**EXTENDED ABSTRACT**


**Paper Proposal Title** : "Linkages among sibling survival and death clustering in Nigeria: A panel data analysis"

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## Background

Globally, nearly two and a half decades of continuous efforts in improving child survival, the number of deaths of children under 5 years of age fell from 12.7 million in 1990 to 6.3 million in 2013. Now, the further reduction in U5MR can be achieved only after curbing the factors associated with infant mortality. In 2013, 4.6 million (74 percent of all under-five deaths) deaths were occurred within the first year of life. Among them maximum number of deaths are concentrated in the first 28 days of life – the "neonatal period". It represents the most vulnerable time for child's survival. Even though, there is a reduction in overall child deaths but in 2013 according to World Health Organisation, around 44 percent of under-five deaths occurred during this period, up from 37 percent in 1990.

It was estimated that 98 percent of under-five deaths were contributed by developing nations. Despite the goal of reducing infant and child mortality rate as stated in the MDGs, Child mortality rates still remain unacceptably high especially in sub-Saharan African countries, where close to 50 percent of childhood deaths takes place, even when the region accounts for only one fifth of the world's child population (Mesike and Mojekwu 2012). For instance, in sub-Saharan Africa, 1 in every 8 children dies before age five- nearly 20 times the average of 1 in 167 in developed parts of the world (Mojekwu and Ajilola, 2011). Similarly, UNICEF (2010) in the state of the world 's children report noted that 8.1 million children across the world who died in 2009 before their fifth birthday lived in developing countries and died from a disease or a combination of diseases that could easily have been prevented or treated. It also noted that, half of these deaths occurred in just five countries namely, India, Nigeria, the democratic republic of Congo, Pakistan and China; with India and Nigeria both accounting for one third of the total number of under five deaths worldwide.

Among sub-Saharan countries Nigeria is the most populous country with population over 170 million people, of which nearly 30 million of them are of less than five years of age. According to latest estimates of WHO (2013), Nigeria has the IMR of 74.3 and NMR 39 per thousand live-births. Although according to the Nigerian Demographic and Health Survey (NDHS) shows some improvement in IMR, but this rate still fall short of the World Summit for Children (WSC) national goals for reducing IMR (50/60 per 1,000). The huge variations in these rates among different parts of the country notably urban and rural areas and north and south, are striking. UNICEF's 1999 Multiple Indicator Cluster Survey (MICS) shows that U5MR was almost 1.5 times higher in rural areas than in urban areas and that almost twice as many children died before their fifth birthday in the northwest than in the southwest of Nigeria.

In the backdrop of high mortality situation prevailing in the developing nations across the world, especially in Sub- Saharan African countries, the situation of high mortality is not only an issue of concern in itself but it also have a strong linkages with the intra-family clustering of deaths in a particular region. In other words, there may be a situation when there is a high mortality in the region but deaths are not randomly distributed in the entire exposed families of the area rather there are certain High- risk families which only experiences deaths frequently and other families in the nearby in spite of sharing the similar socio-cultural environment do not experience

frequent child loss. This situation is known widely among researcher as death clustering. This phenomena was first highlighted in 1990 by Monica Dasgupta in her paper entitled "Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India.". Since then it is on the research agenda while studying infant mortality and also a new dimension of familial component got added and entire research community has seen this phenomena as another important approach for studying infant and child mortality.

Death clustering has been defined consistently in most of the studies in following two ways: i). Counting the number women who have experienced more than one child loss [19, 20-22]. ii).Whether the number of women with different number of child deaths exceeds that which would be expected if the risks were constant for all women and their children [23-24]. Two aspects of death clustering make it an important issue in the analysis of mortality: one of the aspects is a methodological one in the sense that observations are not independent since siblings living in the same family have a shared environment. They share the same genetic pool and socioeconomic position, and they share the same parental competence in terms of childcare. The other aspect is the clustering in itself [25-26].

Hence, understanding the characteristics of death clustering among both the subsets (i.e., neonates and infants) of Under-five deaths, will help us in highlighting families at higher risk of newborn deaths. Therefore in present research we have tried to capture the nature and the extent of death clustering among neonates and infants by families across different regions of Nigeria and also highlighted the impact of previous siblings' survival status on the intra family clustering of infant and neonatal deaths.

**Method**

The birth history data from third round of Nigerian Demographic Health Survey (NDHS) data conducted in the year 2013 has been used for the study. The retrospective information related to birth history of the child provided by the mothers for more than 30 years facilitated us to make it as a panel data. Then we studied the clustering of infant and neonatal deaths using dynamic mixed effect logit model which will simultaneously capture the previous death (lagged variable) as fixed effect in the model and the mother level unobserved heterogeneity as random effect in the model. The model of this sort will also take care of the endogeneity which arises due to the inclusion of previous death (lagged variable) as explanatory variable in the model. The dependent variable used in our study was infant death and neonatal death. Both were recoded as binary variable where the value '1' indicated that the infant or neonate will be died and '0' indicate otherwise. Child specific regressor used in the model: Birth order, sex of the child, preceding birth interval. Mother specific regressor used in the model: Year of birth, place of residence, religion, ethnicity, educational attainment of partner, educational attainment of the respondent.

**Result**

The sample characteristics of the studied population is shown in table 1. There are approximately 27,500 families (with at least one child birth) in the sample, to which nearly 120 thousand children were ever-born. Further there are 10,270 infant deaths of which, nearly 52 percent infant were died in first 28 days of life. The clustering of death is viewed among those families that has experienced at least two sibling deaths. Accordingly there are about 8.4 percent families with at least two infant deaths and nearly one-fourth (26 percent) families with two neonatal deaths. The eight-six percent of the index infant (died infant) and 83 percent of the index neonate (died neonate) are from those families that has experienced previous infant/ neonatal deaths in their family. The residential status represented that, the majority of families (58 percent) belongs to rural areas and over half of the sample are belongs to Muslim religion followed by Other Christian and Catholic. The entire population is poorly educated, where 40 percent of men (husband) were illiterate and merely 14 percent are educated upto higher schooling. The preceding birth interval characteristics shows that nearly three-fourth of the total births were took place over an interval of more than 23 months. A higher proportion of index child

belongs to first/ second birth order followed by five and more (29 percent). The sample is nearly equally constituted among male and female child population. The Hausa (27 percent) tribe is predominantly found in the country followed by Igbo/Ibo and Yoruba (14 percent).

Broadly, if we observe at the pattern of regional distribution among Infant and neonatal deaths, it represent that about 3/4th (nearly 75 percent) of deaths are found in northern part of the Nigeria. Further, within northern division 64 percent of death are concentrated in North-West region, affirming its prevailing vulnerable conditions for child survival.

It is apparent from table no. 2 (2.1-2.3) that, there is substantial amount of clustering of infant deaths by families across all three rounds of survey in Nigeria. Nearly 96 percent of children belongs to families that contribute two or more children to the sample. Whereas, the mean number of children per family is observed nearly 4.3. The magnitude of the family effect in the model is determined primarily by the number of deaths per family, since children in family in which there are a large number of deaths face higher mortality risks. Accordingly, we have observed that, the pattern of death clustering by families has been narrowed over the period years and it is shrinking to those families that has experienced prior infant deaths in their family. The selected sample have 10,272 infant deaths from 3941 families of which only 8 percent of the families contributes approximately 58 percent of the infant deaths in 2013. Further, it is noteworthy to mention that, merely 3 percent of the families contribute three or more deaths; together these families account for nearly one third of the total infant deaths. Similarly, clustering of neonatal deaths by family is shown in table no. 3. The neonatal deaths accounts nearly 52 percent (5,341) to the infant deaths. It is interestingly seen that, families with three or more pervious neonatal deaths in their family are only 1 percent but account for one-fifth of the total neonatal deaths. Hence, we can make inference that, families with previous neonatal deaths are at higher risk of losing subsequent newborns.

In table 4.1, the raw data probability of infant deaths are shown in column 1. The raw data illustrates that, the probability of infant death is 81/1000 live-births in Nigeria. Further, it has been observed that, there are marked regional differences existed across the landmass. The North-West region is experiencing fairly high probabilities of infant death and is nearly two times higher of South-South region (i.e., 57/ 1000 live-births). The high mortality in northern part indicate vulnerability of frequent infant deaths .It also indicates that Northern part of Nigeria is lesser well off than southern region in terms of maternal and child health services. In column no. 2nd & 3rd, we have raw data probabilities for infant death of the index child based on survival status of the previous sibling. Further, the difference between the two is calculated in column no. 4. It indicates the probability of extent of death clustering within a family. We found the maximum probabilities of infant deaths clustering is existed in North-East region (0.156) and minimum in South –West (0.103). It indicates that these infants have their prior siblings died as infant in the respective families.

Column no. 5 shows an alternate representation of data in terms of relative odds. The relative odds ratio of infant death based on previous sibling's death varies from 3.14 in North-West to 4.62 in South-South region in Nigeria. Here, the relative risk shows that the effect of previous infant death in a family on the risk of death of the index child. The relative odds ratio in South-South is 4.62 which means that a newborn in this region will have five times more likely to risk of death, if one of his earlier sibling died as an infant as compared to those families where none of the earlier siblings had died as an infant. The relative odds results based on the model is also quite close to what we have tried to capture from raw data and it is highly statistically significant ($p<0.01$) for all regions. Overall, the data demonstrates, that all regions have moderate deaths clustering among infants and the risk of death will increase when there is a prior sibling's death in the family.

Similarly, the raw data probability among neonatal deaths are shown in Table 4.2. The estimated probability of neonatal deaths is 45 per 1000 live births in Nigeria. It is highest in North-East and North-West regions while it is lowest in South-South region. If we compare the extent of probability of death clustering among infant and neonates, we can conclude that behind every thousands live-births, nearly 150 infants and 660 neonates are

clustered among various families. Hence, it can be assumed that lateral distribution of infant deaths is greater as compared to neonatal deaths. Further, it is interestingly seen that unlike from relative odds ratio of infant deaths, odds ratio for neonatal deaths are depicting mottled conditions. The probability of neonatal death is extremely high among those families that has no prior neonatal death as compared to families with prior neonatal death. In column 6th model based relative odds ratio for neonatal deaths is far from that we have tried to capture from raw data.

If we observe the odds ratio based on raw data [column. 5] and model based odds ratio [column 6] of the table 4.2, they are surprisingly different and contradictory. The odds ratio shows that, the risk of neonatal deaths is higher in families with no prior neonatal death as compared to those families that has experienced prior neonatal deaths. Whereas the model based odds ratio is depicting just the opposite scenario. (i.e. Model based estimates suggest that in South -South region the risk of neonatal death is 7 times more likely, if one of his/her siblings died within their first month of birth in comparison to those families where the sibling survived the first month of their life. The same odds ratio from raw data suggests that a neonate will have 96 percent less likely to die when there is a prior sibling's death as neonates in the family in comparison to those families where prior sibling survived the neonatal period.

**Table- 1.1:** The sample characteristics of the studied sample

| Variables | Percentage | n |
|---|---|---|
| Total No. of families | ---- | 38948 |
| Total No. of families having at least one child | ---- | 27451 |
| Total Children | ---- | 119386 |
| Survived Infant | 91.4 | 109,116 |
| Died Infant | 8.6 | 10,270 |
| Survived Neonate | 95.5 | 114,045 |
| Died Neonate | 4.5 | 5,341 |
| Total No. of families in which infant died | 24.3 | 6665 |
| Total No. of families in which neonates died | 14.3 | 3914 |
| At least 2 infant deaths | 57.5 | 5903 |
| Families contributing in infant Death clustering | 8.4 | 2296 |
| At least 2 neonatal deaths | 45.6 | 2433 |
| Families contributing in neonatal Death clustering | 25.7 | 1006 |
| Previous infant deaths in the family | 85.8 | 8,815 |
| Previous neonatal death in the family | 83.4 | 4456 |
| Urban | 42.1 | 15,545 |
| Rural | 57.9 | 23,403 |
| Religion | | |
| Catholic | 11.1 | 4,081 |
| Other Christian | 35.7 | 15,757 |
| Islam | 51.7 | 18,578 |
| Others | 1.4 | 532 |
| Husband's Education | | |
| Illiterate | 39.8 | 10,969 |
| Primary | 18.4 | 5,602 |
| Secondary | 28.1 | 8,288 |
| Higher | 13.7 | 4,269 |
| Preceding Birth Interval | | |
| >23 | 74.7 | 68,533 |
| <23 | 25.3 | 23,096 |
| Birth order | | |
| 1 to 2 | 42.6 | 50,503 |
| 3 | 16.0 | 19,040 |
| 4 | 12.7 | 15,202 |
| 5+ | 28.7 | 34,641 |
| Sex of the child | | |
| Male | 51.3 | 61,287 |
| Female | 48.7 | 58,099 |
| Ethnicity | | |
| Hausa | 27.5 | 9,386 |
| Igbo/Ibo | 14.5 | 5,448 |
| Yoruba | 14.1 | 5,606 |
| Others | 40.0 | 18,508 |
| Respondent's highest educational level | | |
| No education | 37.8 | 13,740 |
| Primary | 17.3 | 7,104 |
| Secondary | 35.8 | 14,407 |
| Higher | 9.1 | 3,697 |

**Table-1.2:** Regional distribution of neonatal and infant deaths

| Regions | Infants died | Neonates died |
|---|---|---|
| North Central | 10.1 | 10.6 |
| North East | 17.2 | 18.6 |
| North West | 47.8 | 43.9 |
| South East | 8.8 | 8.2 |
| South South | 6.7 | 7.4 |
| South West | 9.4 | 11.4 |
| Nigeria (Total) | 10270 | 5341 |

**Table 2.3 & 3.3:** Distribution of families according to number of children per family and number of child deaths [Infant Death (table 2.3) & Neonatal Death (3.3)] per family in Nigeria, 1975-2013

| **Table 2.3: 2013** | No. of **Infant Deaths (ID)** Per Family | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Children per family | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | Families | Total children | Percent of children | Percent of ID |
| 1 | 4,148 | 251 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,399 | 4399 | 3.68 | 2.44 |
| 2 | 3,609 | 373 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,012 | 8024 | 6.72 | 4.22 |
| 3 | 3,272 | 466 | 90 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,838 | 11514 | 9.64 | 6.58 |
| 4 | 2,910 | 592 | 118 | 26 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3,651 | 14604 | 12.23 | 9.01 |
| 5 | 2,360 | 590 | 174 | 39 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 3,169 | 15845 | 13.27 | 10.50 |
| 6 | 1,732 | 564 | 220 | 52 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 2,581 | 15486 | 12.97 | 11.80 |
| 7 | 1,181 | 471 | 237 | 74 | 17 | 6 | 2 | 0 | 0 | 0 | 0 | 1,988 | 13916 | 11.66 | 12.43 |
| 8 | 722 | 394 | 199 | 62 | 26 | 6 | 3 | 1 | 0 | 0 | 0 | 1,413 | 11304 | 9.47 | 11.07 |
| 9 | 413 | 303 | 145 | 77 | 39 | 8 | 1 | 2 | 0 | 0 | 0 | 988 | 8892 | 7.45 | 10.12 |
| 10 | 236 | 198 | 139 | 59 | 20 | 13 | 7 | 3 | 2 | 0 | 0 | 677 | 6770 | 5.67 | 8.54 |
| 11 | 125 | 83 | 74 | 40 | 28 | 9 | 5 | 1 | 2 | 1 | 0 | 368 | 4048 | 3.39 | 5.55 |
| 12 | 56 | 61 | 46 | 38 | 32 | 15 | 8 | 3 | 0 | 0 | 1 | 260 | 3120 | 2.61 | 5.34 |
| 13 | 19 | 11 | 11 | 11 | 5 | 1 | 4 | 0 | 1 | 0 | 0 | 63 | 819 | 0.69 | 1.20 |
| 14 | 2 | 9 | 5 | 6 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 27 | 378 | 0.32 | 0.60 |
| 15 | 0 | 2 | 2 | 1 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 10 | 150 | 0.13 | 0.33 |
| 16 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 48 | 0.04 | 0.10 |
| 17 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 51 | 0.04 | 0.11 |
| 18 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 18 | 0.02 | 0.05 |
| Total: | 20,786 | 4,369 | 1,490 | 497 | 195 | 63 | 32 | 10 | 7 | 1 | 1 | 27,451 | 119386 | 100.00 | 100.00 |
| Percent of Children: | 64.89 | 20.28 | 8.83 | 3.44 | 1.52 | 0.55 | 0.29 | 0.09 | 0.07 | 0.01 | 0.01 | 100.00 | - | - | - |
| Percent of ID: | 0.00 | 42.53 | 29.01 | 14.52 | 7.59 | 3.07 | 1.87 | 0.68 | 0.55 | 0.09 | 0.10 | 100.00 | - | - | - |

| **Table 3.3: (2013)** | No. of **Neonatal Deaths (ND)** per family | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Children per family | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Families | Total Children | Percent of Children | Percent of ND |
| 1 | 4,226 | 173 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,399 | 4399 | 3.2 | 3.7 |
| 2 | 3,777 | 216 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,012 | 8024 | 4.8 | 6.7 |
| 3 | 3,496 | 293 | 47 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3,838 | 11514 | 7.4 | 9.6 |
| 4 | 3,228 | 348 | 63 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 3,651 | 14604 | 9.6 | 12.2 |
| 5 | 2,694 | 374 | 85 | 12 | 4 | 0 | 0 | 0 | 0 | 0 | 3,169 | 15845 | 11.2 | 13.3 |
| 6 | 2,100 | 354 | 96 | 29 | 2 | 0 | 0 | 0 | 0 | 0 | 2,581 | 15486 | 12.0 | 13.0 |
| 7 | 1,543 | 317 | 102 | 18 | 5 | 3 | 0 | 0 | 0 | 0 | 1,988 | 13916 | 11.4 | 11.7 |
| 8 | 1,034 | 264 | 83 | 18 | 10 | 3 | 0 | 1 | 0 | 0 | 1,413 | 11304 | 10.2 | 9.5 |
| 9 | 655 | 212 | 77 | 28 | 11 | 5 | 0 | 0 | 0 | 0 | 988 | 8892 | 9.7 | 7.4 |
| 10 | 414 | 159 | 67 | 21 | 8 | 3 | 4 | 0 | 1 | 0 | 677 | 6770 | 8.1 | 5.7 |
| 11 | 208 | 98 | 36 | 16 | 6 | 3 | 0 | 0 | 0 | 1 | 368 | 4048 | 5.0 | 3.4 |
| 12 | 119 | 68 | 45 | 12 | 9 | 4 | 1 | 1 | 1 | 0 | 260 | 3120 | 5.1 | 2.6 |
| 13 | 31 | 16 | 7 | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 63 | 819 | 1.1 | 0.7 |
| 14 | 8 | 9 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 378 | 0.6 | 0.3 |
| 15 | 2 | 5 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 10 | 150 | 0.3 | 0.1 |
| 16 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 48 | 0.1 | 0.0 |
| 17 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 51 | 0.1 | 0.0 |
| 18 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 18 | 0.1 | 0.0 |
| Total: | 23,537 | 2,908 | 733 | 180 | 58 | 24 | 6 | 2 | 2 | 1 | 27,451 | 119386 | 100.0 | 100.0 |
| Percent of children: | 79.3 | 14.3 | 4.4 | 1.3 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 100.0 | - | - | - |
| Percent of ND: | 0.0 | 54.4 | 27.4 | 10.1 | 4.3 | 2.2 | 0.7 | 0.3 | 0.3 | 0.2 | 100.0 | - | - | - |

**Table 4.1:** Raw data based probabilities of **Infant Deaths** among different regions of Nigeria, 1975-2013

| Country & Regions | **Raw Data:** Col., [1] to [5] | | | | | **Estimated Model:** Col., [6] |
|---|---|---|---|---|---|---|
| | Probability of infant death **[1]** | Probability of death given previous sibling's surviving **[2]** | Probability of death given previous sibling's death **[3]** | Probability of death clustering **[4]** | Relative odds ratio **[5]*** | Model based Relative odds ratio [p value] **[6]**** |
| North Central | 58 | 0.052 | 0.181 | 0.129 | 4.03 | 3.564[0.000] |
| North East | 87 | 0.076 | 0.231 | 0.156 | 3.68 | 2.991[0.000] |
| North West | 106 | 0.092 | 0.241 | 0.149 | 3.14 | 2.157[0.000] |
| **Nigeria** | **81** | **0.071** | **0.220** | **0.149** | **3.70** | **2.588[0.000]** |
| South East | 77 | 0.069 | 0.209 | 0.140 | 3.58 | 2.257[0.000] |
| South South | 57 | 0.050 | 0.197 | 0.147 | 4.62 | 4.208[0.000] |
| South West | 58 | 0.053 | 0.156 | 0.103 | 3.32 | 2.256[0.000] |

**Table 4.2:** Raw data based probabilities of **Neonatal Deaths** among different regions of Nigeria, 1975-2013

| Country & Regions | **Raw Data:** Col., [1] to [5] | | | | | **Estimated Model:** Col., [6] |
|---|---|---|---|---|---|---|
| | Probability of neonatal death **[1]** | Probability of death given previous sibling's surviving **[2]** | Probability of death given previous sibling's death **[3]** | Probability of neonatal death clustering **[4]** | Relative odds ratio **[5]*** | Model based Relative odds ratio [p value] **[6]**** |
| North Central | 36 | 0.839 | 0.161 | 0.678 | 0.037 | 4.116 [0.000] |
| North East | 51 | 0.799 | 0.201 | 0.598 | 0.063 | 4.107 [0.000] |
| North West | 51 | 0.840 | 0.160 | 0.679 | 0.036 | 2.859 [0.000] |
| **Nigeria** | **45** | **0.828** | **0.172** | **0.657** | **0.043** | **3.624 [0.000]** |
| South East | 41 | 0.830 | 0.170 | 0.661 | 0.042 | 4.180 [0.000] |
| South South | 35 | 0.823 | 0.177 | 0.646 | 0.046 | 7.519 [0.000] |
| South West | 39 | 0.845 | 0.155 | 0.690 | 0.034 | 2.631 [0.000] |

Note:*The relative odds ratio is calculated as the ratio of Column [2]/ (1- column [2]) to Column [3]/ (1- Column [3]) This is the exponential of the estimated scarring coefficient in a simple logit model that includes an intercept and the survival status of the previous sibling.
**Column [6] reports the equivalent numbers from the estimated model which control for the effects of other covariates and for unobserved mother- specific effects. These are exponentials of the estimated scarring coefficients $\gamma$. The p-values refer to those associated with the estimated $\gamma$.