Individual and family level clustering of child mortality in Orissa.

By

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Abstract

This paper assesses the individual and family level child death clustering in Orissa using the national family health survey–II data set. Proportional hazard and binomial models have been employed to examine clustering with various socio economic, environmental, maternal and demographic factors as covariates in the models. Though death clustering heavily occurs among the families of poor socioeconomic background, the question arises, why do some families experience distressful clustered mortality and not all? Is genetic frailty an important cause of child death clustering? The individual and family level clustering of child mortality suggests that assimilated genetic factor is a crucial component of child mortality. Are there any differences in the mother's behavioural approaches in child caring? The case studies in two selected villages of Koraput district of Orissa indicate that mother's competence and husband's role regarding childcare are also two important factors that contribute to child death clustering.

Introduction

In India mortality for children less than 5 years of age is around 95 and it contributes to nearly half of the total death in the population (UNICEF, 1995). Past research on infant and child mortality in India have mainly dealt with the role of various maternal, socioeconomic and environmental factors in determining the levels and pace of infant and child mortality transition. Despite the recent attention on the subject, two major gaps in child mortality analysis that are important to be dealt with are: 1) assessing the influence of health service impact on child survival and 2) analyzing clustering of child mortality. In this paper we examine death clustering in view of its implication for direct policy intervention. Death clustering is expressed as heterogeneity in the risk of child deaths between subgroups of population. Heterogeneity in child mortality has considerable implications for reproductive health and child survival programmes in India. As in many other developing countries resources are scarce and health services facilities are not adequate to meet the need for services.

Individual clustering is the death of a sibling is related to another, while family level clustering is the concentration of multiple child deaths among small fraction of mothers. The case of connected sibling mortality may originate due to genetic frailty of mothers passed to the children. Family level death clustering suggests that substantial improvements in child mortality could be achieved by adopting more cost-effective techniques of focusing health-care re-sources specifically on the sub-group of families with greater risk of child death and multiple child deaths (Das Gupta, 1989). Though studies have examined child mortality clustering, varying explanations have been provided (Das Gupta, 1990; Sashtry, 1997). Given such variety of

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explanations, there has been very little inputs into policy intervention. Therefore, the phenomenon of clustering needs to be examined carefully because there are several reasons why observed heterogeneity in risks could be misled due to method of data analysis.

Theoretical background

Many studies have identified the phenomena of death clustering within family and community level. These studies have suggested different hypotheses as to why child deaths are clustered. Living conditions of residents in different areas may be very different, and could affect mortality e g. through differences in access to health services, nutrition, and exposure to disease, The same considerations apply to local studies in a setting in which mortality has changed over time; in this case aggregation of the experience of different age groups of women will have an effect similar to that of aggregating samples from different regions. Another reason for clustering within a population is that mortality may differ in families in different socio-economic status groups. Thus, Guo (1993) found that most of the clustering in Guatemalan families could be explained by the household's economic status and the mother's education. As he points out, the discovery of clustering owing to such well-known factors does not add much to our understanding of child mortality. Clustering in any group of families will disappear after all the relevant factors in child mortality have been controlled; it is of interest only if it points to factors that have not been analyzed. Given the background, recent analyses on the subject have suggested three types of explanations (Das Gupta, 1987; Sastry, 1995; Serreo, 1990).

First of these hypotheses is the frailty component, suggesting that genetically assimilated factors are vital in explaining the heterogeneity between women in developed countries. The second argument emphasizes parental competence as a possible factor for child death clustering, that is some mothers are more capable of caring and treating their children illnesses better than others (Das. Gupta, 1989). Third, Sastry (1995) showed that community factors are significant predictors of clustering rather than mother's individual competence. Fourthly, there are known causes of heterogeneity in the risk of deaths between children such as low socio economic status of the households, first births or higher order births, births to adolescent and to older mothers or a short birth interval fail to explain the entire pattern of clustering. For example significant clustering of child deaths was found in lower socio economic and education group in Punjab (1996). This suggests that child mortality is the result of very complex situation in which individual, family and social /community aspects all play an important role (Serreo, 1990;Sastry, 1995). The increased or decreased risk of mortality relative to the average risk could be considered as the cumulative effect of a number of observed and unobserved characteristics related to economic, behavioral and physical characteristics of the family (Curtis and Steele, 1996). Given these competing explanations, it is also important to know if clustering is independent of lower or similar socio economic status.

Need for the study and approach

Infant and child mortality in India are the highest in the world and evidences of very high levels of child death clustering. The state of Orissa has one of the highest levels of IMR and CMR and the pace of decline in IMR and CMR has been very slow. In the last two decades i.e. from 1981-2001, IMR declined by 28.2 percent, at the rate of 1.5 percent per annum. This is lower than the extent of decline in IMR in the case of other low-income states. The decline was 44.7 percent in

Utter Pradesh, 47.5 percent in Bihar, 38.7 percent in Madhya Pradesh and 36.4 percent for India during the same period.

Orissa is distinguished from other backward states in India in terms of socioeconomic condition. It has relatively higher literacy and antenatal care coverage but contrasted with higher levels of poverty and malnutrition compared to Uttar Pradesh, Madhya Pradesh and Bihar. In the context of steeper fertility decline in Orissa compared to these bigger states, the accompanying pace of decline in IMR and CMR is far behind. Thus, Orissa provides a central testing ground for exploring child mortality clustering and determinants.

Review of previous studies suggests that a multiple method approach needs to be address to dig up clear evidence on clustering and its determinants. In the literature on child mortality, the clustering problem was identified using simple and very crude approaches that as we now know in retrospect could lead to misinterpretation (Cleland & Sathar, 1984; Pebley & Stupp, 1987; Desweemen, 1984; Gribble, 1993; Hobcrafts, McDonald and Rutstein, 1985; Koening et al., 1993; Lantz, Partin and Palloni, 1992; Miller, 1989; Miller et al., 1992; Retherford et al., 1989, Wini Koff, 1983; Palloni & Tienda, 1986; Palloni & Millman, 1986). For example logistic regression or log linear, which assumes that the observations are independent. More recently, estimation of mortality models with data gathered on the cluster designs has been explore with more sophisticated procedures that include hazard models and multilevel hazard model. (Curtis, 1991; Curtis, Diamond & McDonal, 1991; Curtis & Steele, 1994; Madise & Diamond, 1995; Guo & Grummer – Strawn, 1993; Guo & Rodrigues, 1991; Guo, 1993; Sastry, 1995 a, b). These methods have clear merits over their predecessors because they explicitly indicate the correlation between sibling's mortality risks.

From the above context, the basic survival models for data on related individuals were developed in the mid 1970s by Holt and Prentice (1974) and Clayton (1978) and were extended by Oakes (1982), Cox and Oakes (1984), Clayton and Cuzick (1985) and Hougaard (1986), Guo and Rodrigues (1992) and Guo (1993) presented a multivariate survival model with a single random effect to allow for family level heterogeneity and discussed estimation of their model using EM algorithm. Curtis et al., (1993) and Zinger (1993) have applied random effect logistic models to the study of family effects on child mortality; because previous studies have tended to concentrate on clustering.

A related stream of research has developed measures that deal with the concentration of child mortality in certain families, which have examined the factors underlining family clustering of child mortality (Zaba & David, 1996, Ronesman, 1995). So, there is a wider range of methods to chose and examine the subject: 1) adoption of updated hazard models with sibling survivorship components, besides socioeconomic status factors 2) incorporation of community level variables and 3) supplementation with case studies. These diverse methods are useful to examine the relative importance of three streams of hypotheses based on the result of the models and case studies that will provide crucial insight on mother's ability or children genetic frailty in contributing to clustering. With this background this study aims at:

First, to assess socioeconomic correlates of clustering which will indicate the extent of clustering by socioeconomic factors. Second, it is important to examine using multiple methods the relevance of these three explanatory hypotheses: whether genetic frailty, mother's competence and community factors are important determinants of child mortality clustering. Third, there is a need to address the issue of clustering in terms of policy implications.

Data and methodology

For the core statistical analyses, data have been used from NFHS-1998-99, Orissa, which was conducted between March 1999 and June 1999. Data sets are used in two different ways according to the requirements of analyses and statistical models. First, for studying the extent of individual level clustering the births in the preceding 10 years period were extracted from the birth history. Second, for studying family clustering the full birth history data has been used, because sufficient number of cases with two and more child deaths are required.

The analysis and discussion are structure into three sections. Section one examines individual clustering of child deaths using proportional hazard model. It has been employed to obtain a robust measure of child mortality to the 10-year birth history prior to survey with time dependent dummy variables. This model examines if a death of a child related to previous death and controlling for other socioeconomic variables. The important assessment of this technique is that it permits a regression analysis of censored data and provides an estimate of the relative magnitude of the hazard to which different subgroups are subjects.

In section two, family level deaths' clustering is assessed using binomial distribution model. This model considered suitable to see whether the distribution of number of children died for women follow certain form. It assesses the extent of heterogeneity or death clustering which is measured as the difference between observed and expected number of child deaths by socioeconomic risk factor classification. This approach estimates distribution of failure to be expected in a given number of trials with a constant probability of failure. It generates the expected distribution of deaths in a group of live born children who are subject to a given mortality risk. An excess of the observed number of women with different number of deaths over the expected number is taken to indicate clustering. Rejection of Ho implies the presence of clustering, but it does not distinguish between different causes, which need to be assessed further.

A number of demographic, socioeconomic and household environmental variables, which are theoretically known to influence child survival, have also been included to understand the basic correlates of clustering of child mortality in Orissa. Most of socioeconomic status factors will remain unaffected by time period, except standard of living and body mass index. However, both are expected to remain stable for larger period as standard of living is a permanent income measure and body mass index is a long-term measure of nutritional status.

In the last section explanatory hypotheses concerning child mortality clustering have been tested based on in-depth interview with prestructured guidelines among a small number of purposely-selected cases. The hypotheses examined are whether mother's competence or genetic frailty or community factors are important factors in explaining child mortality clustering.

Sample selection for case studies
The in-depth interviews are conducted from from Koraput district (one of the KBK Districts). From district medical/social welfare department, details of PHC/SC and Anganwadis were obtained. From health and Anganwadi workers (key informants), information on child deaths were collected. Based on these information two villages were selected one, with more cases of multiple child deaths and another with fewer cases. The two selected villages were more or less homogeneous in socioeconomic conditions (i.e. education, living conditions etc.). A preliminary listing of number of children born and died in the preceding 10 years prior to date of listing for ever married women was undertaken. Four case studies each for women with more than one child deaths and four case studies of women without any child death from each village were completed.

Proportional hazard model analysis
Cox (1972), introduced a proportional hazard model with general non-parametric base allowing for the analysis of survival data with and without censoring. It assumes that for each object or individual under observation, there exists a hazard proportional to a standard underlying hazard that may or may not essentially possess a parametric form. The proportionality factor, in the above approach, is a function of covariates or explanatory variables of each individual subjects involved through a linear model.

When survival time is continuously distributed then the hazard is defined as

$$\lambda i\ (t, \underline{z}) = \lambda_0\ (t) \exp [\beta_1 x_{1i} + \beta_2 x_{2i} + \ldots\ldots + \beta_p x_{pi}]$$
$$= \lambda_0\ (t) \exp [\Sigma \beta_j x_{ji}]$$
$$= \lambda_0\ (t) \exp [\beta \underline{z}]$$

where, λ_0 (t) is the underlying hazard function when all covariates (x's) are equal to zero and β is a row vector of regression coefficients. Cox's model assumes that the hazard λi (t) of a study group is proportional to that of the underlying survival distribution λ_0 (t).

The hazard functions of each of the two samples are λ_0 (t) and $\lambda 1\ (t) = \lambda_0\ (t) \exp [\beta]$ respectively. This means that the hazard function of sample II has a proportional relation with the sample I. This is known as the Cox- Mantel test based on the assumption of a proportional hazard between the two samples.
In addition, suppose we have x variables which are functions of time like $x_2 = tx_1$, then the hazard in the first sample is given by

$$\lambda_1\ (t) = \lambda_0\ (t) \exp [\beta_1 + \beta_2 t]$$
$$= c\lambda_0\ (t) \exp [\beta_2 t]$$, where $\exp [\beta_2 t]$ is the relative risk of dying.

Description of covariates
Since analysis covered last 10 years births from birth history, the estimation of coefficients would not be so much affected by changes in fertility and mortality and socioeconomic conditions would not have changed significantly. A total of 5507 children born to 3945 women in Orissa are analyzed. The theoretically relevant covariates considered in the hazard model analysis are; mother's education level, age of the mother at birth, combination variables of birth order and preceding birth interval, nutritional status of the mother, sex of the child, survival status of the any previous child, household standard of living, caste, place of residence and year of birth.

A percentage distribution of births by the individual and household level variables is presented in Table 1. The hazard coefficients of the covariates are converted into relative risks are presented in Table-2.

Table –1: Percentage distribution of children born in the last 10 years by covariates.

Variables	Percent in category
Residence	
Urban	19.3
Rural	80.7
Mothers education	
Illiterate	61.5
Literate up to middle	31.4
High school and above	7.1
Mothers working status	
Working	30.0
Not working	70.0
Sex of the child	
Male	51.0
Female	49.0
Women's age at birth of child	
Less than 18	10.5
18-34 years	86.1
>34 years	3.4
Birth order/preceding birth interval	
1st birth	29.2
2-3 order and less than 24 months	14.6
2-3 order and greater than 24 months	31.1
Order 3+ and less than 24 months	8.8
Order 3+ and greater than 24 months	16.3
Birth order	
1st order	29.2
2-3 order	45.7
3+ order	25.1
Caste	
Others	57.3
SC	21.7
ST	21.0
Household standard of living	
Low	56.4
Medium	33.8
High	9.3
No of births	**5507**
No of deaths	**612**

Table-2 Proportional hazard model analysis of individual clustering with maternal, health care, household environmental and socioeconomic factors influencing neonatal, infant and childhood mortality

Predictor variables	Relative risk of dying for likelihood of child deaths		
	Neonatal (0-28days)	**Infant (1-11 months)**	**Childhood (12-47 months)**
Survival status of the any previous Child *(individual clustering)*			
Died®	1.623*	2.005*	1.986*
Alive			
Year of births			
0-4 years prior to the survey®			
5-9 years prior to the survey	1.336	2.305*	2.258*
Sex of the child			
Male®			
Female	0.997	1.001	1.772
Combination of birth order and preceding birth interval			
1^{st} order®			
Order 2-3 / <24 months	0.969*	1.860*	1.327
Order 2-3 / >23 months	0.376*	1.042*	1.762*
Order 3+ / <24 months	0.664	1.215	1.612
Order 3+ / >23 months	0.756	0.874	1.059*
Women's age of the mother at birth			
18-34 years®			
Less than 18	1.467*	0.810	0.669
>34 years	1.314*	1.723	1.998
Nutritional status of the mother (BMI)			
Low (<18.5 $k.g/m^2$) ®			
High (>=18.5 $k.g/m^2$)	0.826*	0.876	0.859
Mother's education			
High school and Above®			
Literate and up to middle	1.162	1.421*	1.005*
Illiterate	2.331*	2.693*	2.410**
Household standard of living			
High ®			
Middle	0.296	1.372	2.365**
Low	1.236	2.496*	2.028***
Caste			
Others®			
SC	0.884	1.610*	1.235*
ST	1.121	1.414*	1.016
Place of residence			
Urban®			
Rural	1.318**	1.355	1.159*
No of deaths (unweighted cases)	**300**	**177**	**106**

*P level, ***<0.01, **<0.05, *<0.1*

An important departure in this analysis is the use of a newly constructed variable by birth order and birth interval. Earlier analyses have dealt with the effects of birth order and birth interval separately. However, recent literature shows that both the combination of birth order and birth interval is a suitable variable to examine its combined effect on child survival.

Table 2 presents the result of hazard model analysis on mortality clustering of sibling and relative risks of neonatal, infant and childhood mortality by maternal and socioeconomic factors.

In hazard model analysis, the individual level child death clustering is assessed based on survival status of previous children, commonly known to be related to the relative risk of dying of the present child. This is one way of assessing clustering of child deaths that is majority of the child deaths followed by another child death in the family. In the model the survival status of any previous child has been incorporated as a variable to assess individual levels of child death clustering. It is also important to recognize that the incidence of child mortality clustering can occur in the reverse way, that is in all the cases of multiple sibling deaths, a death of a child can either be preceded or followed up with another child death. In essence, this suggests that multiple sibling mortality are clustered interdependently.

Results of proportional hazard model shows the extent of clustering of child deaths at individual level that is the survival status of the any children has significant effect on the survival status of the index child. The prevalence of child deaths is high among the children if their siblings have died through out neonatal, infant and childhood. Relative risk of dying for index child is about two times higher if any of the previous sibling has died either at neonatal or infant or childhood. Individual level clustering is more prevalent during infancy and childhood compared to neonatal period. The level of clustering is nearly the same for infant and childhood mortality. These results clearly suggest that an incidence of child death is more likely either to be preceded or followed with a death of his/her siblings.

Result shows that, by controlling for birth order, if birth interval is longer the relative risk of dying is less compared to the same birth order. This indicates that birth interval impact is stronger than birth order effect on child survival. The year of birth of child also indicates variations in the survival chances of the children, implying period effects for child survival. The relative risk of dying is more than twice for the children who were born between 5 - 9 year prior to survey as compare to 0 – 4 years prior to survey period. The period effects are quite substantial. The combined variable of birth order and birth interval and the time period dummy variable also significantly explains the level of neonatal, infant and child mortality.

Family level clustering of child deaths

Family level clustering of child deaths is the concentration of deaths among small fraction of mothers. It is an extended form of death clustering of siblings. In Rural Punjab, Das Gupta (1989) found that 61 percent of the deaths are experienced by only 12 percent of the mothers with multiple child deaths.

It was also found that even after considering many societal and biodemographic components such as education, standard of living, type of residence, maternal age, parity and birth interval etc, certain level of variability remains unexplained because of the unobserved heterogeneity in population (Guo, 1993;Guo and Rodrigues, 1993; Sastry, 1996; Khaskal, 1998). The factors responsible for such clustering of deaths could be socioeconomic, demographic, behavioral and environmental. However, the extent of heterogeneity that certain mothers have with regard to child mortality e.g. certain mothers have experienced no child death while others have experienced child death and there are some mothers who have experienced more than one death, cannot be explained with these factors alone. So it is important to investigate how and why child deaths are clustered among a small proportion of mothers. The family level child death clustering is examined in two stages. First, with distribution of number of deaths and births by socioeconomic status categories and second, using binomial model.

Description of the sample

In the present study, the analysis of child mortality clustering covers all ever-married women between the ages 15 and 49 years who have had at least one live birth. In Orissa 3945 the ever-married women reported 12529 live births. The full birth history is used in the analysis of binomial model. The mean family size was 3.7 per family. The total numbers of child deaths were 1807 and the proportion of dead was 0.1442. The basic characteristics of this sample are presented in the Table 3.

A large proportion of women i.e. 58 percent belong to the age group of 20-34. About 58 percent of women are illiterate, 26 percent of are literate women with middle school, 7 percent of women have completed middle school and 9 percent of women have attended high school and above. About 61 percent of women belong to the non-SC/ST women and 39 percent belong to Scheduled Caste and Scheduled Tribe communities. About 37 percent of women have higher parities of 3+, 73 percent of women are not working and 45 percent of women have low body mass index.

Extent of clustering

About 95 percent of the children are born to families that contribute two or more children to the sample. Families with five or more children comprised of 20 percent of all families, but contributed to nearly 37 percent of the total number of children in the sample. The mean number of children per family is 3.7. The magnitude of the family effect in the model is determined preliminarily by the number of deaths per family, since children in families in which there are a larger number of deaths face higher mortality risks. Nearly 56.8 percent of total child deaths have occurred to 10.4 percent of families and have had two or more child deaths. About 3 percent of the families in the sample have had three or more deaths, together these families account for almost two thirds of the total number of child deaths.

Table –3: Percentage distribution of ever-married women used for the analysis of child mortality in Orissa 1998-99

Variables	No of women	Percentage
Women's age		
15-19	144	3.7
20-34	2290	58.0
35-49	1511	38.3
Women's education		
Illiterate	2299	58.3
Literate <middle school	1038	26.3
Middle school completed	265	6.7
High school completed and above	343	8.7
Women's working status		
Not working	2850	72.2
Working	1095	27.8
Women's body mass index		
Low (<=18.5 k,g/m2)	1775	45.0
High (>18.5 k.g/m2)	2170	55.0
Household standard of living		
Low	2017	51.1
Middle	1398	35.6
High	515	13.1
Caste		
Scheduled Caste (SC)	824	20.9
Scheduled Tribe (ST)	725	18.4
Others	2395	60.7
No. of parity		
1	655	16.6
2	968	24.5
3	866	22.0
>3	1456	36.9
Death levels		
0	2750	69.7
1	781	19.8
2	283	7.2
2+	131	3.3

Deaths are not clustered equally to a specified socioeconomic group. Women who experience multiple child deaths are designated as high-risk women. About 70 percent of the women have not experienced any child deaths. Twenty percent of women have experienced one child death,7 percent 2 child deaths and about 3 percent more than two child deaths(Fig-1). The extent of clustering also examined subgroup wise in Table- 4,5,6,7 and 8.

In urban area 8 percent of the women have experienced 56 percent of the child deaths compare to 11 percent of the women with 57 percent of the child deaths in rural area. It is interesting to see deaths are clustered more among women in the urban compared to rural areas. These deaths are likely to be concentrated in extremely poor hygiene and sanitary conditions in the slum or due to lack of childcare practices. The distribution of deaths by education indicates that 14 percent of illiterate women have experienced 60 percent of child deaths and similar levels of concentration of deaths are found from low socio-economic status women.

Fig 1: Percentage distribution of child deaths by number of deaths experience by women in Orissa, 1998-99.

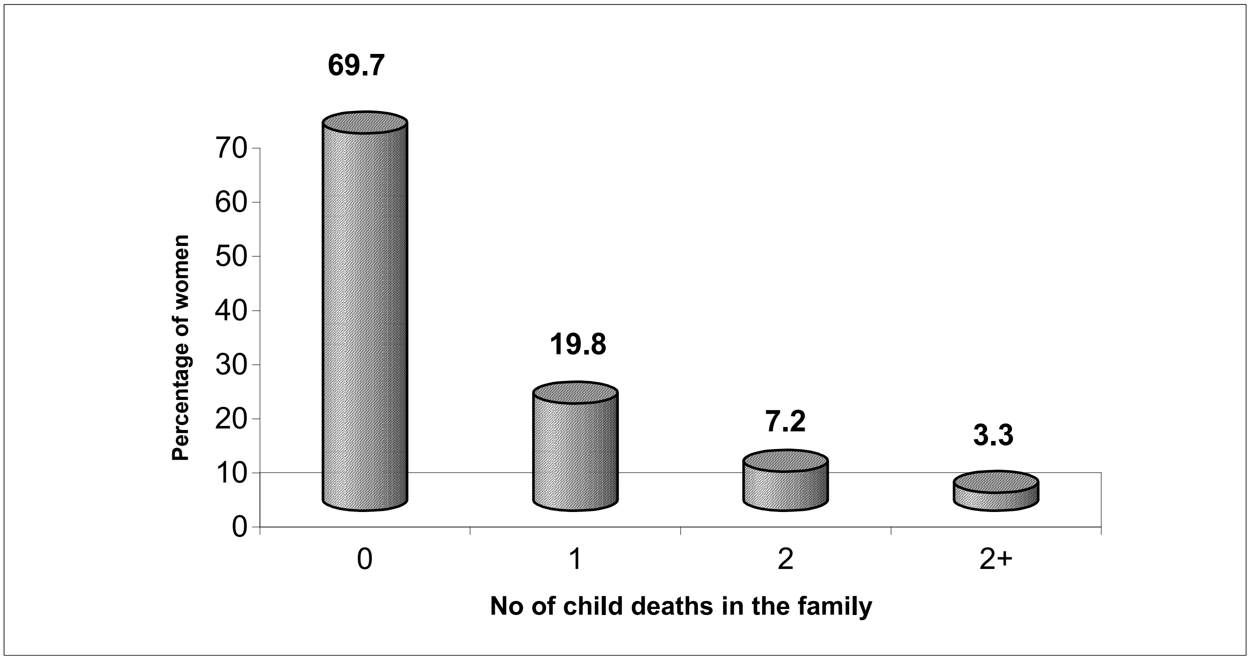

Table-4: Pattern of death clustering by number of children born in Orissa 1998-99

Children per Family	Deaths per family							
	0	1	2	3	4	5	6	Total
1	606	49						655
2	842	114	12					968
3	639	189	33	5				866
4	404	186	64	9				663
5	167	131	66	25	5			394
6	59	62	63	20	3	5		212
7	26	29	25	15	4	4	1	104
8	3	15	12	7	7	2		46
9	3	4	6	4	2	4	1	24
10	1	2	2	2	1	3		11
12					1	1		2
Total	2750	781	283	87	23	19	2	3945

Table-5: Pattern of death clustering by number of children born in urban Orissa 1998-99

Children per Family	Deaths per family						
	0	1	2	3	4	5	Total
1	124	6					130
2	206	16	2				224
3	131	26	5	1			163
4	81	36	7	2			126
5	35	24	10	1			70
6	11	10	11	4	1	2	39
7	5	5	6		2	1	19
8		4	1	2	1		8
9		3	2	2		1	8
10		1	1			1	3
Total	593	131	45	12	4	5	790

Table-6: Pattern of death clustering by number of children born in rural Orissa 1998-99

Children per Family	Deaths per family							
	0	1	2	3	4	5	6	Total
1	482	43						525
2	636	98	10					744
3	508	163	28	4				703
4	323	150	57	7				537
5	132	107	56	24	5			324
6	48	52	52	16	2	3		173
7	21	24	19	15	2	3	1	85
8	3	11	11	5	6	2		38
9	3	1	4	2	2	3	1	16
10	1	1	1	2	1	2		8
12					1	1		2
total	2157	650	238	75	19	14	2	3155

Table-7: Pattern of death clustering by number of children born to illiterate group of women, Orissa 1998-99

Children per Family	Deaths per family							
	0	1	2	3	4	5	6	Total
1	278	37						315
2	383	77	9					469
3	358	126	26	4				514
4	240	125	52	7				424
5	110	89	45	22	5			271
6	36	49	49	17	3	4		158
7	22	22	19	11	3	4	1	82
8	2	13	9	5	5			34
9	3	2	6	3	1	4	1	20
10	1	1	2	2	1	3		10
12					1	1		2
Total	1433	541	217	71	19	16	2	2299

Table-8: pattern of death clustering by number of children born to the women belong to low standard of living group in Orissa 1998-99

Children per Family	Deaths per family						
	0	1	2	3	4	5	
1	300	37					337
2	362	72	7				441
3	314	103	22	4			443
4	193	106	49	6			354
5	83	67	47	17	4		218
6	27	37	38	11	3	4	120
7	11	16	16	11	2	4	60
8	1	8	7	3	3	1	23
9	2	2	3	2	1	2	12
10		1	1	1	1	3	7
12					1	1	2
Total	1293	449	190	55	15	15	2017

How does child mortality cluster in families?

Binomial Model

The distribution of family level clustering is statistically examined using binomial model. It shows whether the number of women with different numbers of child deaths exceeds that, which would be expected if the risks were constant for all the women and their children. Under the null hypothesis of no clustering, the distribution of women by the number of child deaths is binomial and the probability of observing k deaths for women with family size n is given by

$P(X=k) = (n! / k! (n-k)!)\, p^k(1-p)^{n-k} \quad 0<=k<=n$

Accordingly probability of observing k deaths for parity 1 women is given by

$P(X=k)= (1! / k! (1-k)!)\, p^k(1-p)^{1-k} \quad k=0,1$

Probability of observing 0 deaths (no deaths) for parity 1 women is given by

$P(X=0)= p^0 (1-p)^1 = q$

and the probability of observing 1 death for women of parity 1 is

$P(X=1)= p^1 (1-p)^0 = p$

Similarly we can estimate the probability of observing k deaths for women of parity j.

Further expected number of women to experience j deaths is,

$E(j)= \Sigma w_i P(X=j/i) / \Sigma w_i$

The average number of child deaths among women with n children is np and the variance is np (1-p). The parameter p is estimated from the observed proportion of children who have died among all live born children of women of a given age.

An excess of observed number of women with different number (either lower or higher in terms of multiple child deaths) over the expected number is taken to indicate clustering. If the null hypothesis (H_0) is violated, the departure from the chance distribution can assessed by a χ^2 test, in which the observed distribution of child death is compared with the expected distribution under Ho. Rejection of Ho implies the presence of clustering, but it does not distinguish between different causes.

Binomial distribution

The binomial distribution was fitted to the data using the observed proportion of children who have died for all the women within each group of equal family size n, and the expected number of women by number of child death was later combined for all women. The distribution of the observed and expected number of child death for women aged 15 – 49 is presented in Table- 9.

Table-9: Difference in the observed and expected number of women with different levels of child Deaths under binomial model.

Covariates	Positive and negative deviations from expected by number of child deaths (0-47months)			
	0 death	**1 death**	**2 deaths**	**2+ deaths**
Education of Mother				
Illiterate	-7.37	**3.73**	**2.26**	**1.37**
Less than middle school	3.79	-1.30	-1.20	-1.29
Middle school completed	18.97	-9.98	-6.41	-2.56
High school completed and above	23.29	-13.38	-6.59	-3.32
Age of mother at birth				
15-19	17.09	-8.68	-5.78	-2.62
20-34	6.36	-2.41	-2.32	-1.61
35-49	-11.27	**4.49**	**4.07**	**2.70**
Standard of living				
Low	-5.53	**2.43**	**2.21**	**0.88**
Medium	1.74	**0.13**	-1.40	-0.47
High	16.95	-9.91	-4.87	-2.16
Place of residence				
Urban	5.35	-3.21	-1.47	-0.66
Rural	-1.34	**0.80**	**0.36**	**0.16**
Caste/Tribe				
Scheduled Caste	-2.73	**0.97**	**0.83**	**0.92**
Scheduled Tribe	-3.10	**0.63**	**2.61**	-0.14
Others	1.88	-0.52	-1.07	-0.27
Parity				
1	-0.5	**2.6**	-	-
2	0.7	**3.4**	**1.5**	-
3	1.2	**0.6**	**2.1**	**0.8**
3+	4.5	-5.6	**2.3**	**1.6**
Birth interval				
<24 months	-1.27	**1.38**	**2.38**	**1.09**
>23 months	2.34	-0.36	-0.37	-0.58

Table-9 shows the results of observed and expected number of child deaths by categories of maternal, demographic and socioeconomic factors. A positive deviant is seen if the women's age at birth of child is 35 and above, but the opposite is found for the ages at births of 15-19 and 20-34. This suggests that there is a concentration of child deaths among women, who gave births at ages 34 years and after. A higher proportion of women with pregnancy interval less than 24 months, are observed with 1, 2 and 2+ child deaths than expected (deviation is 1.38, 2.38, 1.09). This result suggests that the greater likelihood of multiple child deaths for mothers with shorter birth interval. Parity of women similarly shows very significant association with clustering than expected levels of child deaths. An increasing positive deviation for women with '0' death and women with 2+ deaths point to the fact that heterogeneity in child deaths increases with parity.

A positive deviant is indicated for 1,2 and 2+ child deaths for women with low standard of living, which is reversed for the medium and high SLI status women. Child deaths are extremely clustered among illiterate women. Thus a heavy concentration of child deaths in general and multiple child deaths in particular are demonstrated for illiterate and poor (low SLI) women, SC and ST women, Women aged 35+, high parity and shorter birth interval women. On the other hand educated women, women with high SLI are associated with lesser risk of child deaths as well as multiple child deaths than expected level of child deaths. Higher education and high SLI explain a major part of positive deviations both for no risk of child deaths and high risks of multiple child deaths. The deviation varied from -7.37 to 23.29 for education of women and from –5.53 to 16.95 for standard of living index for women with no child deaths.

Causative factors of child death clustering

The socioeconomic and biodemographic determinants of child mortality are at best described as the covariates of child mortality clustering. However, they provide very little understanding as to the real cause of individual and family level clustering of child mortality. On the one hand socioeconomic and environmental factors are core determinants of child mortality risks, on the other hand child deaths are clustered regardless of sociodemographic and economic factors. Question arises why some illiterate and low socioeconomic status mothers are experiencing multiple child deaths and not others. It is very difficult to assess the reasons for this from large-scale sample survey, which provides data in quantitative form and questions regarding different aspects of childcare, community, and genetic factors are limited. Insight from in-depth interviews provide clues whether household environmental factors, mother's competence and genetic frailty are possible directly mediating causes of child mortality clustering.

Insights from in-depth interview

In-depth interviews were conducted on purposely selected cases of women a) case *group*, where women who have had experienced multiple child deaths and b) *control group,* where women had no child deaths. The aim is to study the behavioral difference between these two groups of women in terms of child health care and household environment from homogenous socioeconomic status group.

Insights about the behavioural and household environmental factors related to susceptibility of mothers to multiple child deaths are summarized below based on four cases of women with high risk multiple child deaths and four cases of women with no child deaths.

Case group

Case 1: The experience of *Mrs. Kumudini* suggests that high-risk families have less awareness about health care services available at the neighboring. *Mrs. Kumudini* who is married for 12 years, gave birth to six children. However, five of these children died between day two and one year after birth. These children were born in quick succession of two-year birth interval. Though the family lives closer to a primary health center at a distance of 4 K.M, all the deliveries took place at home attended exclusively by indigenous Dai who used a household knife for cutting umbilical cord and dressed the cord with ash. Prenatal, natal and postnatal care were given by this untrained Dai. This illustrates "poor utilization of maternal health care services leading to multiple child death for this women.

Case 2: Most high-risk families live with cumulative stresses arising from very poor economic condition. Consequently, they poorly managed their livelihood and lacked efficiency in caring their children. The case of *Mrs. Santi* provides evidence about this; Her husband is a daily wageworker and they live in a dilapidated single room hut with moderate ventilation. In the process of family building she gave birth to four children and three of them died between age 1 month to 2 years. Their income was very small, and they spent ninety percent of the income for their subsistence. Very little was left for health and education of children. The environmental hygiene around their house is extremely poor with wastewater stagnating without being properly drained up. She is less bother about childcare, and in many cases small children are looked after by elder children of the family who themselves are not mature (less ability) enough to take care of small child properly, as in one of the cases; due to lack of proper child care one child went to a open well, fell in and died.

Case 3: The case of *Mrs. Birupa* illustrates the importance of husband's role in terms of economic and emotional support and childcare are also important, apart from mother's individual ability for childcare. *Mrs. Birupa's* husband is not ready to discuss with her about childcare. She has already experienced deaths of three children. In her husband's word children are gift of god. We can't do anything if god won't help us".

In most of the high risk families, husbands had not been able to take advantage of the new economic possibilities open up in this region and continued to work in poorly paid occupation.

They worked long hours and their wives felt worried about them and unable to cope with the household matters including childcare. They had poor expectation for future prosperity.

Case 4: Assimilated genetic factors also appear to the part of the reason. For example several of the mothers who have experienced multiple child deaths reported that their mother too had multiple child deaths. The experience of a mother is described below.

Mrs.Lata had a record of number of nine conception over a period of twenty years from the date of her marriage. She has experienced death of six children out of nine. She was the second child and eldest daughter of her parent. She had seven brother and two sisters. Of whom two brothers and one sister younger to her died at ages of 1 month, 9 months and 2 years respectively. Out of the three living children one of their daughter was married, who gave birth to two children and subsequently she lost one child after one month.

Control group

In contrast, the following four case studies illustrate the experience of no risk families. Though their economic condition is poor they have been careful about the health care of their children.

Case 5: Mrs. Pratima belongs to the same set of village and gave birth to five children. She used to receive recommended maternal care at the time of delivery. All of her birth took place at medical". She had notion about the relationship between children born in quick succession and their survival chances, equally she had the knowledge of the various aspects of child rearing.

Case 6: Mrs. Sakuntala gave birth to six children and all are alive. Though she belongs to poor socioeconomic status, she manages all expenses as it should be and used to keep their household environment clean and hygienic. She was very careful towards the health care of their children. In other words, caring in a comprehensive sense is very important for no risk group.

Case 7: Mrs. Uma had six children and not experienced any child deaths. Her husband had greater hope for future prosperity, and hence they were caring their children better. They also had good communication with nearby town areas and shared their views relating to child health care with their wives.

This suggests that husband's role regarding childcare plays a crucial role for the survival status of the children.

Case 8: Mrs. Nidhi had six children and her mothers had also six children and none of them have experienced any child deaths. Her grandmother had also five children and nobody had experienced death during child hood. She was the eldest daughter of her parents. Her husband had five sisters and one brother. But none of them died during child hood. For this couple, out of the six living children one of them is married got two children after marriage.

This suggests that mothers assimilated genetic factors may be the part of the reasons for multiple child deaths.

In sum
In earlier studies, mother's competency was a central issue relating to causes of multiple child deaths. It was suggested, no risk family mothers are more competent than high-risk families in terms of childcare. Though in both the cases, women followed traditional method of birth practices and cut umbilical chord of their own by old blades, but mothers in low risk families are very careful about this and they preserve even old blades carefully. Most of the mothers of no risk group preserved all instruments, which is necessary at the time of birth. More importantly, no risk families did not believe in use of folk medicines. The value of the children in terms of health care among no risk families is very high as compared to high-risk families. Since most of the mothers are daily wageworkers and have to perform many duties in the morning hours and hence could not give much attention to her child. But among no risk group, mother's first priority was proper childcare relating to bathing, dressing and feeding. Along with this husband's role regarding childcare and genetic assimilated factors are also parts of the reason for multiple child deaths.

Conclusion

The results from different models of child mortality confirm that child deaths are clustered among low socioeconomic status categories such as poor and illiterate women. Multiple child deaths are also clustered where women have higher parities and shorter birth interval. Binomial model shows that parity, birth interval, standard of living and women's education stands as core determinants of child survival but clustering as well. A combination variable of birth order and birth interval used in model suggests that birth interval effects predominates child survival than birth order. Proportional hazard model analysis indicates the significant demographic and socioeconomic determinants of neonatal, infant and childhood mortality. Mother's education is a robust determinant through all ages of child mortality and Standard of living index (SLI), birth interval and period factors are more robust determinants of child mortality.

However, even among these high-risk groups, only a fraction of women have experienced multiple child deaths and others have not. By using hazard and qualitative insights, three streams of hypotheses were examined. Insights from in-depth interviews suggest two important explanations. First it is not only mother's competence but also husband's role and economic stability in the family which are critical for lowering risks of multiple child deaths and second, it is not only mother's but also grandmother's experience of multiple child deaths i.e assimilated genetic factors, are also part of the reason.

Though the state resources may be extremely limited, health policy goals in addition to poverty reduction require priority in terms of investment. This is an imminent necessity where otherwise larger numbers of children are at risk by lack of policy thrust. If Orissa is to achieve millennium development goals in respect of infant and child mortality, the policy goals need to augment health infrastructure and focus on ways and means of improving the institutional and safe delivery coverage. Children will continue to be at greater risk of dying if the policy fail to address this issue on an urgent basis. The existing trend of deteriorating investment in health infrastructure and related health infrastructure needs to be reversed slowly in this context.

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