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Cover Page Footnote
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Categorical outcomes with environment factors analyzed by log linear model are frequent in the environmental epidemiological literature. Epidemiological and socio-economical factors were obtained on 1,119 children below the age of 5 from Infectious Diseases Hospital (IDH) at the Kolkata, India. Significant associations of diarrhea were observed in the rural areas with family income, father's occupation as a daily labor, literacy of parents, non-cemented floor and wall constructed of mud, and type of storage (wide mouthed earthen pot). The results of the study with specific Log linear model confirm environmental factors were important implications for childhood diarrhea in the rural community. To reduce the diseases burden, the intervention strategies such as education, improvement of economic status and living environment are recommended.

Key words: Log-linear model**,** Systematic sampling, hospital based surveillance

Introduction

Unhygienic environment is one of the major factors for spreading infectious diseases in the developing countries. Poor socioeconomic and the environment are profusely interrelated to infectious diseases. In many studies it has been shown that epidemics of diarrhea were due to poor hygiene and water sanitation. Diarrhea causes high mortality and morbidity of children less than five years mainly due to water pollution and deterioration of environmental sanitation (Zeitlin et al., 1995). In rural Bangladesh, incidence of diarrhea was found to be highest among children of 10-12 months (Alam, 1995). This age group has greater exposure to environmental contamination and the other risk factors including fecal contaminations, garbage disposal in the open field and inadequate cleaning after defecation (Alam N et al., 1989).

Many intervention studies showed that the reduction of diarrhea up to 40% could be achieved through health education, domestic hygiene, maternal education, occupation and household size (Aziz, 1990). Studies conducted at community level showed that socio-economic factors are profoundly associated with slum dwelling (85%), less economic feasibility (41%) to buy soap for hand washing (Hoque , 2003). In West Bengal, a rural community study indicated that children could be protected significantly from diarrhea if mother's wrong concepts about diarrhea can be altered through educational intervention (Sircar et al., 1987). In Nigeria, street vendor's food played significant roll to flare the high risk of prolonged diarrhea among children (Ekanem et al., 1994). Socioeconomic status and exposure to health programs showed significant relationship with selected maternal preventive behaviors in the northeast Thailand (Thongkrajai et al., 1990).

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A cross-sectional survey found association between mother's hygiene, socio economic status, household environment and mother's education level may contribute to the attitude of hand washing in Philippines (Sakisaka et al., 2002). From many investigations it is evident that a prime factor for environment is water born diseases all over the world. The Log –linear model should consider many categorical variable and environmental factors to generate useful information (Lakhan et al., 2002).

The categorical data can be highlighted the interrelationship with log linear analysis. The main emphasis of log linear analysis is that linear in the logarithms of expected frequencies of a contingency table that adequately describes or fits the associations and interaction which exist in the original frequency table. Log linear techniques are especially useful for frequency table with more than three variables when the number of possible associations and interactions among the variables became very large (Gibert et al., 1981). The main objective of this study is to analyze the socioeconomic and environmental factors in relation with diarrhea among children less than five years by log-linear model.

Materials and Method

Systematic sampling of every 5th hospitalized diarrhea case was made in two randomly selected days (24 hours) in a week from an active surveillance system at the Infectious Disease Hospital (IDH), Kolkata, India. Data were based on patient's information such as socio-economic status, demography, water source, sanitation and living environment, clinical outcome, patient management and laboratory diagnostic report. The IDH treats about 30,000 patients yearly as in and out patients from Kolkata city as well as semi-urban areas around the city.

Data were collected by pre-trained professional and manually edited before sending to data management center. The data were entered in the personal computer by two data entry professional in the pre-designed format profarma with inbuilt validation that run on Epinfo (version 6.02) package. Data were randomly checked and matched for validation and was finally analyzed by employing SPSS 4.0 ver. and S-plus software's.

Log Linear Model

Log linear model can be classified as non-standard or conventional. Non-standard models require specification of a set of hypotheses concerning the structure of the data. Non-standard log linear models are not hierarchical and therefore do not consider main effects and interaction used in conventional log linear models (Kennedy et al., 1983; Magidson et al., 1981; Breen, 1984; Rindskopf , 1990;). Conventional log linear models can be grouped into saturated and unsaturated models. A saturated log linear model fits the original frequency tables exactly. Unsaturated log linear models are also referred to as hierarchical log linear models (Bishop et al., 1975; Hagenaars, 1990; Agresti, 1990). The model does not distinguish between independent and dependent variables. All variables are treated alike as response variables whose mutual association is to be explored. The model to represent the association between the variables

$$\ln F_{ij} = u + u_1(i) + u_2(j) + u_{12}(ij)$$

where the parameter u12(ij) represents the association between category i of variable 1 and category j of variable 2. u1(i) is the "main effect " if category ith of th e row variable and u2(j) is the "main effect " if category jth of the column variable. This is known as a saturated model.

Environmental and socio-economic parameters were included to co-relate with diarrhea of less than five years age children. The independent variables were classified into three groups: socio-economic, resident pattern and sanitation and water source (Table 1). It can be assumed that the number of cases per cell has a multinomial distribution. The relationship between independent variable and occurrence of diarrhea in areas was studied employing Log linear Model. A backward procedure for log-linear modeling (SPSS- ver.4.0 software) was

Table 1. Three Groups of Independent Variables

Socio-economic	Resident pattern & Sanitation	Water source
i) Family Income (Faminc) ii) No of children(<=5Yrs age) in the family(Child) iii) No of members in the family (Nomemb) iv) Fathers occupation (Ocufath) v) Mothers occupation (Ocumoth) vi) Education of father (Educf) vii) Education of mother (Educm)	i) Floor structure (Floor) ii) Wall structure (Wall) iii) No of rooms in the resident (Noroom) iv) Place of defecation (Plcedefe) v) Place of disposal (Plcedisp)	i) Source of drinking water (Drinkwat) ii) Drink water from where (whrhrpvt) iii) Type of storage (Typestor) iv) Water used for washing utensils (wasuten) v) Water used for bathing (Wtrbath)

used to identify the best model. The independent variables significantly associated with the outcome variable from three groups were selected and pooled. The second order hierarchy model was constructed and analyzed. In the explained model, socio-economic, resident pattern & sanitation and water source were considered (Table 3).

Out of 4,601diarrhoeal patients enrolled in this study, 1,119 cases were of children below 5 years of age. Using the distribution of the day frequency of diarrheal cases, the peak season of diffusion of diarrheal diseases was determined. The data was edited and scrutinized as two days in a week and determined mean distance of all patients those who were admitted at IDH in selected days of the week to know the distance from where the patients were coming that was fitted in the polar graph using the S-Plus software. The day frequencies are fitted into time series curve, which will explore exact existence of the distribution.

Final Models:

1) Socio-economic
Areas+Faminc+Ocufath+Educf+Educm +Child+(Areas*Faminc) +(Areas*Ocufath) +(Areas*Educf)+(Areas*Educm)+(Areas*Child).

2) Resident Pattern & Sanitation
Areas+Noroom+Floor+Wall+Plcedisp+ Plcedefe+(Areas*Noroom)+(Areas*Floor) +(Areas*Wall)+(Areas*Plcedisp)+(Areas*Plcedefe).

3) Water source
Areas+Whthpvt+Typestor+Wtrbath+(Areas*Whthpvt)+(Areas*Typestor) +(Areas*Wtrbath).

Results

Among the 1,119 children, 871(77.8%) and 248(22.2%) were from urban and rural areas respectively with the ratio of 3.5:1. Environment and economic status of patients were given importance. The distribution of socio-economic, resident pattern & sanitation and water source are presented in Table 2. Many variables were modified according to generated measure of central tendency of that variable. For example, occupation of the father was classified in to daily labors (e.g., day laborer, share cropper),

Table 2. Distribution of grouped variables with area wise diarrhea cases

S.No	Factors	Urban (n=871)		Rural (n=248)	
I	Socio-economic variables	No	%	No	%
1	Family Income				
	≤1000	189	21.7	108	43.5
	1001 - ≤2000	320	36.7	79	31.9
	2001 - ≤3000	268	30.8	46	18.5
2	>3000	94	10.8	15	6.0
	No of children (≤5yrs age) in the family				
	Single	545	62.6	137	55.2
	Double	214	24.6	56	22.6
	3-4 child	43	4.9	11	4.5
3	>4 child	69	7.9	44	17.7
	No of members in the family				
	1-3 members	232	26.6	63	25.4
	4-6 members	525	60.3	154	62.1
4	>6 members	114	13.1	31	12.5
	Fathers occupation				
	Daily labor	307	35.3	118	47.6
	Skilled workers	327	37.5	69	27.8
	Owns petty business	158	18.1	43	17.3
5	Others	79	9.1	18	7.3
	Mother occupation				
	House wife	731	83.9	162	65.3
	Skilled workers	137	15.8	85	34.3
	Others	3	.3	1	.4
6					
	Father education status				
	School completed	512	58.8	131	52.8
	College & University	88	10.1	13	5.2
	Illiterate	271	31.1	104	42.0
7					
	Mother education status				
	School completed	455	52.2	102	41.1
	College & University	31	3.6	6	2.4
	Illiterate	385	44.2	140	56.5
8					
	Resident Pattern				
	Floor Structure				
	Non cemented	659	75.7	103	41.5
	Cemented	131	15.0	58	23.4
		66	7.6	69	27.8
		15	1.7	18	7.3
9					

10	Place of defecation				
	Sanitary	696	80.0	116	46.8
	Service	62	7.1	19	7.7
	Dughole	57	6.5	34	13.7
	Open field	56	6.4	79	31.8
11	No of Room in the house				
	≤2 Rooms	787	90.4	220	88.7
	3-4 Rooms	75	8.6	24	9.7
	>4 Rooms	9	1.0	4	1.6
12	Place of disposal				
	In to latrine	267	30.7	41	16.5
	In to drain	340	39.0	54	21.8
	In field	130	14.9	112	45.2
	Others	134	15.4	41	16.5
III	Water Sources				
13	Source of drinking Water				
	Tap	602	69.1	56	22.6
	Tube well	262	30.1	180	72.6
	Open well	7	.8	12	4.8
14	Drinking water from where				
	Private	233	26.8	54	21.8
	Common	635	72.9	185	74.6
	Others	3	.3	9	3.6
15	Type of storage				
	Earthen Pot (nm)	390	44.8	91	36.7
	Earthen Pot (wm)	197	22.6	98	39.5
	Bucket	257	29.5	56	22.6
	Others	27	3.1	3	1.2
16	Water used for washing utensils				
	Tap	401	46.0	32	12.9
	Tube well	149	17.1	94	37.9
	Pond	7	.8	6	2.4
	Open well	12	1.4	34	13.7
	Others	302	34.7	82	33.1
17	Water used for bathing				
	Tap	377	43.3	31	12.5
	Tube well	145	16.6	78	31.5
	Pond	7	.8	7	2.8
	Open well	24	2.8	41	16.5
	Others	318	36.5	91	36.7

skilled workers (e.g.., boatman), small business owner (e.g., street vender, fisherman). Similarly other variables were modified (Table 2). The area wise results of the significantly associated independent variables from log-linear model of different groups are presented in Table 3.

In rural areas, family income of ≤ Rs 1000 ($p < 0.001$), father's occupation as daily labors ($p < 0.001$), illiterate mothers ($p < 0.003$) and father's education as an illiterate ($p < 0.001$) in Socio-economic group; non-cemented floor structure ($p < 0.001$), wall structure with mud ($p < 0.001$) and fecal disposal in field ($p < 0.001$) in resident pattern & sanitation group, and in water source category, type of storage with wide mouthed earthen pot ($p<0.001$) and water used for bathing from open well and others ($p < 0.001$) were significantly associated with diarrhea. In urban areas, family income > 1000 but ≤ 2000 ($p < 0.001$), in socio-economic group; non-cemented floor structure ($p < 0.0001$), wall structure with brick ($p < 0.001$) place of defecation with sanitary ($p < 0.001$) and fecal disposal in latrine ($p < 0.001$), were significantly associated with diarrhea. In resident pattern & sanitation group no one was found significantly associated with diarrhea.

Discussion

Developing countries can reduce disease burden by 25% that is the equivalent to averting more than 9 million infant deaths by control and treatment of infectious diseases including malnutrition. The burden of diarrheal diseases was 92.8 million of Disability adjusted life years for fewer than 4 years children. Improving household environments could avert the annual loss of more than 80 million disability-free years of human life (World Bank, 1993). Environment and economic status are core factors for stabilizing the human life in health prosperity, particularly poor and unhygienic environment help in the spread of many infectious diseases in human. Different environmental factors have been proposed for the subsistence and spread of diseases. Previous community based studies conducted in Calcutta, showed that maternal behavior, feeding practices, living in non-cemented house, less family income, illiterate mother, wide mouth container for drinking water storage, sharing common latrine, leftover food for next feeding, dirty baby cloths, less birth space between two children were responsible for childhood diarrhea (Ghosh et al., 1998).

The interest was focused on the use of log linear models to explore the data because this model is categorical and specially deals with environmental features. The log-linear model with broad spectrum of environmental factors previously has been used (e.g., Valtonen et al., 1994; Gonzalez et al., 1995; Badia et al., 1996). Log linear modeling permits to assess different factors such as for the socio-economic, resident pattern & sanitation and water source, which might influence diarrheal disease.

The independent variables have been grouped in to three viz. socio-economic, resident pattern and sanitation and water source, with at least 5 independent variables in each group viz. family income (Faminc), Floor structure (Floor), Source of drinking water (Drinkwat), etc. Faminc is formed a main effect and interaction association between two variables in the frequency table such as (Areas) and (Faminc), is denoted as Areas Faminc in the log linear model. By the definition of hierarchical log linear model, the term (Areas * Faminc) contains the two lower order main effect; similarly interaction among three variables can be analyzed in the log linear model.

The order interaction among three variables did not show any significant relation. Generally, various log linear models can be fitted to the data, the final log linear model that is selected need not contain all possible interaction in the frequency table since the purpose of log linear analysis is to find the simplest model that adequately describes the data. As a rule the greater the number of variables in the frequency table, the larger the number of possible log linear models that can be constructed.

Partial and marginal association tests and backward elimination procedure are normally used for selecting log linear models to be tested. The procedures of marginal and partial association are described to test main effects of three groups the log linear model is used (Dillon et al., 1984). All main effects are included in the base model, which is fitted to the original frequency table, and its level of significance is

noted. Models are then fitted that omit each main effect in succession. The significance of the main effect variable is then determined by finding the difference between the chi-square values and the degrees of freedom of the base model. In a similar manner, all two-way, three-way interaction terms, and omitting each of the respective interaction term were conducted.

The log-linear model explored various factors associated with childhood diarrhea both in urban and rural community. In rural area, we found the socioeconomic factors like income of the family, father's occupation; parents' education and environmental factors like resident pattern, place of disposal of their children faces, water usage like drinking, bathing were significantly associated with diarrhea. In developing countries providing good living and socioeconomic conditions can prevent diarrheal diseases. In addition, many effective preventive measures should be adopted to reduce the diarrheal episodes.

In Australia, randomized controlled trail diarrhea on infection-controlled intervention has shown that 66% diarrheal episodes at the child care centers (Borghi et al., 2002; Roberts et al., 2000; Tompson , 1994). Compared to control group, hand-washing practice reduced 89% of diarrheal episodes in Indonesia (Wilson et al., 1991). In northern Pakistan, a case-control study revealed after village level implementation of water supply, sanitation awareness and practices about hygiene behavior as confounders were controlled 33% of diarrheal episodes at the early stage (Jensen et al., 2003; Nanan et al., 2003). In this study, July – October (monsoon to north monsoon) was peak season for arrival of maximum diarrheal cases. Studies conducted in china have also shown a similar trend in the occurrence of diarrhea (Yang et al., 1990). As shown in other studies, this study supports improvement of environment and economic status of the people is the first step in the prevention of diarrheal diseases.

Figure 1 (see Appendix) focuses the promotion of community education directly influence quality of human life. In this study, we have shown that in rural community less than five years old children were susceptible for diarrheal diseases owing to deterioration of personal hygiene of the parents and child which are directly related with economic status of the family, education status of parents and water quality around them. It is known that in many developing countries the population is in progress nature due to which, eradication of infectious diseases particularly diarrhea is a hard task as lack of both education and economic status succumb the personal hygiene of every family. As shown in the hypothetical model (Fig-1), educate people, evaluate the economic status, emancipate poor environment might help to eradicate the infectious diseases in the rural community.

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APPENDIX

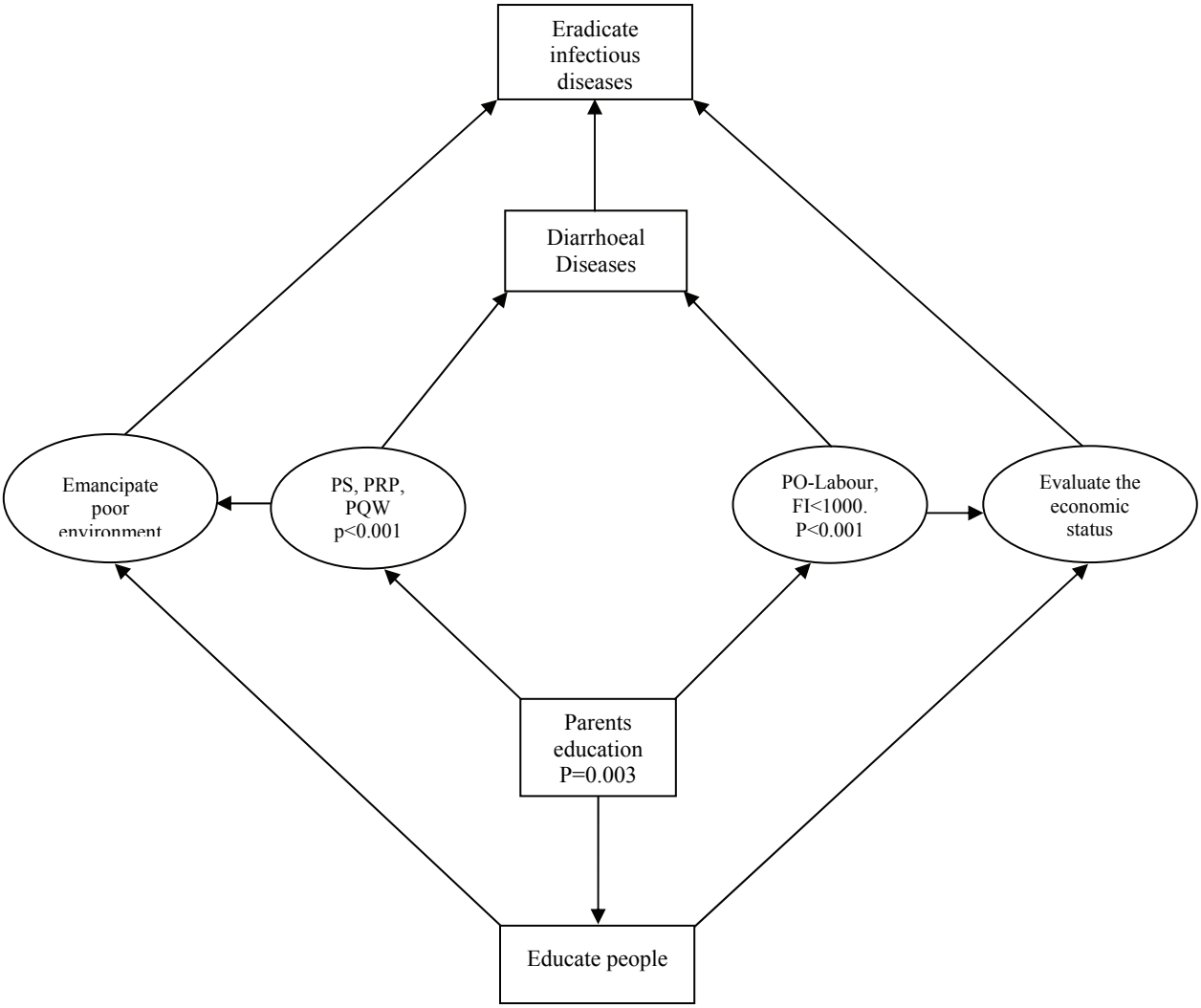

Figure 1. Hypothetical model showing several intervention strategies in controlling diarrheal diseases. PS-Poor sanitation, PRP-Poor resident pattern, PQW-Poor quality water, PO-Parents Occupation, FI-Family income.