Survival of Orphans:
Examples from Southern Zambia and South Africa

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Abstract (146 words)

HIV/AIDS is and will kill large numbers of adults in sub-Saharan Africa and as a consequence many children will be orphaned. In this context it is important to understand the excess risk of dying faced by orphans so that the total number of surviving orphans can be estimated with reasonable accuracy. This paper utilizes data from two long-term, community-based field sites in Southern Africa to quantify the additional risk of dying experienced by young children after one of their parents dies. An infant living in southern Zambia whose mother dies faces odds of dying 34 times greater than a similar infant whose mother is alive; a father's death is associated with a two-fold increase in an infant's odds of dying. In comparison, an infant living in northeast South Africa whose mother dies faces odds of dying 23 times that of an infant whose mother is alive.

Background

The HIV/AIDS pandemic in sub-Saharan Africa produces a large number of orphans (Foster and Williamson, 2000; Grassly et al., Submitted 2003; Grassly and Timæus, Submitted 2003; Monk, 2002). Consequently understanding the impact of orphanhood on a child's likelihood of dying is increasingly important. An important social consequence of the HIV/AIDS epidemic in many sub-Saharan African countries is or will soon be the number of orphans that result from adult's HIV-related mortality. To properly estimate or predict the number of orphans it is necessary to know both how many will be created through the death of parents and also how many will survive the period immediately following their parent's death. Significant work has been done to predict the number of orphans who will be created, but comparatively little is known about the survival chances of orphans. This paper presents a simple quantification of the excess risk associated with the recent death of a young child's parent in two distinctly different rural populations in southern Africa.

An analysis of child mortality conditioned on the survival status of parents is only possible when data linking parents to their children is available, along with the vital dates of the parents and children, and such data are rare in sub-Saharan Africa. One such data source is the Gwembe Tonga Research Project that has recorded the demographic and social history of the Gwembe Tonga of the Zambezi Valley, Zambia from the mid 1950s until 1995 as part of a long-term social anthropology study. Another such source of data is the Agincourt Health and Demographic Surveillance

System (AHDSS) in northeastern South Africa (Tollman et al., 1999). A baseline census of the entire Agincourt study population was conducted in 1992 and has since been updated annually recording all birth, death and migration events, both into and out of the study area.

Hypotheses

Hypothesis 1

The primary hypothesis this paper investigates is that *a young child's risk of dying increases at and following the time of a parent's death.* Most young children depend on their parents for care and nurture of all sorts so when a parent dies at least two mechanisms may contribute to increasing the risk that their young children will die:

1. the proximate cause(s) of the parent's death may also effect the children because they live in the same domestic milieu as the parent, and

2. a decrease in the level of care and nurture resulting from the loss of a parent may result in increased risks of malnourishment and falling victim to disease and accident.

Hypothesis 2

A corollary hypothesis that this paper begins to explore is that *the HIV epidemic in Southern Africa is increasing the likelihood that young children die shortly after their mother (or father) dies.* During the recent past HIV has infected a significant fraction of adults in

both of the populations contributing data to this work. HIV-related mortality of adults has increases steadily over the late 1980s and 1990s, and these increases are expected to result in increased child mortality associated with HIV passed from an infected mother, and through the mechanisms enumerated in Hypothesis 1 (above) effecting children who are not infected with HIV but become orphans as a result of HIV-related adult mortality.

Methods

Discrete Time Event History Analysis (DTEHA) (Allison, 1982, 1984; Rodríguez, 2002) is used to calculate the period-sex-age- specific ***annual hazards*** of death for maternal and paternal (Gwembe only) orphans between birth and exact age ten years. DTEHA provides a statistical framework in which the time-since-parent's death-dependent effect of a parent's death can be quantified and separated from other confounding factors such as age and historical period.

Specifically, the DTEHA method provides a means to statistically test the null hypothesis that there is no difference between the annual hazards of death of young children who have recently lost a parent and young children whose parents are still alive. This analysis yields period-sex-age-specific annual hazards of death for non-orphans and orphans with p-values testing the null hypotheses that they are equivalent.

Results are obtained as output from logistic regression of the dependent variable, in this case whether or not a death occurs during an observed person year, on the independent

variables – including sex, age, calendar year and years since a parent's death. In addition to the regression output, estimated probabilities are calculated that correspond to the annual hazard of death for various categories defined by the independent variables. These are further transformed into life table ${}_nq_x$ values that can be compared to other life tables.

All of the independent variables included in the regressions are coded as dummy variables so that each estimated coefficient corresponds to a category of the independent variable. This allows effects to vary by duration (age, time since a parent's death or calendar year) category and for interactions between the effects to be tested.

Models

Hypothesis 1

The models used to test Hypothesis 1 relate the probability that a child dies during an observed year, the annual hazard of death, to the number of years since a parent's death, controlling for sex and age. Interactions between age and years since a parent's death are included to test for a relationship between a child's age and their vulnerability to a parent's death.

Hypothesis 2

Models used to test Hypothesis 2 build on those used to test Hypothesis 1 by adding a period (calendar year) variable and interactions between the period variable and the time since a parent's death variable. These models relate the probability that a child

dies during an observed year to the years since a parent's death, the calendar year during which the observed year started and the two-way interactions between the years since a parent's death and the calendar year during which the observed year started, controlling for sex and age. If HIV/AIDS is having the hypothesized impact, there should be a positive interaction between the historical period and years since a parent's death variables as time progresses over the 1990s, especially at short durations of time since a parent's death.

Data

Gwembe

Data describing 155,229 person years of exposure contributed by 11,162 individuals living in the Gwembe Valley, Southern Zambia between 1957 and 1995 were collected by Anthropologists Elizabeth Colson and Thayer Scudder as part of a long term study in Social Anthropology. The data used here form a small part of their collection and were primarily used to identify and re-identify members of the study communities. To fulfill this task, accurate genealogies were constructed and maintained over the study that included individuals' birth and death dates, marriage dates and links between parents and children. This is sufficient to calculate period-sex-age-specific mortality rates for the population at large and for maternal, paternal and possibly dual orphans (who are very rare under normal mortality conditions). The Gwembe field site and these data have been described in detail elsewhere (Clark et al., 1995; Clark, 2001;

Colson, 1960, 1971; Scudder, 1962; Scudder and Colson, 1977). Important to note for the purposes of this investigation are that the population observed by the Gwembe Study lives in a remote rural area of Southern Zambia and occupies itself primarily with subsistence agriculture and stock-keeping. The overall level of development is low and the macro economy of Zambia functions poorly, with the result that basic health and education services are poorly delivered.

The Gwembe data presented here have been transformed for DTEHA into a "person year" file that contains one record for each year of each child's life for children less than ten years old. Records are included only for complete years over which the child was observed, except in the case of a death during the year. The dependent variable in all cases is a binary variable indicating whether or not the child dies during the year. Independent variables include the age of the child at the beginning of the year, the calendar year during which the observed year starts, the child's sex, and the number of years that the child's mother and/or father have been dead. The last is a categorical variable with categories for "parent still alive" and parent has been dead 0, 1-3, 4-6 or 79 years. The category "0" is true when the parent dies *during* the year represented by the record.

Table 1 displays a summary of the person years used for the analysis of the influence of a mother's recent death on a child's likelihood of dying, by the child's age, years since the mother died and whether or not the child dies during the year. There are a total of 47,810 person years with sufficient information to be included in this analysis. There

are 1,603 deaths, 1,578 of which occur to children whose mother is still alive, and 25 of which occur to children whose mother has recently died. The total person years exposed with a mother recently dead is 545.

Table 2 displays the same summary for years since a father's death. In this case there are a total of 38,283 person years with sufficient information to be included. The substantially smaller number is due to the fact that fewer links are available between fathers and children – mainly as a result of unmarried women migrating into the study area with children. In the "father's" data set there are 1,284 deaths, 1,256 of which occur to children whose father is still alive and 28 of which occur to children whose father has recently died. The total person years exposed with a father recently dead is 1,267.

The age and years since a parent's death ranges used in both data sets are 0, 1-3, 4-6 and 7-9 years. These slightly unusual three-year periods were chosen to maximize the chance of identifying fine-grained duration effects without making cells so small that they don't contain any observations or events.

Agincourt

The Agincourt data were collected over the period 1992 to 2000 by a Demographic Surveillance System (DSS) site that was designed to monitor the impact of community health initiatives during the 1990s (Tollman et al., 1999). In 2002 the study population was slightly over 70,000 individuals living in 11,500 households. Information linking children to their mothers is recorded for all births. Mortality surveillance is conducted

through the application of verbal autopsy (VA) interviews with the nearest caregiver to each deceased individual. Validation of VA diagnoses during the mid 1990s for infectious and parasitic diseases had a sensitivity of 82% and specificity of 93% (Kahn et al., 2000). Verbal autopsy results are available for the majority of deaths through the end of 1999.

The Agincourt study population lives in a rural area in northeastern South Africa. By comparison to the Gwembe population the South African population is well serviced with basic infrastructure, health care and education services. Additionally, the macro economy of South Africa was and is far healthier and more productive than that of Zambia, with the result that employment and services provided by the private sector are at much higher levels in terms of quantity and quality compared to Zambia.

The Agincourt data used for this investigation are very similar to the Gwembe data with the important difference that links between fathers and children are not recorded consistently in the data. The same variables and age ranges defined for the Gwembe data are also defined for the Agincourt data.

Table 3 displays a summary of the person years available for analysis in the Agincourt data set linking mothers and children. Person years included in the analysis data set are drawn from observation over the period 1993-2000. There are a total of 149,895 person years available for analysis, 718 of which contain a death, 24 of which occur to children

whose mother has recently died. The total person years exposed with a mother recently dead is 587.

Table 4 contains a list of the 24 mother-child death pairs that occur in the Agincourt data and for each displays the mother's cause of death, the child's cause of death, the number of years between the mother and child's deaths (using the same duration ranges as described above), the child's exact age at death, the mother's age at death and the year of the child's death.

Table 1: Summary of Child Years by Age and Years Since Mother's Death - GWEMBE

Years Since Mother's Death	Age (years) 0	1-3	4-6	7-9	Total
			Dies		
Mother Alive	770	589	170	49	1,578
0	18	1	1	1	21
1-3	0	2	1	1	4
4-6	0	0	0	0	0
7-9	0	0	0	0	0
Subtotal Dies, Mother Dead	18	3	2	2	25
Subtotal Dies	788	592	172	51	1,603
			Does Not Die		
Mother Alive	5,929	15,485	13,079	11,169	45,662
0	4	42	42	49	137
1-3	0	34	116	117	267
4-6	0	0	25	91	116
7-9	0	0	0	25	25
Subtotal Does Not Die, Mother Dead	4	76	183	282	545
Subtotal Does Not Die	5,933	15,561	13,262	11,451	46,207
Grand Total	6,721	16,153	13,434	11,502	47,810

Table 2: Summary of Child Years by Age and Years Since Father's Death – GWEMBE

Years Since Father's Death	Age (years) 0	1-3	4-6	7-9	Total
			Dies		
Father Alive	612	472	137	35	1,256
0	5	9	1	0	15
1-3	0	4	4	3	11
4-6	0	0	1	1	2
7-9	0	0	0	0	0
Subtotal Dies, Father Dead	5	13	6	4	28
Subtotal Dies	617	485	143	39	1,284
			Does Not Die		
Father Alive	4,678	12,164	10,205	8,685	35,732
0	22	90	85	113	310
1-3	0	116	248	246	610
4-6	0	0	81	196	277
7-9	0	0	0	70	70
Subtotal Does Not Die, Father Dead	22	206	414	625	1,267
Subtotal Does Not Die	4,700	12,370	10,619	9,310	36,999
Grand Total	5,317	12,855	10,762	9,349	38,283

Table 3: Summary of Child Years by Age and Years Since Mother's Death - AGINCOURT

Years Since Mother's Death	Age (years) 0	1-3	4-6	7-9	Total
			Dies		
Mother Alive	331	289	41	33	694
0	9	6	2	3	20
1-3	0	3	1	0	4
4-6	0	0	0	0	0
7-9	0	0	0	0	0
Subtotal Dies, Mother Dead	9	9	3	3	24
Subtotal Dies	340	298	44	36	718
			Does Not Die		
Mother Alive	15,037	43,899	45,341	44,313	148,590
0	18	50	78	108	254
1-3	0	56	98	133	287
4-6	0	0	15	25	40
7-9	0	0	0	6	6
Subtotal Does Not Die, Mother Dead	18	106	191	272	587
Subtotal Does Not Die	15,055	44,005	45,532	44,585	149,177
Grand Total	15,395	44,303	45,576	44,621	149,895

Table 4: Mother's and Child's Causes of Death for 24 Pairs in which Mother Dies before Child's 10th Birthday - AGINCOURT

Main Cause of Mother's Death	Main Cause of Child's Death	Years Since Mother's Death	Child's Age at Death (years)	Mother's Age at death (years)	Year of Child's Death
Stroke	Ill defined	0	8.5	46.0	1993
Ill defined	Ill defined	0	7.4	35.1	1993
AIDS	Assault	0	4.5	22.8	1994
Ill defined	AIDS	1-3	1.4	27.3	1995
Assault	Diarrhea	1-3	2.6	21.6	1995
?	?	0	2.8	22.4	1998
AIDS	AIDS	0	1.3	35.3	1999
?	Kwashiorkor	0	1.9	25.1	1999
AIDS	AIDS	0	2.0	21.7	1999
Acute infection - malaria?	?	0	2.3	40.9	1999
AIDS	?	0	0.3	33.5	1999
AIDS	AIDS	0	0.3	20.0	1999
Postpartum hemorrhage	AIDS	0	0.9	40.5	2000
Meningitis	?	0	0.2	19.9	2000
AIDS	AIDS	0	0.3	37.9	2000
?	?	0	0.7	28.4	2000
?	?	1-3	4.1	33.9	2000
Causes Not Yet Coded		0	4.1	22.6	2001
		0	0.7	46.5	2001
		1-3	2.2	30.5	2001
		0	1.4	22.6	2001
		0	9.4	25.0	2001
		0	0.4	21.4	2002
		0	0.8	24.1	2002

Findings

Mother's Death

Gwembe

Table 5 presents summarized regression output from the best fitting and most parsimonious model relating a child's death to the child's sex and age and the years since the child's mother's death for the Gwembe. Various models were tried including ones that included dummy variables for the historical period during which a person year was lived. Although the period variable does have significant and important effects, interactions between it and the "years no mother" variable were not significant or important. Consequently no support is found for Hypothesis 2 – although the period variable is important to accurately estimate the level of mortality during specific historical periods, the period effect is not related to, nor does it modify the "years no mother" effect, and hence the period variable was dropped from the model.

The model presented contains main effects for the child's sex and age and the number of years since the child's mother's death. Interactions between the child's age and the years since the mother's death were included to test whether or not the main effect of years since mother's death was modified by the age of the child. In the case of a mother's death in the Gwembe, these interactions are highly significant as a group and contain three important and significant interactions as individual dummies, and as a result they are included in the final model and presented Table 5.

The reference category for sex is female, and the odds ratio associated with being male is 1.15 and highly significant – confirming that young boys face a higher likelihood of dying. The reference category for age is age 0, and the odds ratios for ages 1-3, 4-6 and 7-9 are 0.29, 0.10 and 0.033 and all highly significant – also confirming the steady decrease in a child's likelihood of dying as age progresses. The reference category for "years no mother" is "mother alive". The highly significant odds ratio associated with a mother's death during the year is 34.12 and for a mother's death within the past 1-3 years 0.65, not significant. It is not possible to estimate a coefficient for a mother's death in the last 7-9 years because there are no deaths in that category. The interactions between child's age 1-3 and mother's death in the year, child's age 4-6 and mother's death in the year, and child's age 7-9 and mother's death in the year are significant at or below the 10 percent level. All three modify the astonishingly large value of the odds ratio on the mother's death in the year dummy variable to bring it down to much lower levels for children who are *older than one year* when their mother dies. The overall result of including the interactions is to allow the excess risk of dying for infants (less than one year old) whose mother dies to be *far* greater than that of children older than one year whose mothers die. In the Gwembe if you are an infant and your mother dies you face a very high likelihood of dying compared to infant's whose mother is still alive, and if you are greater than one year old that excess likelihood is substantially diminished.

Agincourt

The Agincourt results presented in Table 6 largely corroborate the findings in the Gwembe. As with the Gwembe, interactions between the "years no mother" variable and the period variable were not important or significant, so the period variable was dropped from the models. Additionally, in the Agincourt case interactions between the child's age and years no mother variables were not significant, so they were also dropped from the model.

The resulting model includes main effects for the child's sex and age and years since the child's mother's death. All of the dummy variables defining categories of those variables are important and significant except for the sex variable. The sex effect is in the right direction but only mildly important or significant.

The child's age effects are very important and significant, demonstrating a steadily decreasing likelihood of dying as a child ages, and in comparison to the Gwembe reveal a generally greater decrease in the likelihood of dying at ages older than zero – suggesting that the overall levels of child mortality are significantly lower in Agincourt.

The years no mother effect is very strong for a mother's death during the year with an odds ratio of 23.03 compared to children whose mother is alive. Moreover, the effect is still strong 1-3 years after a mother's death with an odds ratio of 7.08. Unlike the Gwembe there is no differentiation of these main effects by child's age category, see above.

These findings clearly support Hypothesis 1; a mother's death is very strongly associated with large increases in the likelihood of dying for children living in both the Gwembe and the Agincourt study areas. The effect is stronger in the Gwembe and appears to ameliorate more quickly with age – a comparison that likely reflects the differing socio-economic conditions of the two populations. The fact that a mother's death is not associated with large excess risk of dying for children one year and older in the Gwembe may also reflect a more general selection effect. The overall levels of child mortality are much higher in the Gwembe, see below, which may result in a majority of particularly vulnerable children dying before their first birthday, leaving a generally hardier population of children one year and older who are better able to cope with the stress of a mother's death. Another possible explanation has to do with the fact that the kin networks that may support children whose mother dies are likely to be more vibrant and active in the Gwembe where the overall society is less modernized, less individualistic and less integrated into the larger cash economy (and hence more self-reliant).

In contrast no support is found for Hypothesis 2. Neither the Gwembe nor Agincourt data reveal important or statistically significant interactions between more recent historical periods and the duration since a parent's death. Possible explanations for this are discussed below.

Life Table Values for Child Mortality by Years Since Mother's Death

Annual hazards of death were estimated from the models discussed above and transformed to the life table ${}_nq_x$ values that are presented in Table 7 and plotted in Figure 1. The most important comparison between the ${}_nq_x$ values for the Gwembe and for Agincourt is the substantial difference in the overall level of mortality in all categories. Whereas a male infant has a 0.125 chance of dying in its first year in the Gwembe, the same infant in Agincourt has only a 0.023 chance of dying. Similar comparisons hold across all of the values presented in Table 7.

Apart from this striking difference, the impact of a mother's death is similar. A male infant in the Gwembe whose mother dies has a probability of dying before his first birthday of 0.826 compared to 0.122 for the same infant with a living mother. The same infant in Agincourt faces a 0.346 change of dying after his mother's death and a 0.022 change of dying with a living mother.

Table 5: Logistic Regression of "Dies" on Sex, Age and Years Since Mother's Death – GWEMBE. Predicts Annual Hazard of Death.

Variable ID	Name	O.R.	P-value	95% C.I.	
0	Female	1.000			
1	Male	1.146	**0.009**	1.034	1.270
2	Age 0	1.000			
3	Age 1-3	0.293	**0.000**	0.262	0.327
4	Age 4-6	0.100	**0.000**	0.084	0.118
5	Age 7-9	0.033	**0.000**	0.025	0.045
6	Mom Alive	1.000			
7	YNM 0	34.123	**0.000**	11.469	101.517
8	YNM 1-3	0.655	0.673	0.091	4.676
9	3 X 7	0.017	**0.001**	0.001	0.173
10	3 X 8	2.297	0.498	0.207	25.439
11	4 X 7	0.054	**0.012**	0.005	0.523
12	4 X 8	1.000			
13	5 X 7	0.136	**0.086**	0.013	1.324
14	5 X 8	3.007	0.441	0.183	49.355

N:	47,669
Log likelihood:	-6,180.51
Model P-value:	0.0000
Pseudo R^2:	0.1188

Age (years)

YNM - Years No Mother (years)

Table 6: Logistic Regression of "Dies" on Sex, Age and Years Since Mother's Death – AGINCOURT. Predicts Annual Hazard of Death.

Variable ID	Name	O.R.	P-value	95% C.I.	
0	**Female**	1.000			
1	**Male**	1.091	0.248	0.941	1.265
2	**Age 0**	1.000			
3	**Age 1-3**	0.298	**0.000**	0.255	0.349
4	**Age 4-6**	0.042	**0.000**	0.031	0.057
5	**Age 7-9**	0.034	**0.000**	0.024	0.048
6	**Mom Alive**	1.000			
7	**YNM 0**	23.031	**0.000**	13.929	38.079
8	**YNM 1-3**	7.079	**0.000**	2.567	19.520

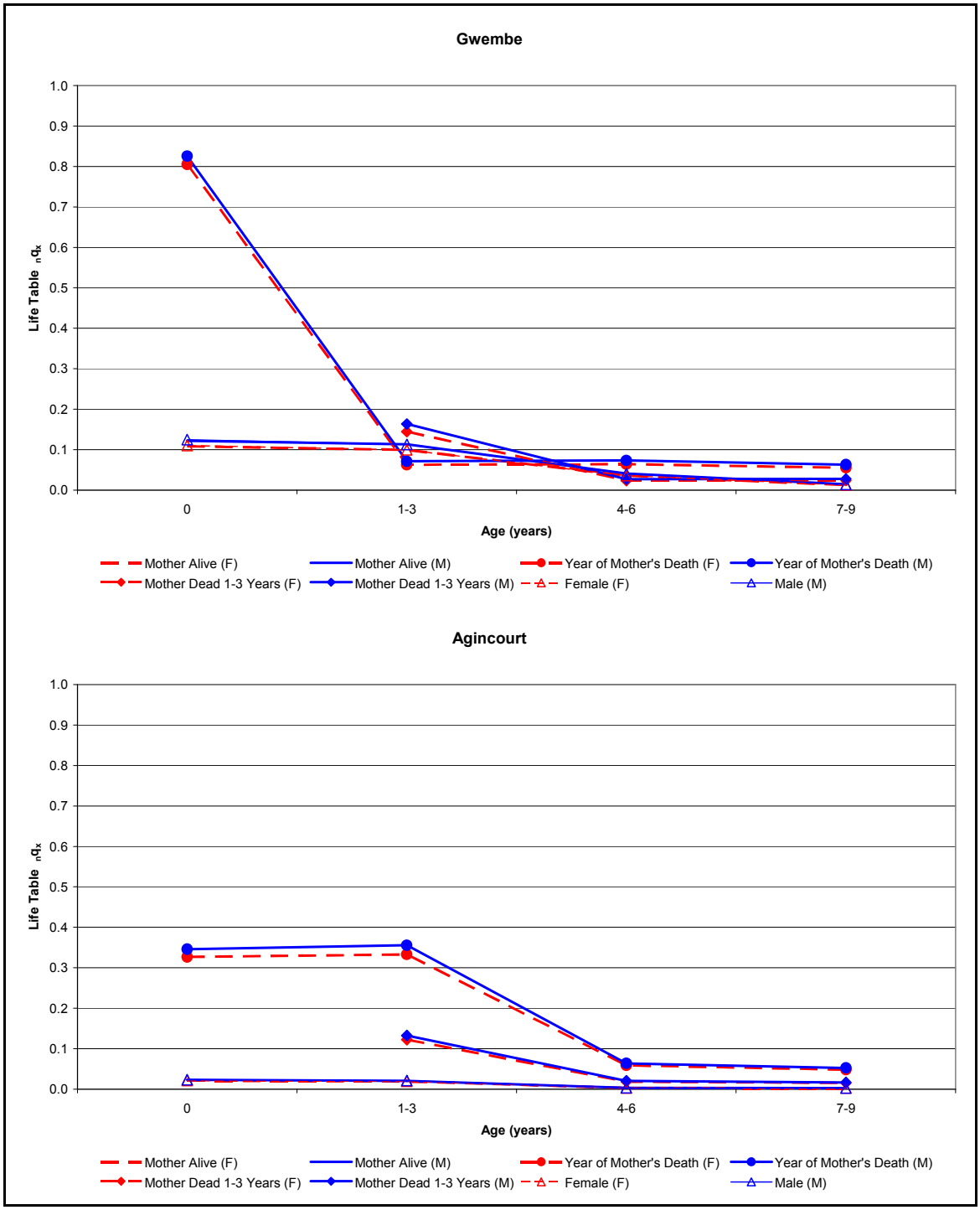
N:	149,849
Log likelihood:	-4,015.96
Model P-value:	0.0000
Pseudo R^2:	0.1176

Age (years)
YNM - Years No Mother (years)

Table 7: Life Table Probability of Dying ($_nq_x$) by Sex, Age and Mother's Survival Status.

Age	All	Mother Alive	Year of Mother's Death	Mother Dead 1-3 Years
- GWEMBE -				
Female				
0	0.10995	0.10799	0.80511	
1-3	0.09913	0.09932	0.06230	0.14452
4-6	0.03536	0.03552	0.06420	0.02346
7-9	0.01234	0.01219	0.05495	0.02382
Male				
0	0.12450	0.12187	0.82565	
1-3	0.11295	0.11274	0.07098	0.16328
4-6	0.04056	0.04058	0.07314	0.02683
7-9	0.01419	0.01395	0.06265	0.02724
- AGINCOURT -				
Female				
0	0.02111	0.02062	0.32651	
1-3	0.01915	0.01859	0.33298	0.12224
4-6	0.00276	0.00263	0.05841	0.01846
7-9	0.00231	0.00216	0.04820	0.01515
Male				
0	0.02306	0.02245	0.34594	
1-3	0.02094	0.02026	0.35544	0.13235
4-6	0.00302	0.00287	0.06349	0.02011
7-9	0.00253	0.00236	0.05242	0.01652

Figure 1: Age-Specific Life Table Probability of Dying ($_nq_x$) by Years Since Mother's Death



Father's Death

Gwembe

Regression results from the Gwembe "fathers" dataset are presented in Table 8. Unlike the relationship between the likelihood of a child's death and years since a mother's death in the Gwembe, the relationship between a child's death and years since a father's death does not contain important or significant interactions between the child's age and the years since the child's father's death. In this case only the main effects associated with the child's sex and age and the years since the child's father's death are important and/or significant. As with the years since a mother's death relationships in both the Gwembe and Agincourt, there is an important and significant period effect, but interactions of this with the years since father's death are neither important nor significant, so the period variable is not included in the model presented here whose purpose is to identify an independent effect of years since father's death. Again, no support is found for Hypothesis 2.

Table 8 shows that in this more selected dataset the sex effect is no longer significant, even though it is in the correct direction. The age effects are as expected and are very similar to the "years since mother's death" analysis, Table 5, with a steadily decreasing likelihood of dying as a child ages.

Odds ratios on the years since father's death dummy variables are all greater than 1.0, but the only one to reach significance (p-value = 0.022) is on the category corresponding

a father's death during the year with an odds ratio of 1.87 compared to the father being alive. This means that a child whose father dies has a nearly twofold chance of dying during the year including the father's death. After surviving the year of a father's death, a child may have a very slightly elevated risk of dying, but the odds ratios associated with these durations are not statistically different from 1.0.

Life Table Values for Child Mortality by Years Since Father's Death

Table 9 and Figure 2 present the life table ${}_nq_x$ values estimated from the regression of a child's likelihood of dying against the child's sex, age and years since the father's death that is discussed above. Compared to the corresponding values estimated in the similar regression for years since a mother's death, the overall probability of dying for all children is the same, while the probability of dying for infants who lose a father is much less than for infants who lose a mother. However, the probability of dying for children living through the 1-3 year-old age group is substantially greater 1-3 years after a father's death than 1-3 years after a mother's death.

Table 8: Logistic Regression of "Dies" on Sex, Age and Years Since Father's Death – GWEMBE. Predicts Annual Hazard of Death.

Variable ID	Name	O.R.	P-value	95% C.I.	
0	**Female**	1.000			
1	**Male**	1.070	0.242	0.955	1.200
2	**Age 0**	1.000			
3	**Age 1-3**	0.297	**0.000**	0.263	0.337
4	**Age 4-6**	0.102	**0.000**	0.084	0.123
5	**Age 7-9**	0.032	**0.000**	0.023	0.044
6	**Dad Alive**	1.000			
7	**YNF 0**	1.867	**0.022**	1.093	3.192
8	**YNF 1-3**	1.251	0.475	0.677	2.313
9	**YNF 4-6**	1.058	0.937	0.258	4.342

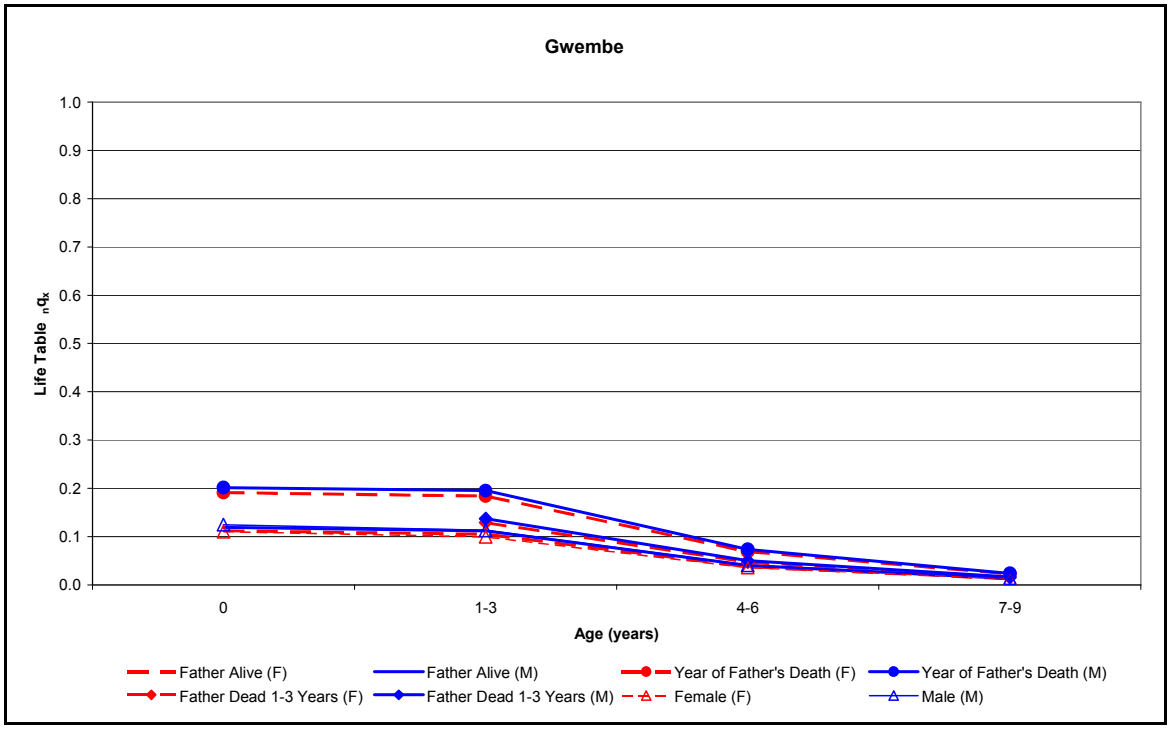
N:	38,213
Log likelihood:	-4,982.97
Model P-value:	0.0000
Pseudo R^2:	0.1132

Age (years)
YNF - Years No Father (years)

Table 9: Life Table Probability of Dying ($_nq_x$) by Sex, Age and Father's Survival Status – GWEMBE.

Age	All	Father Alive	Year of Father's Death	Father Dead 1-3 Years
Female				
0	0.10995	0.11211	0.19079	
1-3	0.09913	0.10468	0.18396	0.12863
4-6	0.03536	0.03756	0.06862	0.04668
7-9	0.01234	0.01192	0.02210	0.01488
Male				
0	0.12450	0.11907	0.20153	
1-3	0.11295	0.11150	0.19516	0.13685
4-6	0.04056	0.04013	0.07322	0.04986
7-9	0.01419	0.01275	0.02364	0.01592

Figure 2: Age-Specific Life Table Probability of Dying ($_nq_x$) by Years Since Father's Death



Mother-Child Cause of Death Profile – Agincourt

As a consequence of the comparatively low levels of female adult mortality in the Agincourt study population throughout most of the 1990s, there are few mother-child pairs for which the mother dies during the same year or preceding the child's death by less than ten years – a total of 24 during the period 1993-2000 that is used for this analysis. These pairs are listed in Table 4 that displays the cause of death for both the mother and child (when it is available), the years since the mother's death, the ages at death of the mother and child and the calendar year when the child's death occurred.

Although this sample of mother-child cause-of-death pairs is too small to effectively analyze statistically, it is perhaps useful to summarize and speculate on. The observation that six of the fifteen known causes of mothers' deaths and six of the eleven known causes of children's deaths are "AIDS", and that most of these occur after 1998 tempts one to conclude that the number of mothers and children dying of AIDS increased toward the end of the 1990s, although this was not statistically evident when models were estimated to investigate Hypothesis 2. The ages of the mothers who die of AIDS is generally young compared to the mothers who die of other or unknown causes, and so are the ages at death of the children of those mothers who die of AIDS. The fact that infected mothers infect one in three of their newborn children creates the potential for a high level of correlation between mother's and children's deaths when HIV prevalence of women is high. Female prevalence was in the vicinity of ten to twelve

percent in this population during the late 1990s which is sufficient to begin generating a large number of mother-child AIDS death pairs. Perhaps the lack of a statistically significant impact is a result of the relatively long time between infection and death for adults. We expect the number of mother-child HIV death pairs to increase steadily during the coming decade.

Apart from the possible impact of HIV, there does not appear to be any other interesting relationships in Table 4.

Discussion

Clear support is found to validate Hypothesis 1. The likelihood that young children - and in particular infants – die shortly following their mother's death is very substantially higher than for infants whose mothers are alive. This finding holds across both the Gwembe and Agincourt sites, with the magnitude of the effect substantially greater in the less developed population living in the Gwembe Valley in southern Zambia.

No support is found to validate Hypothesis 2. No important and/or significant interactions exist between the period and duration since parent's death variables. This indicates that the time since a parent's death effect does not change over the period of observation for either the Gwembe or Agincourt populations. The data used here largely describe a period before HIV-related mortality of mothers and their infants began to rise significantly (up to 1995 in the Gwembe, and up to 2000 in Agincourt), and

likely explains why no statistically significant effect is observed. We expect to observe this effect in data describing these populations in the future.

Future work on this topic will merge the data from the Gwembe and Agincourt sites and estimate models that take into account and quantify the age and duration since parent's death effects-specific differences in the likelihood of dying for young children living in the two sites. Newly coded data will also be added to the data sets to enable a re–examination of Hypothesis 2 during historical periods when HIV/AIDS was having a more significant impact on mortality of the two populations.

The very substantial excess risk of dying faced by very young children when their mothers die will have a large impact on the number of orphans who survive to older ages during the next decade when HIV-related mortality will kill large numbers of adults in sub-Saharan Africa. If the levels of excess risk measured here are experienced more broadly, the majority of infants who are born shortly before their mother dies will also die. However, if an infant is able to survive its first year and remain uninfected by HIV, its risk of dying falls quickly so that by the time it is three years old its risk of dying is about the same as children whose parents are still alive. Because many children will lose their parents to HIV at older ages (older than one year), there will still be a very substantial increase in the number of orphans in the population – but not as much as would be predicted if orphans and non-orphans shared the same risk of dying at all ages and durations since a parent's death.

References

Allison, P. 1982. "Discrete-time Methods for the Analysis of Event Histories." Pp. 61-98 in Sociological Methodology, edited by S. Leinhardt. San Francisco: Jossey-Bass.

—. 1984. Event History Analysis. Regression for Longitudinal Event Data. Beverly Hills: Sage.

Clark, S., E. Colson, J. Lee, and T. Scudder. 1995. "Ten Thousand Tonga: A Longitudinal Anthropological Study form Southern Zambia, 1956–1991." *Population Studies*, 49:91–109.

Clark, S. J. 2001. "Part 2: The Demography of the Gwembe Tonga." Pp. 55-195 in An Investigation into the Impact of HIV on Population Dynamics in Africa, edited by Demography. Philadelphia, Pennsylvania: University of Pennsylvania.

Colson, E. 1960. Social Organization of the Gwembe Tonga. Manchester: Manchester University Press.

—. 1971. The Social Consequences of Resettlement: The Impact of the Kariba Resettlement upon the Gwembe Tonga. Manchester: University of Manchester Press.

Foster, G. and J. Williamson. 2000. "A review of current literature on the impact of HIV/AIDS on children in sub-Saharan Africa." *Aids*, 14 Suppl 3:S275-84.

Grassly, N. C., J. J. C. Lewis, M. Mahy, N. Walker, and I. Timæus. Submitted 2003. "Comparison of Survey Estimates with UNAIDS/WHO Projections of Mortality and Orphan Numbers in sub-Saharan Africa."

Grassly, N. C. and I. Timæus. Submitted 2003. "Orphan Numbers in Populations with Generalised AIDS Epidemics." *J. AIDS*.

Kahn, K., S. Tollman, M. Garenne, and J. S. S. Gear. 2000. "Validation and application of verbal autopsies in a rural area of South Africa." *Tropical Medicine and International Health*, 5(11):824-831.

Monk, N. O. 2002. "Enumerating Children Orphaned by HIV/AIDS: Counting a Human Cost". http://www.albinasactionfororphans.org/learn/OVCstats.pdf. Accessed: September 24, 2003.

Rodríguez, G. 2002. "Lecture Notes for Generalized Linear Statistical Models". http://data.princeton.edu/wws509. Accessed: October, 2002.

Scudder, T. 1962. Ecology of the Gwembe Tonga. Manchester: Manchester University Press.

Scudder, T. and E. Colson. 1977. "Long-Term Field Research in Gwembe Valley, Zambia." Pp. 227-254 in Long-Term Field Research in Social Anthropology, edited by F. G. New York: Academic Press.

Tollman, S., K. Herbst, M. Garenne, J. S. S. Gear, and K. Kahn. 1999. "The Agincourt Demographic and Health Study: Site Descriptions, Baseline Findings and Implications." *South African Medical Journal*, 89:858-64.