Statistics and Applications **{ISSN 2452-7395(online)}**
Volume 14, Nos. 1&2, 2016 (New Series), pp 159-169

Multi-level Modeling Approach to Analyze Child Health Care Services, Utilization and its Correlates

Tulsi Adhikari, Jiten Kh Singh, Atul Juneja and Arvind Pandey
National Institute of Medical Statistics (ICMR), Ansari Nagar, New Delhi, India

Received April 12, 2016; Revised September 05, 2016, Accepted December 07, 2016

Abstract

Multilevel modeling for studying the relationship between health care service and utilization indicator with various factors and determinants has been identified as an improved approach over the traditional regression model specially in the context of large scale community level surveys, where sample is drawn using cluster sampling. The present study deals with, modeling child health care services and studying, the influence of the context within which the people live and other explanatory variable. Also the superiority of multilevel modeling over the traditional regression modeling has been studied.

The information collected by District Level Household and Facility Survey (DLHS-RCH III: 2005-06) round three survey for the state of Madhya Pradesh is used to examine the access/utilization of the child health care services under the Reproductive and Child Health (RCH) programme. To study the associations of the child health indicator with the contextual and other explanatory variables, Binary logistic regression with step wise method was used. The multilevel modelling approach was also used for analysing the dependent nature of the outcome variable. Comparison of the two approaches is also done to evaluate the superiority of the one over the other. Likelihood Ratio (LR) test for multilevel VS the traditional regression model results in a Chi-square statistics value of 239.29 with p-value<0.001 which shows a strong advocacy for the multilevel level model.

The findings of the study advocate the use of hierarchical modeling (multilevel modeling) in analyzing the association for multistage sample surveys being conducted in the community setup.

Keywords: Multi-level modeling, Reproductive and Child Health (RCH), Immunization, District Level Health Survey (DLHS)

1. Introduction

One of the important goal of reproductive and child health (RCH) programme in the country is to reduce the infant and maternal mortality and morbidity. To achieve these objectives, the RCH service package, with the component of Maternal Health, Child Health, Family Planning, Adolescent Reproductive and Sexual Health, Urban Health, Tribal Health, has been introduced

Corresponding Author: Tulsi Adhikari
E-mail: tulsi_adhikari2003@yahoo.co.in

under the programme in all the states of India. This goal can only be achieved by maximizing the utilization of these services and by finding the factors associated with the utilization.

The present study aims at emphasizing the role of hierarchical modeling in analyzing the association between the utilization of child health care services with the individual level, Community level and District level factor.

The specific objectives of the study are:

a. To assess the inequity in the access and utilization of different child care services, viz, breast feeding practices, child immunization, management of diarrhea and treatment seeking behavior for children.
b. To investigate the degree to which the child care services utilization is influenced by the contexts within which the people live and other explanatory variables and to assess the superiority of Multi-level modeling approach over the Standard Logistic Regression for the current situation.

2. Material and Methods

The information collected by District Level Household & Facility Survey (DLHS-RCH III: 2005-06)[1] round three survey for the state of Madhya Pradesh is used to examine the access/utilization of the Health programmes.

The outcome indicators and the explanatory variables are as under

Outcome indicators

- Complete Immunization (BCG, 3 doses of DPT, 3 doses of polio and measles vaccine) – dependant variable for regression analysis,
- Oral Rehydration Solution(ORS) given to child for Diarrhoea,
- Seek advice or treatment for illness from cough and fever,
- Breast feeding practices

Explanatory Variables

Level 1: Household and individual level

- Own Electricity,
- Religion,
- Caste Group,
- Water Treatment,
- Type Of Toilet,
- Type Of Fuel Used In The Kitchen,
- Type Of House,
- Separate Room For Kitchen,
- Wealth Index Quintiles,
- Age Group,
- Age at Consummation of Marriage,
- Women's education level,
- Husband's Education
- Living With Husband or Husband Staying Elsewhere,
- Age at First Birth ,
- Total Number of Children,
- Heard/Seen Message-breast feeding,
- Heard/Seen Message-Immunisation

Level 2 : Village level

- Primary or Middle School,
- Any Govt Health Facility in the Village,
- Health Provider In The Village,
- Drainage Facility-Available,
- Distance To Nearest Bus Station

Level 3 : District Level

- District indicator

Univariate analysis was carried out to filter out the insignificant determinants for further analysis. For testing the co-linearity of the explanatory variables we have analysed the magnitude of multicollinearity by considering the size of the Variance inflation factor VIF(β_i). A common rule of thumb is that if VIF(β_i) >5 then multicollinearity is high. After checking the VIF of all the explanatory variables, binary logistic regression with step wise method was used.

The multilevel modelling approach[2] was also adopted for analysing the dependent nature of the outcome variable. Further, comparison of the two approaches is also done to evaluate the superiority of the one over the other.

The Traditional Logistic Regression Vs the Multi level Regression Analysis

The model at **level-1** (The Traditional Logistic Regression model) can be formally expressed as:

$$y_{ij}=ß_{0j}+\sum_{l=1}^{p} ß_{lj}\chi_{lj}+e_{ij}$$

where χ_{ij} *s* are explanatory variables, $ß_{0j}$ is the value of $E(Y_{ij})$when $\chi_{ij}=0$ for all $i=1,2,....,p$, e_{ij} = residual variation in y_{ij} that cannot be explained

$$e_{ij} \overset{iid}{\sim} N(0, \sim\sigma_e^2)$$

To make this a **two-level** random intercept model, we let $ß_{0j}$ become a random variable, with an assumption that:

$ß_{0j} = ß_0+u_{0j}$, where u_{0j} *is the random part*

A multilevel model based on a **three-level** structure of individuals (level-1 denoted by 'i' subscript) nested within neighbourhoods/Primary Sampling Units (PSUs) (level-2, denoted by 'j' subscript) nested within regions/district (level-3, denoted by 'k' subscript). The micro model can be written as:

$$y_{ijk} = ß_{0jk}+ ß_1x_{1ijk}+ e_{0ijk}$$

$$y_{ijk}=ß_{0jk}+\sum_{l=1}^{p} ß_{ljk}\chi_{ljk}+e_{ijk}$$

with an additional subscript to represent the regions. In addition, there would be a macro model at the neighbourhood level (level-2):

$$ß_{0jk}= ß_{0k}+ u_{0jk}$$

where, u_{0jk} is the differential for the *jth* neighborhood in the region from average $ß_{0k}$. There would also be a macro model at the region level (level-3):

$$ß_{0k}= ß_0+ u_{0k}$$

where, v_{0k} is the differential for the *k*th region from the average $ß_0$

3. Analytical Framework

Inequity in access and utilization of under consideration child health services would be determined by seeing the access utilization differentials.

As one of the key aims of this study is to investigate the degree to which the child health utilization is influenced by the contexts within which the people live, the use of a conventional regression analysis framework has critical limitations. Multilevel statistical techniques provide a technically robust framework, to analyze outcome variable, overcoming the limitations of traditional regression technique.

4. Results:

4.1. Birth Details, Immunization and Treatment seeking behaviour

Table 1 presents the status of child health in the state of MP. Health of a child depends on many factors, staring from the birth, whether the child had check-up within 24 hours of his/her birth. Feeding of colostrums has long lasting effect on the immunity of a child, hence it is very important to give colostrums to the new born. Also breast feeding the child should be started immediately after the birth. Another way of improving the immunity against the deadly disease is to immunise the child with the set of vaccines prescribed under the universal immunisation programme. Management of diarrhoea and treatment seeking behaviour during cough and fever also have long lasting effect on the health of a child.

Out of the 25370 total number of children, who were the last child born in the state of MP for the last 2 years, about one third of the children had check- up done within 24 hours of the birth. About 81% of the children were fed the colostrum. Only 26% of the children were fully immunised in the state of Madhya Pradesh.

About 15% of the children had diarrhoea in the last 2 weeks of the survey date. Only 26% of them were given ORS and about 5% were on mother's milk and about 69% of the children were not given the required ORS.

About 19% of the children had fever or cough in the last 2 weeks of the survey date. Only about 55% of the respondents sought treatment for their children having illness from any source.

4.2. Outcome indicator by background characteristics of the mother

- ***Village Level Indicators***

Table 2 presents the village level indicator, viz., availability of schooling facility in the village, Government health facility in the village, health provider in the village, drainage facility in the village and distance to the nearest bus station. These are the village level indicator which are supposedly associated with the outcome indicators.

Those villages, which had schooling facility in place, which had government health facility available in the village, where health provider was present in the village and where distance to the nearest bus station was less than 5 kms, had greater proportion of new born babies, taken for check-up with 24 hours of heir birth.

Similarly other child health indicators like colostrums feeding, complete immunization ORS given to child for diarrhoea and seeking medical advice for illness were more prevalent in villages where primary or middle school facility was there. Same phenomenon was seen in the villages where government health facility was in place, where drainage facility was present,

where distance to nearest bus station was less than 5 kms and in the villages where health provider was present in the village.

- ***Household Level Indicators***

The Child health indicators are supposedly influenced by the household level indicators also, viz, household having own electricity, religion of the household, their caste and the quality of life indicators, viz., treated drinking water facility, type of toilet facility, type of house, separate room for cooking in the house, fuel used for cooking and their wealth index quintile.

All those households with own electricity, Muslim households, households from general caste, with water treatment facility in the house, with flush toilet in the house, using LPG or Bio-gas for cooking, living in pucca houses, using separate room for cooking or with wealth index quintiles as richest had improved child health indicators. (Table 3).

4.3. Individual Level Indicators:

Background characteristics of currently Married Women of age 15-49 years

The various child health indicators had varying patter in terms of mother's age (Table 3). Check-up with 24 hours of birth was more prevalent among the young mothers, i.e. 15-19 years. Feeding of colostrums, first breast fed the child with 24 hours and seeking medical advice for illness was highest among the mothers of age group 20-24 years. Complete immunization of the child was highest among the mothers of age 30-34 years. Mothers of age 25-29 year were more frequently giving ORS solution to their children during the diarrheal episodes. The women, whose age at consummation of marriage were 18 years or above, had improved child health indicators. The educational status of the mother and father both had positive effect on the child health indicators. The utilization was also positively affected by the education of the women and her husband as well. Women whose age at her first delivery was more than 18 years and whose total number of children were <= 2 were having better child health indicators.

Heard/seen message for breast feeding/immunization

The mothers who have heard or seen message of breast feeding or message of immunization were visibly better in term of child health indicators (Table 4). Percentage of children taken for check-up with 24 hours of their birth, percentage of children fed colostrums, percentage of children first breast fed immediately of percentage of children completely immunised were higher among the mothers who had heard or seen message of breast feeding or immunization.

5. Association of Complete Immunization with the Contextual and Individual Level Factors: Traditional Logistic Regression Vs Multi-Level Modeling Approach

In this section we explore the association of the child health indicator, viz, Complete immunization with the covariates at individual and community level. Also, the traditional logistic regression and multilevel modelling approaches are compared to assess the superiority on one on the other. (Table 5).

The traditional regression logistic regression analysis and also the two level model shows that there is statistically significant association between the complete Immunization and the village level indicators viz., health provider in the village, household level covariates, viz, wealth index quintiles of the family and individual level covariates viz., mother's age, age at consummation of marriage, mother's education, father's education, women living with husband or not.

LR test for multilevel VS the traditional regression model however, results in a Chi-square statistics value 239.29 with p-value<0.001 which indicates at a strong advocacy for the two level model.

The 3 level model with district at the second level and PSUs at third level shows that there is statistically significant association between the complete Immunization and the village level indicators viz., health provider in the village and individual level covariates viz., mother's age, age at consummation of marriage, mother's education, father's education and also the number of children ever born to the women.

Comparing with the traditional regression model with same covariates, we find that the LR test for multilevel VS the traditional regression model results in a Chi-square statistics value 656.22 with p-value<0.001, which is even greater than for the 2 level model, Chi-square statistics value 239.29, indicating a stronger advocacy for the three level modeling.

6. Concluding Remarks

A study by Abebe etal[3], assess the immunization differentials between regions in Malawi and attempts to relate regional disparities in immunization to factors on individual, household and village level. The study suggests that the low immunization coverage in Malawi is less likely to be result of geographical clustering of social groups with difficult level of living conditions.

Another study by Wiysonge et al[4], assesses the individual and contextual factors associated with low childhood immunization coverage in Sub-Saharan Arica using the multi-level approach. The study finds that individual and contextual factors are associated with childhood immunization and the public health programmes designed to improve the coverage of childhood immunization should address people, and the communities in which they live.

Our study suggests that, comparing the traditional regression model and multilevel model with same covariates, we find that the role of some of the individual and household covariates in utilizing of the complete immunization is mediated by the community level covariates. Also it is evident from the LR test for comparing multilevel Vs the traditional regression model, that the multilevel approach render a better regression model than the traditional regression model,

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Table 1. Child Health Indicators - Birth Details, Immunization of children 12-23 months of age and Treatment seeking behaviour for illness from cough and fever (%)

child have check-up within 24 hours of birth	yes		32.2
	no		66.8
	child did not survive		1.0
feed mother's milk 'colostrum/khees' (yellowish thick milk)	yes		81.5
	no		18.5
first breastfeed the child	immediately/within one hour of birth		41.0
	within 24 hours		28.3
	2 to 3 days		17.5
	after 3 days		12.0
	never		1.2
complete immunization	No		74.0
	Ýes		26.0
diarrhoea in the last 2 weeks	yes		14.7
	no		84.9
	Don’t know		0.3
	ORS given to child for diarrhoea	yes	25.7
		no	69.6
		child on breast milk	4.7
fever any time in the last 2 weeks	yes		18.9
	no		80.8
	dk		0.3
cough any time in the last 2 weeks	yes		22.1
	no		77.4
	dk		0.5
seek advice or treatment for illness from any source	yes		54.7
	no		45.3

Table 2. Child Health Indicators by Village level Indicators (%)

		Primary or middle school		Any Govt Health Facility in the Village		Health provider in the Village		drainage facility-available		Distance to nearest bus station		
		No	Yes	No	Yes	No	Yes	Yes	No	<=5km	5-10 km	>10 km
Child have check-up within 24 hours of birth		22.3	32.4	25.5	32.9	24.6	32.3	38.9	30.6	34.2	30.3	30.0
Feed mother's milk 'colostrum/khees' (yellowish thick milk)		84.3	81.4	79.7	81.7	77.0	81.6	81.7	81.5	81.4	79.1	83.9
First breastfeed the child	Immediately/with in one hour of birth	39.3	41.0	38.3	41.2	49.8	40.8	42.5	40.6	40.6	40.8	41.8
	Within 24 hours	25.7	28.3	29.1	28.2	25.3	28.3	30.1	27.9	28.7	27.4	28.3
	2 to 3 days	21.3	17.5	19.9	17.3	15.8	17.6	14.5	18.3	17.0	18.4	17.8
	After 3 days	12.3	12.0	11.7	12.0	9.1	12.1	12.1	12.0	12.4	12.4	11.0
	Never	1.3	1.2	1.1	1.2	0.0	1.2	0.8	1.3	1.3	1.0	1.2
Complete Immunisation		31.3	32.8	26.5	33.4	16.7	33.0	40.3	30.9	36.3	32.3	26.1
ORS given to child	Yes	21.6	26.5	22.3	26.9	20.5	26.5	30.0	25.6	29.7	21.7	23.6
	No	74.5	68.3	70.2	68.2	65.9	68.5	64.7	69.2	65.1	73.7	70.4
	Child on breast milk	3.9	5.3	7.4	5.0	13.6	5.0	5.3	5.2	5.1	4.6	6.0
Seek advice or treatment for illness from any source		54.2	60.3	54.7	60.7	46.2	60.4	67.5	58.4	63.5	59.4	54.0

Table 3. Child Health Indicators by Household and Individual level Indicators (%)

		child have check-up within 24 hours of birth	feed mother's milk 'colostrum /khees' (yellowish thick milk)	first breastfeed the child			Complete Immunisation	ORS given	seek advice or treatment for illness from any source
				immediately/within one hour of birth	within 24 hours	2 to 3 days			
own electricity	yes	35.2	82.5	42.5	28.2	16.7	34.9	29.2	62.9
	no	24.6	79.0	37.2	28.4	19.8	27.1	19.7	52.9
Religion	Hindu	32.0	81.4	41.0	28.1	17.7	32.6	26.2	60.0
	Muslim	40.2	87.0	41.4	36.4	10.7	35.8	34.5	70.0
	Others	20.5	89.7	38.5	33.3	15.4	42.9	14.3	35.3
caste group	scheduled caste	31.9	79.3	41.3	28.6	16.9	28.8	27.1	64.0
	scheduled tribe	24.5	83.3	40.0	25.6	19.6	27.0	26.1	51.1
	no caste/tribe	35.0	80.0	40.5	29.9	17.1	35.6	23.9	63.3
	none of them/ others	44.6	84.7	44.9	29.6	14.3	43.2	34.6	68.8
water treatment	yes	40.5	86.0	43.9	27.1	16.2	40.0	32.4	65.9
	no	27.9	79.2	39.4	28.9	18.3	28.7	23.4	57.1
Type of toilet	Flush	51.8	85.4	46.6	30.3	12.6	47.6	49.1	77.4
	Pit	47.1	85.7	40.3	37.8	12.6	41.0	11.8	67.6
	No facility, Open field	30.0	81.1	40.4	28.0	18.1	30.8	24.4	58.1
Type of Fuel used in the kitchen	Electricity	28.6	71.4	42.9	28.6	21.4	20.0		100.0
	LPG or Bio-gas	61.5	91.2	47.9	33.0	11.9	51.4	55.0	85.5
	kerosene, cow dung, coal etc	31.6	81.3	40.8	28.2	17.7	32.3	25.8	59.6
Type of house	kachha	29.1	81.5	40.3	27.8	18.4	30.7	24.6	56.4
	semi-pucca	38.1	80.9	42.4	29.4	15.7	35.4	30.6	67.2
	pucca	43.9	82.9	43.0	29.9	15.0	41.9	32.2	72.6
Separate room for kitchen	yes	37.7	84.8	44.6	28.1	16.6	36.0	29.4	63.9
	no	28.5	79.3	38.5	28.4	18.2	30.4	24.7	57.8
Wealth index quintiles	poorest	23.1	78.8	38.1	26.8	19.7	25.8	20.4	53.2
	second	29.3	81.1	39.0	28.8	18.6	31.9	26.2	57.9
	middle	38.8	83.3	45.3	28.2	15.4	35.3	28.4	63.8
	fourth	47.5	85.7	45.6	30.5	13.3	42.6	37.4	72.5
	richest	63.0	89.1	49.0	31.3	11.5	50.7	52.3	90.1
Age Group	15-19	40.2	78.9	40.2	26.0	17.7	13.0	13.8	54.7
	20-24	37.3	82.8	42.3	28.8	17.1	27.3	26.1	62.4
	25-29	29.0	81.8	41.5	28.2	17.7	38.6	28.5	62.0
	30-34	27.5	81.8	40.3	28.6	17.1	45.5	27.2	53.3
	35-39	23.4	77.7	34.4	29.5	17.7	42.0	27.4	54.7
	40-44	15.1	73.5	32.2	23.2	23.7	27.3	32.1	65.2
	45-49	16.9	65.8	31.6	18.4	28.9	23.8	36.4	36.8

Age at consummation of marriage	Below 18 years	27.2	79.4	37.6	27.8	19.2	32.3	23.3	58.1
	18 years & above	38.8	84.3	45.4	29.0	15.3	33.2	30.8	63.1
Education of mother	No education	25.2	78.6	37.3	27.8	19.7	28.7	21.3	56.0
	< 5 year of schooling	33.1	84.3	40.9	29.1	17.0	36.1	29.9	55.5
	5-9 years	41.4	85.3	46.5	28.5	14.7	36.9	33.1	65.5
	10-11	54.0	89.2	50.7	31.8	9.9	40.7	29.6	82.6
	12 and more	67.2	93.0	53.8	31.8	8.3	49.0	67.5	82.3
Education of Father	No education	22.9	78.1	36.3	27.2	20.7	24.9	20.7	54.2
	< 5 year of schooling	27.5	82.5	41.2	24.5	17.8	30.2	27.7	57.9
	5-9 years	33.8	82.0	42.3	28.6	16.7	35.0	26.8	60.1
	10-11	42.5	85.3	45.0	29.1	14.9	36.6	32.6	66.7
	12 and more	48.8	86.9	46.8	32.0	12.7	43.5	37.4	72.7
Living with husband or husband staying elsewhere	living with husband	31.9	81.7	41.2	28.2	17.6	32.9	26.8	60.0
	staying elsewhere	43.9	73.2	31.0	31.0	15.7	23.9	11.1	65.6
Age at first birth	>=18	34.7	82.5	42.1	28.9	16.7	33.8	28.4	61.6
	<18	23.4	78.0	36.8	25.9	20.5	28.6	20.0	55.7
Total Number of Children	<= 2	38.7	82.7	42.7	28.9	16.4	31.5	27.0	63.0
	>2	23.6	80.0	38.7	27.4	19.1	34.4	25.6	56.2

Table 4. Child Health Indicators by Knowledge, facilitation or motivation for the RCH facilities(%)

		child have check-up within 24 hours of birth	**feed mother's milk 'colostrum/ khees' (yellowish thick milk)**	**first breastfeed the child**			**Complete Immunization**
				immediately/ within one hour of birth	**within 24 hours**	**2 to 3 days**	
heard/seen message-breastfeeding	yes	34.9	84.0	43.2	28.6	16.6	34.2
	no	16.6	67.0	27.8	26.4	23.2	22.7
heard/seen message-immunization	yes	33.4	82.2	41.5	28.2	17.2	33.9
	no	11.7	71.1	32.4	28.8	22.6	7.4

Table 5. Association of Complete Immunization with covariates at individual and community level

Full Immunisation			**Odds Ratio**	**[95% Conf. Interval]**	
Traditional Logistic Regression Analysis					
District			1.01933	1.015754	1.022919
Health provider in the village			2.056671	1.347769	3.138441
wealth index quintiles			1.152291	1.087815	1.220589
Age of mother			1.309617	1.233973	1.389899
Age at consummation of marriage			.7696584	.6945288	.852915
Women education			1.084079	1.032362	1.138388
Husband education			1.134379	1.088047	1.182685
Not Living with husband			.716568	.5196332	.9881389
Constant			2.23e-21	5.89e-25	8.44e-18
Multilevel Logistic Regression Analysis (MLR-1)					
Health provider in the village			2.189885	1.423462	3.368966
Wealth index quintiles			1.088558	1.024099	1.157074
Age of mother			1.308890	1.231573	1.39106
Age at consummation of marriage			.741196	.6671977	.8234005
Education of mother			1.114305	1.05943	1.172022
Education of Father			1.124981	1.077798	1.174229
Not living with husband			.675561	.4865565	.9379847
Constant			.060748	.0278177	.1326591
Std Dev (cons)= .4185826 with CI (.329687 .5314477) **LR test vs. logistic regression gives χ^2=239.29 with p=<0.001**					
Multilevel Logistic Regression Analysis (MLR-2)					
Health provider in the village			2.471835	1.320509	4.62698
Age of mother			1.385379	1.289399	1.488504
Age at consummation of marriage			.6845775	.6056569	.7737819
Women education			1.141927	1.076421	1.211418
Education of husband			1.143657	1.087904	1.202267
Women living with husband			.6839309	.4692065	.9969203
Total number of children			1.026526	.9747043	1.081102
Constant			.0452843	.0169441	.1210253
Random-effects	Parameters	Estimate	[95 Conf. Interval]		
District	SD(constant)	.4564192	.3484507	.5978419	
Village(PSU)	SD(constant)	.9918055	.9070664	1.084461	
LR test vs. logistic regression gives χ^2=656.22 with p=<0.001					