LOGLINEAR MODEL TO STUDY THE IMPACT OF DEMOGRAPHIC FACTORS ON THE PREVALENCE OF STUNTING AMONG YEMENI CHILDREN UNDER 5

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Abstract

The sample size of the research was 12612 children that was taken from the raw data of Household Budget Survey (HBS) 2005/2006 in Yemen. The factors of the research are some demographic that are considered as categorical. The aim of the research is to studying the interaction between demographic factors and the stunting status of children. The suitable analyses for studying the propose of the research is the loglinear model. The results of using the loglinear model are found that the main effect of area of residence, dwelling status, treatment drinking water, no. of sleeping rooms, type of sewage disposal, and place of toilet have significant effect on the stunting status of children. Only for area of residence, it should be observed that either dwelling status or place of toilet or no. of sleeping rooms are highly significant associated with stunting status of children (i.e,. (X*Z*D), (X*Z*T), and (X*Z*N) P-value < 0.05).

Key words: Stunting status (HAZ), Categorical data, loglinear model

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Introduction

The health status of child is always affected by many factors. Among of these factors are, for example, living and housing conditions, dietary practices and demographic conditions. Also, vaccination is considered as one of the most important factors. Other factors include the family socio-economic status, post-natal care, number of the family members, and fertility rate.

Recently, researchers have started to study into some other factors that affect health of children such as parental care and education of parents. Some of these studies have reported a strong significant statistically relationship between health of children, parents' education and socio-economic factors, while other studies revealed no such relationship. Naturally, the best socio-economic factors, the better the health of children. Consequently, a positive relationship among environmental conditions including housing with piped water and flush toilet connected to sanitary and the health of children[1,11,16,17]. However, there is a negative association between the source of drinking water or toilet facility and the growth of children[4].

It is almost known that the first five years of life constitute the most important stage of health and growth of a child. So, the present study focuses on children under five years of age because this group is by far the most vulnerable to adverse health risks within the immediate family and community environment.

YDMCHS (Yemeni Demographic and Maternal and Child Malnutrition Survey) 1997 showed that about 63% of population are still drinking from primary sources, i.e., spring, rains, streams, uncovered, covered pools, well with or without pumps. These sources of drinking water are exposed to pollution and randomly using. Also, YDMCHS 1997 showed that about 24.5% of children were still suffered from severely stunting[7].

Accordingly, attention of children has been raised to study this critical age group, i.e., under five years of age, in relation to some socio-economic factors.

Therefore, the main objective of the present research is:

To studying the relationship between some demographic factors (such as sex of child, area of residence, place of toilet, type of sewage disposal, no. of sleeping rooms and treatment of drinking water) and the prevalence of the stunting status for some Yemeni children.

Data Source

The raw data of Household Budget Survey (HBS) 2005/2006 in Yemen was used for this research[14]. SPSS 18 statistical package was used for analysis[19]. The sample size of the research is 12612 children.

Determining the stunting status of children

The stunting status indicator of children is usually measured by Height-for-Age Z score (HAZ) indicator[2,6,25,26].

As recommended by WHO, evaluation of the children malnutrition status is based on comparison of the population of children in the survey with a reference population of well-nourished children[25]. Using of standard UN-reference population is based on the finding that well-nourished children in all populations follow similar growth patterns and, thus, exhibit similar distributions with respect to height and weight of given age[7]. Height-for-age Z score is one of the most recommended malnutrition indicators especially for the children under five years old[2,6,7,25,26].

HAZ is a stunting indicator of chronic malnutrition based on the principle that a child has an expected height for his age. It is an indicator of shortness/tallness and low score is evidence of chronic undernutrition[23,27]. Height-for-age Z-score is an indicator measure of child health since it is believed to be a long-run measure of nutritional status[5]. Also, it is a measure of past nutritional status. A child who is less than 2SD below the reference median of HAZ, is classified as chronically malnourished or stunted[25].

HAZ is computed by the following formula:

$$HAZ = \frac{H(A,S) - M(A,S)}{SD},$$

where

$$HAZ = Height - for - Age\ Z\ score$$

$$H(A,S) = Height\ of\ child\ given\ Age\ and\ Sex$$

$$M(A,S) = Median\ of\ the\ Height\ of\ the\ UN\ reference\ population\ given\ Age\ and\ Sex\ of\ the\ child$$

$$SD = Standard\ Deviation\ of\ the\ UN\ reference\ population.$$

In general, by using the Nutrition Procedure of Epi Info Computing Package Version 6.02[8], the anthropometric measures convert information for children with height, weight and age into Z-scores based on the NCHS (National Center for Health Statistics) recommended reference population.

WHO and CDC (Center for Disease Control) recommended that the cut-off point of Z-score is 2SD units below the reference median of HAZ indicator. So, we will classify the stunting status of children into two categories:

Category 1: Children who are stunting, i.e., their scores are less than -2SD.

Category 2: Children who are not stunting, i.e., their scores are greater than -2SD.

Methodology

Since the stunting status of children and their sex, area of residence, treatment of drinking water, dwelling status, type of sewage disposal, no. of sleeping rooms and place of toilet are classified under the categorical data. Therefore, the data of the current research has transferred into categorical data with six categorical variables.

Categorical data often consist of counts of the number of units with some given attributes. These may be represented in multidimensional tables which is called the contingency table.

Loglinear approach is used to investigate the relationships between several categorical variables. It is used for the analysis of data which the variables are categorical, i.e., they are measured nominal or ordinal scales. Each scale may have more than two categories. Therefore, social scientists are interested in a relatively general procedure for measuring and testing the interactions arising in multidimensional tables through loglinear analysis procedure. Thus, loglinear analysis attempts to identify the structure underlying a set of categorical variables.

The loglinear model deals only with categories of observations and the unit of this analysis is not individual scores, but rather cell probabilities or functions of cell probabilities[20,21]. The loglinear model procedure analyzes the frequency counts of observations falling into each cross-classification category in a contingency table. Each cross-classification in the table constitutes a cell, and each categorical variable is called a factor. The dependent variable is the number of cases (frequency) in a cell of the contingency table, and the explanatory variables are factors and covariates[18,24].

Since the variables for the present research are:

- the stunting status of children (X) (stunting, not stunting),
- sex of children (Y) (male, female),
- area of residence (Z) (urban, rural),
- treatment of drinking water (W) (treatment, not treatment),
- dwelling status (D) (owned, other),
- place of toilet (T) (inside home, outside),
- type sewage disposal (S) (public network, other),
- no. of sleeping rooms (N) (less than 4, 4 rooms and above)

which are classified as categorical data.

Therefore, for example, the loglinear model for three variables is usually written in the following format[3,9,10,13,22]:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ} + \lambda_{ijk}^{XYZ}$$

where:

the expected values of the frequencies are:

F_{ijk} , $i = 1,2,...,I$, ..., $v = 1,2,...,V$;

μ = the grand mean,

λ_i^X , λ_j^Y , λ_k^Z = main effect terms;

λ_{ij}^{XY} , λ_{ik}^{XZ} , λ_{jk}^{YZ} = are the first-order interaction effects; and

λ_{ijk}^{XYZ} = are the second-order interaction effects.

This model is denoted as (XYZ) which is called the saturated model.

Thus, for the present research, the following definitions for the main terms are:

λ_i^X = the stunting status of children main effect term,

λ_j^Y = the children sex main effect term,

λ_k^Z = the area of residence main effect term,

λ_e^W = the treatment of drinking main effect term,

λ_g^D = the dwelling status main effect term,

λ_h^T = the place of toilet main effect term,

λ_l^S = type of sewage disposal, and

λ_v^N = no. of sleeping rooms.

λ_{ij}^{XY} = the interaction effect term between the stunting status of children and the area of residence,

λ_{ik}^{XZ} = the interaction effect term between the stunting status of children and sex of children, and so on.

Analysis and Results

As we stated, the child sex is an important factor in determining the stunting status of children. The aim of the present research is to investigate the relationship between the stunting status (HAZ) of children and treatment of drinking water, dwelling status, and type of sewage disposal, place of toilet, and no. of sleeping rooms in some Yemeni children along with two other dimensions sex of the child and area of residence by using the loglinear models for multidimensional contingency tables.

In other words, the hypothesis to be tested has the following form:

H_0 : There are no interactions between the stunting status of children and some socio-economic factors (such as dwelling status, treatment drinking water, type of sewage disposal, no. of sleeping rooms and place of toilet) along with two other dimensions sex of the child and area of residence.

H_a : There are interactions between the stunting status of children and some socio-economic factors (such as dwelling status, treatment drinking water, type of sewage disposal, no. of

sleeping rooms and place of toilet) along with two other dimensions sex of the child and area of residence.

These variables are considered as categorical variables.

For such reason, loglinear model is the most appropriate data analysis tool[12, 15].

Table (1), indicates some details about the variables used.

Table (1): Variables basic statistics

Variables	Categories	Code	Frequency	%
Sex (Y)	Female	0	6225	49.4
	Male	1	6387	50.6
Area (Z)	Urban	1	8331	66.1
	Rural	0	4281	33.9
Dwelling Status (D)	Owned	1	9002	71.4
	Other	0	3610	28.6
No. of Sleeping Rooms (N)	Less than 4	1	9035	71.4
	4 rooms and above	0	3577	28.6
Treatment Water drinking (W)	Treatment	1	2608	20.7
	Not treatment	0	10004	79.3
Type of Sewage Disposal (S)	Public network	1	3577	28.4
	Other	0	9035	71.6
Place of Toilet (T)	Inside house	1	11490	91.1
	Outside house	0	1122	8.9
Stunting Status (X)	Not Stunting	1	8643	68.5
	Have stunting	0	3469	31.5

It should be observed from Table (1) that there are about 79.3% of households are still drinking water without treatment it. Also, 71.6% of households have not flush connected to public network or cooperative network but their sewage disposal to street or open or close pooled or pit, however 8.9% of households using toilet which lies outside their houses.

Table (1) shows also that there are only 31.5% of the children were considered as suffering from stunting.

Table (2): Factors in the Loglinear Model (XYD)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Y*D	1.519	.218	-.013	-1.231	.218
X*Y	15.752	.000	-.044	-4.086	.000
X*D	21.479	.000	-.050	-4.643	.000
X	1774.186	.000	-.412	-38.103	.000
Y	2.081	.149	-.028	-2.597	.009
D	2381.166	.000	-.477	-44.056	.000

Table (2) shows the results for the studying the relationship between the stunting status (X) of children, sex of children (Y) and dwelling status by using the saturated loglinear model which can be written as:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^D + \lambda_{ij}^{XY} + \lambda_{ik}^{XD} + \lambda_{jk}^{YD} + \lambda_{ijk}^{XYD}$$

It should be observed that there is no interaction between three factors (X*Y*D) since the likelihood ratio chi-square is not significant (P-value = 0.218 > 0.05). This results reveals that the dwelling status and sex of children have no effect on the stunting status of children. However, the interaction between dwelling status and the stunting status of children is highly significant (P-value = 0.000 < 0.05). Also, the factors (X, D) have statistically significance main effects (P-value = 0.000 < 0.05).

Table (3): Factors in the Loglinear Model (XYN)

Effect Terms	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Y*N	.030	.863	-.002	-.172	.864
X*Y	15.769	.000	-.039	-3.658	.000
X*N	.829	.362	.010	.906	.365
X	1774.186	.000	-.386	-36.318	.000
Y	2.081	.149	-.037	-3.467	.001
N	2441.897	.000	-.460	-43.305	.000

Table (3) shows the results for the studying the relationship between the stunting status (X) of children, sex of children (Y) and no. of sleeping rooms (N) by using the loglinear model which can be written as:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^N + \lambda_{ij}^{XY} + \lambda_{ik}^{XN} + \lambda_{jk}^{YN} + \lambda_{ijk}^{XYN}$$

It should be observed that there is no interaction between three factors (X*Y*N) since the likelihood ratio chi-square is not significant (P-value = 0.863 > 0.05) which indicates that the no. of sleeping rooms and sex of children have no effect on the stunting status of children. Also, the interaction between no. of sleeping rooms and the stunting status of children (X*N) is not significant (P-value = 0.362 > 0.05). Also, the factors (X, N) have statistically significance main effects (P-value = 0.000 < 0.05).

Table (4): Factors in the Loglinear Model (XYW)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Y*W	.655	.418	.010	.807	.420
X*Y	14.945	.000	-.044	-3.443	.001
X*W	110.978	.000	.131	10.240	.000

X	1774.186	.000	-.471	-36.861	.000
Y	2.081	.149	-.023	-1.810	.070
W	4628.061	.000	.729	57.059	.000

The loglinear model for studying the interaction of the stunting status (X) of children, sex of children (Y) and treatment of drinking water (W) has the following form:

$$log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^W + \lambda_{ij}^{XY} + \lambda_{ik}^{XW} + \lambda_{jk}^{YW} + \lambda_{ijk}^{XYW}$$

It should be observed that there is no interaction between three factors (X*Y*W) since the likelihood ratio chi-square is not significant (P-value = 0.418 > 0.05). This results reveals that the treatment of drinking water and sex of children have no effect on the stunting status of children. However, the interaction between treatment of drinking water and the stunting status of children (X*W) is very high statistically significant (P-value = 0.000 < 0.05).

Table (5): Factors in the Loglinear Model (XYS)

Effect Terms	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Y*S	.007	.931	.001	.084	.933
X*Y	15.987	.000	-.039	-3.337	.001
X*S	315.715	.000	.201	17.018	.000
X	1774.186	.000	-.490	-41.526	.000
Y	2.081	.149	-.029	-2.476	.013
S	2441.897	.000	.553	46.886	.000

The loglinear model for studying the interaction of the stunting status (X) of children, sex of children (Y) and type of sewage disposal (S) has the following form:

$$log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^S + \lambda_{ij}^{XY} + \lambda_{ik}^{XS} + \lambda_{jk}^{YS} + \lambda_{ijk}^{XYS}$$

Table (5) reveals that there is no interaction between three factors (X*Y*S) since the likelihood ratio chi-square is not significant (P-value = 0.931 > 0.05). This means that the type of sewage disposal and sex of children have no effect on the stunting status of children. However, there are very high statistically significant interaction between type of sewage disposal and the stunting status of children (X*S) (since P-value = 0.000 < 0.05).

Table (6): Factors in the Loglinear Model (XYT)

Effect Terms	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Y*T	3.077	.079	-.029	-1.746	.081
X*Y	15.855	.000	-.062	-3.723	.000
X*T	4.209	.040	.033	1.957	.050

X	1774.186	.000	-.364	-21.888	.000
Y	2.081	.149	-.040	-2.393	.017
T	9913.421	.000	-1.153	-69.402	.000

The loglinear model for studying the interaction of the stunting status (X) of children, sex of children (Y) and place of toilet (T) has the following form:

$$log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^T + \lambda_{ij}^{XY} + \lambda_{ik}^{XT} + \lambda_{jk}^{YT} + \lambda_{ijk}^{XYT}$$

Table (6) shows that there is no interaction between three factors (X*Y*T) since the likelihood ratio chi-square is not significant (P-value = 0.079 > 0.05) which implies that the stunting status of children does not affect by the place of toilet and sex of children. However, there are statistically significant interaction between place of toilet and the stunting status of children (X*T) (since P-value = 0.040 < 0.05).

Table (7): Factors in the Loglinear Model (XZD)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Z*D	5.456	.020	.031	2.351	.019
X*Z	76.331	.000	.110	8.32	.000
X*D	5.694	.017	-.010	-.73	.463
X	1774.186	.000	-.359	-27.24	.000
Z	1323.876	.000	-.469	-35.56	.000
D	2381.166	.000	-.613	-46.48	.000

The loglinear model for studying the interaction of the stunting status (X) of children, area residence of children (Z) and dwelling status (D) has the following form:

$$log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Z + \lambda_k^D + \lambda_{ij}^{XD} + \lambda_{ik}^{XD} + \lambda_{jk}^{ZD} + \lambda_{ijk}^{XZD}$$

Table (7) shows that there are interaction between three factors (X*Z*D) since the likelihood ratio chi-square is statistically significant (P-value = 0.020 < 0.05) which implies that the stunting status of children is affected by the dwelling status and the area residence of children. Also, there are statistically significant interaction between the dwelling status and the stunting status of children (X*D) (since P-value = 0.017 < 0.05). The interaction between stunting status of children and the area residence (X*Z) is statistically significant (P-value = 0.000 < 0.05). Also, all factors (X, Z, D) have statistically significant main effect.

Table (8): Factors in the Loglinear Model (XZN)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Z*N	4.952	.026	.024	2.225	.026
X*Z	92.265	.000	.107	9.679	.000

X*N	.962	.327	.017	1.521	.128
X	1774.186	.000	-.354	-32.172	.000
Z	1323.876	.000	-.296	-26.926	.000
N	2441.897	.000	-.459	-41.728	.000

The loglinear model for studying the interaction of the stunting status (X) of children, area residence of children (Z) and the no. of sleeping rooms (N) has the following form:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Z + \lambda_k^N + \lambda_{ij}^{XN} + \lambda_{ik}^{XN} + \lambda_{jk}^{ZN} + \lambda_{ijk}^{XZN}$$

It should be noted from Table (8) that there are interaction between three factors (X*Z*N) since the likelihood ratio chi-square is statistically significant (P-value = 0.026 < 0.05) which implies that the stunting status of children is affected by the no. of sleeping rooms and the area residence of children. However, the interaction between the no. of sleeping rooms and the stunting status of children (X*N) is not significant (since P-value = 0.327 > 0.05).

Table (9): Factors in the Loglinear Model (XZW)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Z*W	.090	.764	-.007	-.332	.740
X*Z	46.585	.000	.078	3.471	.001
X*W	66.254	.000	.100	4.464	.000
X	1774.186	.000	-.428	-19.111	.000
Z	1323.876	.000	-.720	-32.122	.000
W	4628.061	.000	1.053	47.009	.000

The loglinear model for studying the interaction of the stunting status (X) of children, area residence of children (Z) and treatment drinking water (W) has the following form:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Z + \lambda_k^W + \lambda_{ij}^{XW} + \lambda_{ik}^{XW} + \lambda_{jk}^{ZW} + \lambda_{ijk}^{XZW}$$

Table (9) shows that there is no interaction between three factors (X*Z*W) since the likelihood ratio chi-square is not statistically significant (P-value = 0.764 > 0.05) which implies that the stunting status of children does not affect by the treatment drinking water and the area residence of children. However, there are very high statistically significant interaction between the treatment drinking water and the stunting status of children (X*W) (since P-value = 0.000 < 0.05).

Table (10): Factors in the Loglinear Model (XZS)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Z*S	1.729	.189	-.060	-1.439	.150
X*Z	5.325	.021	.083	2.002	.045

X*S	228.689	.000	.132	3.171	.002
X	1774.186	.000	-.419	-10.075	.000
Z	1323.876	.000	-1.089	-26.192	.000
S	2441.897	.000	1.274	30.652	.000

The loglinear model for studying the interaction of the stunting status (X) of children, area residence of children (Z) and type of sewage disposal (S) has the following form:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Z + \lambda_k^S + \lambda_{ij}^{XZ} + \lambda_{ik}^{XS} + \lambda_{jk}^{ZS} + \lambda_{ijk}^{XZS}$$

Table (10) reveals that there is no interaction between three factors (X*Z*S) since the likelihood ratio chi-square is not significant (P-value = 0.189 > 0.05). This means that the type of sewage disposal and the residence of children have no effect on the stunting status of children. However, there are very high statistically significant interaction between type of sewage disposal and the stunting status of children (X*S) (since P-value = 0.000 < 0.05).

Table (11): Factors in the Loglinear Model (XZT)

Effect Term	Likelihood Ratio Chi-Square	P-value	Parameter Estimate	Z	P-value
X*Z*T	14.694	.000	-.069	-3.882	.000
X*Z	88.064	.000	.039	2.203	.028
X*T	.053	.817	.021	1.178	.239
X	1774.186	.000	-.335	-18.765	.000
Z	1323.876	.000	.020	1.127	.260
T	9913.421	.000	-1.156	-64.686	.000

The loglinear model for studying the interaction of the stunting status (X) of children, area residence of children (Z) and place of toilet (T) has the following form:

$$\log F_{ijk} = \mu + \lambda_i^X + \lambda_j^Z + \lambda_k^T + \lambda_{ij}^{XZ} + \lambda_{ik}^{XT} + \lambda_{jk}^{ZT} + \lambda_{ijk}^{XZT}$$

Table (11) reveals that the interaction between three factors (X*Z*T) is very high statistically significant because the likelihood ratio chi-square is significant (P-value = 0.000 < 0.05) which implies that the stunting status of children is affected by the place of toilet and the residence of children. However, there is no statistically significant interaction between the place of toilet and the stunting status of children (X*T) (since P-value = 0.817 > 0.05).

Conclusion

The aim of this research was to study the interaction between some demographic factors and the prevalence of stunting status of children in the Yemeni children. For such reason, the under five children of the Yemeni Household Budget Survey data (2005/2006) were used. Stunting status of children is usually measured by the height-for-age z-score indicator (HAZ)[(25)]. The demographic factors are dwelling status (D), treatment drinking water (W), type of sewage disposal (S), place of toilet (T), no. of sleeping rooms (N), sex of children (Y) and area residence (Z) which are considered as categorical data. The loglinear model was used to analyze the interaction between these factors and the stunting status (X) of each child. The results of loglinear analyses have indicated that:

- (X*Z*D), (X*Z*N), and (X*Z*T) terms are statistically significant. That is the stunting status is affected by dwelling status and area residence (D,Z), no. of sleeping rooms and area residence (N,Z), and place of toilet and area residence (T, Z).
- For sex of children (Y) or area residence of children (Z), it should be noted that the stunting status of children (X) is significantly associated with dwelling status (X*D), treatment drinking water (X*W) and type of sewage disposal (X*S).
- It has been found that sex of the child and area of residence are significantly associated with stunting status of children.
- Also, for only sex of children (Y), it has been found that there is statistically significant interaction between stunting status of children and place of toilet (i.e., X*T term).

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