Iran J Pediatr. 2019 August; 29(4):e90520. doi: 10.5812/ijp.90520.

Published online 2019 August 25. **Research Article**

Evaluation of the Factors Affecting Growth Impairment of Children Aged Below 6 Years by Using Marginal Models

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Received 2019 February 11; **Revised** 2019 April 24; **Accepted** 2019 May 25.

Abstract

Background: Child growth impairment (GI) causes much psychological, physical and economic harm to the community while a healthy growth and development at early childhood ensures access to a healthy society.
Objectives: This study aimed to evaluate the factors affecting GI of children under 6 years of age by using marginal models in West Azerbaijan Province, Iran.
Methods: In this longitudinal cohort study, 1070 children below 6 years were in a two-stage cluster sampling randomly selected and studied. The growth characteristics of the studied children (height, weight) and their development features (walking, speaking and teething age) were recorded, during a 6-year follow-up. Data were collected by R statistical software and analyzed by using independent marginal model.
Results: The results of this study showed that maternal age at the time of birth (P = 0.001) also her educational level (P < 0.05) and occupational status (P = 0.000), birthing method (P = 0.001), child's gender (P = 0.000), breastfeeding (P = 0.000) and child's walking age (P = 0.000) had a significant effect on GI.
Conclusions: Present study revealed that the demographic factors and child's walking age have a significant effect on children's GI. At early childhood, GI influences many domains of individual's life and subsequently the society status. So, it is recommended that the determinants of this crucial threat to be identified and effective plans to be provided for any problems that may arise at this time.

Keywords: Child Growth Impairment, Growth and Development, Marginal Models

1. Background

At early childhood, healthy growth and development ensures access to a healthy society while child growth impairment (GI) causes much psychological, physical and economic harm to the community (1). Common symptoms of GI include inappropriate growth in weight and height. Motor skills such as sitting, standing and walking in children with GI appear later than other normal children (2).

In children with GI, the proportion of weight and height is less than 80% of children with moderate height and weight (3). In these children, the lack of adequate weight gain compared with healthy children has serious consequences for their health and, ultimately, on the health of society (4, 5). It must be mentioned that not only desired body weight, but also body composition, including bone mass, net weight and fat mass are important factors for healthy growth and development in the childhood (6). While due to public health policy reasons, there are many studies on childhood obesity (7-13), inadequate research has been conducted to assess weight gain among children suffering from GI (14). In addition, GI affects the height of children. According to previous studies, taller people are more likely to have higher self-esteem and better performance than those with a shorter height, which can also have a negative effect on children with GI (15). Other characteristic of children with GI include smaller/larger head than normal head size. One study has showed that children with head circumferences less than normal, have IQs less than 80 (16).

Growth impairment is often multi-factorial and depends on various factors. One of the main causes of GI is the reduction in consumption, high activity and increased intake of calories (17, 18). In fact, there are several pathological factors that can lead to GI, including those who have eating disorders and do not receive the necessary calories, children with chronic diarrhea who need more calories and children with congenital heart disease that increases

calorie requirements (4, 17). While many pathologic factors are involved ln GI, non-pathological factors such as inappropriate nutrition of the child and lack of parents' knowledge about the correct and healthy way to feed the child can also contribute to the GI (3).

Diagnosis of inadequate growth at childhood is important and should be treated at the same period, since non-treatment might lead to delay in growth and other long term effects on his/her health status at childhood and also adulthood (19). One of the effective methods for identifying children with GI is the early detection of these disorders by monitoring of children's height and weight, periodically. Afterwards, children with GI should be separated from healthy children and effective therapeutic measures should be taken (20).

Longitudinal models can be an effective tool for GI monitoring. An important feature of longitudinal models that distinguishes it from other methods is repeated measurements for different variables over a period of time that leads to a correlation between different observations. In general, three methods are used in the longitudinal models including the transmission model, marginal model, and random models (21).

2. Objectives

The objective of this study was to evaluate the factors affecting GI of children under 6 years of age by using marginal models in West Azerbaijan Province, Iran.

3. Methods

This longitudinal cohort study was conducted among infants born in the West Azerbaijan province, Iran in 2010-2011. A total of 1070 neonates were randomly selected in two cluster samples (the first stage consisted of provincial cities and the second stage included health care networks) and were entered in the study. Within 6 years of follow-up, growth characteristics of the children (height, weight) and their development features (walking, speaking and teething age) were recorded. Also, demographic variables like maternal education level and her occupational type, maternal age at the time of birth, birthing method, infant's gender, breastfeeding, and the existence of child health care were collected. In this study, weight disorder was defined based on international reference values (22, 23) as the weight-for-age less than the 5th percentile.

Since the aim of this study is to evaluate the predictive effect of the time independent variable on GI in children under the age of 6 years, the most appropriate model is the marginal longitudinal model. Research variables were selected from health care networks in West Azerbaijani province using checklists at intervals reported by the World Health Organization (WHO). Then the collected data were entered to the statistical software. For analysis of binary data through marginal modeling, R software was used. For this purpose, the GEE (Generalized Estimating Equation) function function was applied in the GEE library, fitted in two methods of exchangeable and autoregressive correlation structures.

4. Results

Among studied children 697 (61.2%) were male. Apropos of maternal status, 588 (51.7%) mothers were living in rural areas, 703 (61.8%) mothers had less education than high school and 1004 (88.2%) of them were housewives. Table 1 shows the demographic characteristics of the studied children.

Table 1. Demographic Characteristics of Children Under 6 Years

Variable/Category	No. (%)
Maternal educational level	
Illiterate	329 (30.7)
Elementary school	388 (36.3)
Secondary school	139 (13)
High school	161 (15)
University	53 (5)
Maternal occupation	
Housewife	1020 (95.3)
Employed	50 (4.7)
Pregnancy type	
Wanted	1003 (93.7)
Unwanted	67 (6.3)
Birthing method	
Normal	799 (74.7)
Cesarian section	271 (25.3)
Child's gender	
Male	565 (52.8)
Female	504 (47.2)
Child's health care	
No	844 (78.9)
Yes	226 (21.1)
Breastfeeding	
Yes	1019 ()95.2
No	51 (4.18)

According to the results of this study, 211 children (19.72%) had suffered GI up to 60 months, out of them 46 children (4.3%) experienced GI once, 49 children (4.58%) had it twice, 33 children (3.08%) experienced GI three times and 83 children (7.74%) had it 4 times or more. Table 2 shows the frequency of GI during 12 measurements.

Table 2. Frequency Distribution of Growth Impairment in Children Aged Below 6 Years During 12 Measurements

Frequency of Growth Impairment	No. (%)
No	859 (80.27)
Once	46 (4.3)
Twice	49 (4.58)
Three times	33 (3.08)
Four times and more	83 (7.74)
Total	1070 (100)

In this study, two marginal models with exchangeable and autoregressive correlation structures were used. Then, with using quasi-likelihood information criterion (QIC) with logarithmic patterns, the odds ratio of exchangeable and autoregressive correlation were assessed. The marginal model is the best model to evaluate children's GI. Since, the exchangeable correlation structure has a smaller QIC, this correlation structure was proposed. Its values are listed in the Table 3.

Table 3. Comparison of Marginal Models Using the Quasi-Likelihood Information Criterion (QIC)

Correlation Structure	QIC
Autoregressive	7125.429
Exchangeable	7123.951

The results obtained from fitting the marginal model using various correlations are presented in Tables 4 and 5.

The results of fitting of the marginal model in Tables 4 and 5 showed that the two considered correlation structures have the same results in terms of significance of regression coefficients. The interpretation of the variables based on the odds ratio showed that the effect of the maternal educational level on the GI was significant (exchangeable and auto-regressive $P < 0.05$). It means that for the maternal education variable, the odds ratio of GI in children whose mothers had elementary education was 1.27 times more than mothers with high school level of education, according to the structure of exchangeable correlation. In addition, the effect of maternal occupation on GI was significant (exchangeable and auto-regressive $P < 0.05$). The odds ratio of GI in children with employee mothers was 1.41 times more than children whose mothers were housewife, according to the exchangeable correlation structure.

The effect of birthing method on GI was also significant (exchangeable and auto-regressive $P < 0.05$). The odds ratio of GI in children born with cesarian section was 1.21 times more than children born with normal delivery, according to the structure of exchangeable correlation. Moreover, the effect of child's gender on GI was significant (exchangeable and auto-regressive $P < 0.05$). In the marginal model with exchangeable structure, the odds ratio of GI among female children was 2.75 times more than male children.

The effect of breastfeeding on GI was also significant (exchangeable and auto-regressive $P < 0.05$). According to the exchangeable correlation structure, odds ratio of GI in children who were breastfed was 2.68 times more than children who were not breastfed (according to Table 5).

Another variable which had significant impact on GI was maternal age (exchangeable and auto-regressive $P < 0.05$). According to the exchangeable correlation structure (Table 4), every one year increase in maternal age was associated with the 2% decreased odds ratio of GI.

Table 4 shows that the effect of walking age on GI was significant (exchangeable and auto-regressive $P < 0.05$). According to the exchangeable correlation structure, every one month increase in walking age was associated with the 7% decreased odds ratio of GI.

5. Discussion

The growth status of children is affected by genetic factors, medical care, socioeconomic status and the family environment. Screening for food security and psychosocial risk factors is a comprehensive tool for identifying families, which are at risk of malnutrition and child abuse (24, 25). This study was conducted to evaluate potential risk factors of GI in 1070 children (aged below 6 years) in West Azerbaijan, Iran. The children are followed over a period of 6 years. For this purpose marginal model was used with the longitudinal outcome.

In the present study, it was revealed that the main effect of maternal education on GI was significant and the odds ratio of GI in children whose mothers had elementary education is more than that in children whose mothers had high school education. In a study by Habibzadeh et al. (26) on 445 children aged 6 to 24 months, it was concluded that maternal education level was correlated with neonatal growth and neonates whose mothers had a higher education level were less susceptible to GI. In studies conducted by Waters et al. (27), it was also observed that children whose mothers had a higher level of education showed a more favorable growth compared to children whose parents had lower education levels. The re-

Table 4. The Results of the Fitting of the Marginal Model for Evaluation of Factors Affecting the Growth Impairment of Children Under the Age of 6 Years with Exchangeable Correlation Structure

Variable/Category	Regression Coefficient	Standard Error	Odds Ratio	Probability Value
Intercept	-1.03	0.625	0.36	0.155
Maternal educational level				
Illiterate				
Elementary	-0.285	0.111	0.75	0.01
Secondary	0.106	0.177	1.11	0.548
High school	-0.216	0.109	0.81	0.047
University	-0.531	0.128	0.59	0.000
Maternal occupation				
Housewife				
Employed	0.343	0.104	1.41	0.001
Pregnancy type				
Unwanted				
Wanted	-0.083	0.079	0.92	0.295
Birthing method				
Normal				
Caesarian section	0.194	0.06	1.21	0.001
Child's gender				
Male				
Female	1.01	0.09	2.75	0.000
Child's health care				
No				
Yes	-0.067	0.052	0.94	0.202
Breastfeeding				
No				
Yes	-0.709	0.22	0.49	0.001
Maternal age	-0.012	0.003	0.98	0.001
Teething age	-0.008	0.021	0.99	0.7
Walking age	-0.078	0.014	0.93	0.000
Speaking age	0.003	0.007	1.01	0.691
Time	0.001	0.001	1.001	0.638

sults of other studies also showed that growth of children whose mothers had low level of education was lower (28, 29). These results were consistent with the results of our study.

In addition, the results of our study indicated that the effect of maternal occupation on GI was significant and the odds ratio of GI in children whose mothers were employed was more than that of children whose mothers were housewives.

In the present study, there was no significant effect of child's health care variable on GI. In a study conducted by Larson-Nath et al. (30) on 92 children with GI in the hospital, they found that children's health care has a significant relationship with their GI, which means the lower health care was associated with increased GI-consistent with our finding.

The results of our study showed that the odds ratio of GI was higher in female children than male children; this result was consistent with the results of research conducted by Habibzadeh et al. (26), Mohammadpoorasl et al. (31) and Hajian et al. (32). However, these results were not consistent with those of research conducted by Vaghari et

Table 5. The Results of the Fitting of the Marginal Model for Evaluation of Factors Affecting the Growth Impairment of Children Under the Age of 6 Years with Autoregressive Correlation Structure

Variable/Category	Regression Coefficient	Standard Error	Odds Ratio	Probability Value
Intercept	3.799	0.446	1.18	0.000
Maternal educational level				
Illiterate				
Elementary	-0.262	0.107	0.77	0.014
Secondary	0.133	0.176	1.14	0.452
High school	-0.193	0.109	0.82	0.078
University	-0.509	0.127	0.6	0.000
Maternal occupation				
Housewife				
Employed	0.353	0.101	1.42	0.000
Pregnancy type				
Unwanted				
Wanted	-0.1	0.077	0.9	0.196
Birthing method				
Normal				
Caesarian section	0.196	0.057	1.22	0.001
Child's gender				
Male				
Female	0.985	0.083	2.68	0.000
Child's health care				
No				
Yes	-0.053	0.051	0.95	0.3
Breastfeeding				
No				
Yes	-0.735	0.21	0.48	0.000
Maternal age	-0.011	0.003	0.98	0.002
Teething age	-0.013	0.021	0.99	0.551
Walking age	-0.081	0.014	0.92	0.000
Speaking age	0.004	0.008	1.05	0.588
Time	0.002	0.002	1.01	0.402

al. (33).

Our findings indicated that the odds ratio of GI in children who were not breastfed was more than that in children who were breastfed. This finding is in line with a study conducted by Habibzadeh et al. (26), which showed that neonates who were breastfed for shorter time, compared to those who were breastfed for longer time, had more GI. The study conducted by Bloss et al. (34) also shows the effect of breastfeeding on preventing GI, which is in line with our study.

Our study revealed that the odds ratio of GI in children born with caesarian method was higher than that of the children born by normal delivery. In a study on 103 children Dubedout et al. (35), found that children whose mothers had cesarean delivery had more malnutrition and GI than children whose mothers had normal delivery; these findings confirm our results.

In the present study, we observed that every one year increase in maternal age was associated with a 2% decreased odds ratio of GI. Studies in this area have been consistent with our study and suggest that with the rise of the maternal age, the potential for GI decreases. Studies by Hadley et

al. (36) and Quevedo et al. (37) reported that mothers who are older are more likely to reduce GI in their infants due to increased maternal and welfare conditions.

Most studies have shown that teething age is directly related to the growth and development of the child (38, 39), but the results from this study were non-consistent with previous studies. In the present study the relationship between teething age and child growth was not significant and showed that teething age does not have any effect on GI.

The present study indicated that every one month increase in the walking age was associated with 7% decreased odds ratio of GI. A study by Miguel-Berges et al. (40) showed that walking has negative effects on the body's growth and weight and causes weight loss, which is comparable with our finding.

Child GI has many negative outcomes both for the individual and for society. To diagnose GI, child's growth should be monitored regularly. For this purpose, a serial measurement of child's anthropometric parameters, such as weight, height and weight to age or height, is required. To treat GI, a multifaceted approach must be considered; parents must be trained and informed of the possible consequences of GI. Childhood is a critical period for growth and development, early diagnosis and treatment of GI in this period brings better consequences for both the individual and the community (19, 41).

5.1. Conclusions

This study was conducted to evaluate the effect of factors affecting the growth impairment of children under the age of 6 years using marginal models in West Azerbaijan, Iran. The results of this study showed that demographic factors and walking age have a significant effect on GI in childhood. Since the early stage of childhood is crucial for growth and development and can affect many domains of life in adulthood, GI must be diagnosed at the childhood and effective therapy provided. Findings point to a need to increase the awareness and empowerment of low-educated mothers about the proper principles of safe child care. Also paying special attention to the growth of girls is one of the most important approaches to coping with GI in the children less than 6 years

Acknowledgments

The authors thank the Deputy of Research in Urmia University of Medical Sciences, Iran. Also we gratefully acknowledge the very helpful cooperation of the health care networks of the West Azerbaijan and all participants in this research.

Footnotes

Authors' Contribution: Vahid Alinejad: data collection and analysis, manuscript preparation, drafting and revising, review and final approval of manuscript. Ebrahim Hajizadeh: data collection and analysis, manuscript preparation, drafting and revising, review and final approval of manuscript. Aliakbar Rasekhi: data collection and analysis, manuscript preparation, drafting and revising, review and final approval of manuscript. Hamid Reza Khalkhali: data collection and analysis, manuscript preparation, drafting and revising, review and final approval of manuscript.

Conflict of Interests: It is not declared by the authors.

Ethical Approval: IR.MODARES.REC.1397.021.

Funding/Support: Tarbiyat Modares University.

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