Visualization of fitness orbits: Rare and Non-Rare events at Agincourt DHSS

Wendy Rabotho, Philippe Bocquier, C.L. Mberi Kimpolo, D. Sherwell, M. Collinson

Introduction

Infant mortality has been widely studied since the 1940s with formal record keeping starting in the 1960s. Studies show that most African countries experienced child mortality decline from the 1960's through to the 1980's. It later stalled in the 1990's owing to the HIV/AIDS epidemic [1]. At Agincourt, infant mortality has been increasing from the mid 1990's [2].

A mother's role in a child's upbringing and its well-being is very important. It is estimated [3] that 1 in 6 women dies, as a result of pregnancy or childbirth, in the poorest parts of the world. Even if maternal mortality is a rare event [3], in 2000 the maternal mortality ratio for sub-Saharan Africa was estimated to be 1000 per 100 000 live births [4].

A study [5] reports that mother's HIV/AIDS and death negatively affects infant survival and others in Agincourt show co-habitation with the mother and parental presence both contribute positively towards infant survival [6,7,8].

This paper presents the results of a study influenced by [6, 7, 8] which sought to understand if there is a link between mother's presence and infant mortality. An extension of the study compared statistical findings with Mberi's fitness orbit PhD work [9]. Comparison and experiences of the move from statistical analysis to fitness orbits are also presented.

Agincourt Statistical Analysis and Findings

Statistical Analysis

Logistic regression in Event History Analysis is used for analysis. Variables besides maternal death and temporary out-migration included in the analysis are listed in the table below. Except for infant death and mother's age at birth of the child, all variables are binary.

Table 1 Dependent and independent variables used

VARIABLES	Dependent	Independent
Infant death		Yes
Biological mother death	Yes	
Biological mother refugee status	Yes	
Biological mother temporary out-migration	Yes	
Younger sibling birth	Yes	
Younger sibling death	Yes	
Older sibling death	Yes	
Biological mother's age at birth	Yes	
Infant age	Yes	

Data used were from the Agincourt Health and Demographic Surveillance Site (HDSS) and span a ten year period from 1998 until 2008. Using STATA, logistic regression on the data was executed for two variations. The first was without unobserved heterogeneity and the second accounted for it. Unobserved heterogeneity (frailty) refers to characteristics that are unobservable which if neglected might affect the coefficient estimates. Both variations account for within subject correlation and bootstrapping ensures robust standard errors.

The Findings:

Sibling birth or death effects were two-fold. The first considers immediate effect within the year of occurrence and the second considers effects from the first year of occurrence until last year of infant observation. The results showed significant evidence that younger sibling and older sibling death improve childhood survival in the long term (trailing effect) as indicated in the output below.

Table 2 Infant mortality effects

Logistic regression

Number of obs	=	74684
Number of clusters	=	27704
Replications	=	500
Wald chi2(15)	=	1724.38
Prob > chi2	=	0.0000
Pseudo R2	=	0.0483

Log pseudolikelihood = -3373.7821

died	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
_Ianalage_1	.1232753	.0994124	1.24	0.215	-.0715695	.3181201
_Ianalage_2	-.5798059	.1254816	-4.62	0.000	-.8257452	-.3338665
_Ianalage_3	-1.607059	.1682603	-9.55	0.000	-1.936843	-1.277275
_Ianalage_4	-1.963764	.2013074	-9.76	0.000	-2.35832	-1.569209
mothermigr~n	-.0437679	.1617989	-0.27	0.787	-.3608879	.2733521
motherdeath	3.26931	.4263591	7.67	0.000	2.433662	4.104959
motherref	.333106	.0847106	3.93	0.000	.1670763	.4991356
_Imotherag~3	.29038	.1272807	2.28	0.023	.0409145	.5398455
_Imotherag~4	.2918214	.1344397	2.17	0.030	.0283243	.5553184
_Imotherag~5	.1648508	.1514276	1.09	0.276	-.1319419	.4616434
_Imotherag~9	.1637676	.1488558	1.10	0.271	-.1279844	.4555197
childsex	-.0211165	.0816902	-0.26	0.796	-.1812263	.1389933
lagtrailsb	.4926701	.2582783	1.91	0.056	-.0135461	.9988863
lagtrailsd	-13.1718	4.508484	-2.92	0.003	-22.00827	-4.335338
lagtrailpd	-14.19922	.3637131	-39.04	0.000	-14.91209	-13.48636
_cons	-4.931681	.2582603	-19.10	0.000	-5.437862	-4.425501

Then the study also found that younger sibling birth in the long term, biological mother's death, refugee status, age (younger mothers less than 35 yrs) and childhood age contribute towards childhood death. It was also found that estimates are not biased when frailty is taken into account.

Table 3 Frailty infant mortality effects

```
Random-effects logistic regression              Number of obs      =     74684
Group variable (i): child_id                    Number of groups   =     27704

Random effects u_i ~ Gaussian                   Obs per group: min =         1
                                                               avg =       2.7
                                                               max =         5

                                                Wald chi2(13)      =    217.44
Log likelihood  = -3364.3057                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
        died |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  _Ianalage_1 |   .3338871   .1333575     2.50   0.012     .0725111     .595263
  _Ianalage_2 |  -.3537107   .1563018    -2.26   0.024    -.6600565   -.0473649
  _Ianalage_3 |  -1.437625   .1981912    -7.25   0.000    -1.826073   -1.049177
  _Ianalage_4 |  -1.886059   .2241197    -8.42   0.000    -2.325325   -1.446792
mothermigr~n |  -.0897344   .1805008    -0.50   0.619    -.4435094    .2640406
 motherdeath |    4.34933    .693644     6.27   0.000     2.989812    5.708847
   motherref |   .4192535   .1111882     3.77   0.000     .2013286    .6371783
_Imotherag~3 |   .3671641   .1602745     2.29   0.022     .0530319    .6812963
_Imotherag~4 |   .3902755    .168875     2.31   0.021     .0592866    .7212644
_Imotherag~5 |    .241113   .1835916     1.31   0.189    -.1187199    .6009459
_Imotherag~9 |   .2255692   .1808495     1.25   0.212    -.1288894    .5800277
    childsex |  -.0067611   .1058909    -0.06   0.949    -.2143036    .2007813
  lagtrailsb |   .5339299   .2950684     1.81   0.070    -.0443936    1.112253
       _cons |  -7.491672   .6937676   -10.80   0.000    -8.851432   -6.131913
-------------+----------------------------------------------------------------
    /lnsig2u |   1.739209   .2802769                      1.189876     2.28841
-------------+----------------------------------------------------------------
     sigma_u |   2.385967   .3343657                      1.812919     3.14015
         rho |   .6337553   .0650549                      .4997572    .7498278
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Likelihood-ratio test of rho=0: chibar2(01) =    19.70 Prob >= chibar2 = 0.000
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From the output above, mother out-migration is insignificant while mother death is significant and the way they affect infant mortality differs. Mother death in Agincourt is rare and out-migration occurs frequently. Subsequently, these two variables are used in fitness orbit visualization.

Fitness Orbits Analysis and Findings

Two sets of data based each on three questions are constructed as follows:

Table 4 Data sets with questions and their hypothesized coding

Data Set 1 **Maternal Death**	**Data Set 2** **Maternal Out-Migration**	**Code (0=Unfit/1=Fit)**
Q_0: Infant Death	Q_0: Infant Death	Yes=0
Q_1: Mother refugee status	Q_1: Mother refugee status	Refugee=Yes=0
Q_2: Mother death	Q_2: Mother out-migration	Both Yes=0

A random sample of 5000 infants was taken from each data set and the fitness orbits algorithm was executed on each. The resulting fitness orbits plotted for maternal death shows that mother death and infant death occur concurrently and there were very few such events. This was contrary to the expectation that mother death will visually precede infant death. This revelation merited a re-visit of the statistical analysis and re-look at the data.

It turns out that the visual orbits were reflecting the fact that maternal mortality is rare in Agincourt and is concurrent with infant mortality. It was decided that the data later be expanded with dates of maternal and infant death for further analysis to visualise possible causality. This means that fitness orbits form a precondition to the statistical analysis. The data sets are further divided into dying and surviving infants for separate analyses.

Secondly, the data set was visually divided into two subgroups by mother refugee status. Transitions for refugees were and for South Africans were clearly separated. No transitions from refugee to South African or vice versa were noted. Thus fitness orbit analysis automatically clusters data.

Lastly, to determine if the plotted fitness orbits will yield the same conclusion as the statistical analysis, ratios are used. The following table illustrates how:

Table 5 Ratio calculations

Mother not out-migrating	**Mother out-migrating**
Number of Infant deaths = A	Number of Infant deaths = C
Number of surviving infants= B	Number of surviving infants= D
Ratio	
AA=A/B	BB=C/D

‘AA’ < 1 and ‘BB’ > 1 forms a conclusion that out-migration positively affects infant death.

References

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