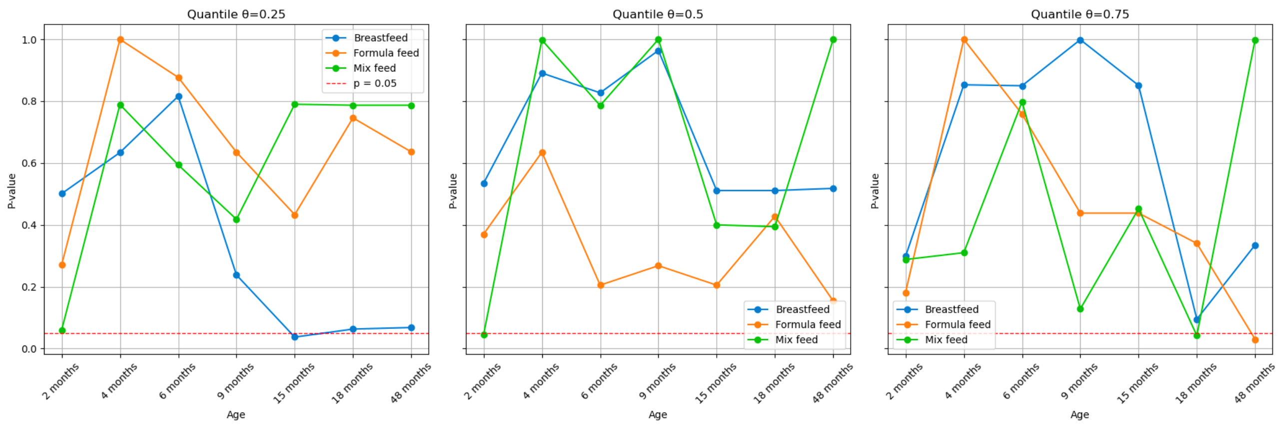

Figure 4: Effect of gender on Height across Feeding Types (Boys as reference group)

At 25th percentile Girls in breastfed group are significantly shorter than boy at 15 months (p = 0.037) and in the median quantiles only mixed-fed girls at 2 months are significantly shorter than boys (p = 0.045) also girls in mixed feeding at 18 months and formula feeding at 48 months are significantly shorter than boys in their own groups at 75th percentile. The findings suggest that BF stable and balanced height growth across genders, while formula and mixed feeding may accelerate early height gains, but with greater gender disparities. **((WHO, 2006))**

Section Four: Conclusions and Recommendations

4.1 Conclusions

The findings of this study demonstrate that the parental demographics and birth timing were not significantly associated with feeding type choice. However, multinomial logistic regression revealed that infants born via Caesarean section had a higher likelihood of receiving formula or mixed feeding rather than exclusive breastfeeding.

Regarding growth outcomes, no significant main effects were found between feeding types and overall baby weight or height. But interaction effects explored through quantile regression allowed more nuanced insights. Breastfed (BF) infants exhibited stable and consistent weight gain across age ranges. In contrast, formula-fed (FF) and mixed-fed (MF) infants demonstrated more rapid but variable weight gain patterns. At the 75th percentile, FF boys at 48 months had significantly higher weights than BF boys, indicating a trend toward greater weight gain in heavier children. FF girls weighed significantly less than BF boys only at the median percentile. Gender and age were consistent predictors of weight, with girls generally weighing less than boys. BMI results for both boys and girls were within the healthy WHO range, though FF boys at 15 months showed a slight tendency toward being overweight.

In terms of height, gender differences were shown across all feeding types, though not always statistically significant. BF girls were significantly shorter than BF boys at 15 months. MF girls were also significantly shorter than MF boys at 2 and 18 months, and FF girls at 48 months were significantly shorter than FF boys.

Based on these results, breastfeeding appears to promote more uniform growth between genders; FF and MF were linked with greater variability and more evident gender-based differences at specific ages. Quantile regression proved to be an effective method for identifying growth differences across the distribution that traditional mean-based methods might overlook. Future research should incorporate maternal, nutritional, and environmental variables to better understand the underlying causes of these infant growth patterns.

4.2 Recommendations

Based on the conclusions of this study, several recommendations can be made for healthcare practitioners, parents, and policymakers:

1. QR is a valuable tool for analyzing the impacts of growth outcomes, such as weight and height, rather than focusing solely on the mean. This would be particularly important for growth studies involving children across whom developmental samples may differ widely. Nevertheless, one should be cautious in interpreting the results at the tails, such as at the 0.1 or 0.95 quantile level, as this demands a large and balanced employed population. Small sample data or uneven subgroups may tend to unstable or unreliable estimates.
2. In the early months of life, Exclusive breastfeeding should continue to be promoted as the optimal feeding method during infancy. Healthcare providers should offer consistent support and education to mothers, particularly those undergoing Caesarean deliveries, who may face additional challenges initiating breastfeeding.
3. While FF and MF may lead to faster weight gain, Paediatricians should monitor the growth trajectories of FF and MF infants more closely to ensure healthy and balanced development, particularly during critical periods such as 15 to 48 months.
4. We recommend that stakeholders input the information about children's development and parents' history information into a valuable database, because the current one does not contain the growth outcomes. The practice of retrieving data from physical files is time-consuming and inefficient for researchers and scientists
5. We recommend conducting similar studies in other cities to allow for regional comparisons and gain a broader understanding of infant feeding impacts. Also, further research is needed to study the effects of early nutrition on children above 48 months of age.

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