Fathers and the living arrangements, mobility and survival of young children in rural South Africa

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ABSTRACT

We use longitudinal population data from the Africa Centre Demographic Surveillance System in rural KwaZulu-Natal to describe the living arrangements of fathers and their children during the first five years of life. We investigate the association between paternal factors and the migration and survival of 5,872 young children resident in the surveillance area at their birth (2000-2003). We find that two thirds of children were not co-members of households with their fathers at birth. The living arrangements of many young children are dynamic and complex; 42% of the children were recorded as migrating at least once before their 5th Birthday. Due to child mobility combined with high levels of non-residence, migration and death by fathers, only 8% of fathers were always co-resident in the same household as their child between birth and 5th Birthday. Fathers' social, residential and vital status was significantly associated with child mobility and child survival. Controlling for maternal and household factors, children were significantly more mobile if their fathers were not co-members, were co-members but only co-resident occasionally, were observed to migrate, were not the head of household, or whose vital status was unknown by household respondents. Child survival was lower among children whose fathers were not co-members, co-members who were occasionally resident, and were not observed to migrate. We conclude that given that the majority of fathers of young children are a co-member of the household, creative approaches to data collection about non-resident fathers and father involvement are needed in South African surveys to understand and support men's involvement in the lives of young children and households.

INTRODUCTION

Fathers remain largely invisible in large South African population studies (Posel et al., 2006) despite increasing interest in fathers, fathering and the impact of men on the health and well-being of children and families in southern Africa (See overviews in (Morrell, 2006; Morrell et al., 2006)). The dearth of survey data about fathers and their involvement with young children partially reflects the large proportion of children, particularly African children, who do not co-reside with their biological fathers. However, that fact that few large surveys and cohorts that have sought to collect detailed information about non-resident fathers and father involvement is probably more indicative of assumptions by researchers and policy makers that involvement by African fathers in the care and support of young children is very limited (Richter, 2006).

Historically labour migration has been the main contributing factor for the low rate of co-residence between fathers and their children in South Africa. The highly regulated Apartheid-era systems of labour migration and 'bantustan' settlements shaped the social structure and residential arrangements of African households. With kin widely dispersed due to migration, fluid domestic arrangements were characteristic of many households particularly those 'stretched' between several different locations (Murray, 1980, 1981; Ramphele, 1993; Spiegel, 1987; Spiegel, 1986). Despite political transformation, male and female labour migration and family dispersal persist strongly in contemporary African communities. Non-resident members are a common phenemona in many households, particularly households in rural areas. Adult members frequently live somewhere else while working or looking for employment, as well as, an increasing number of adult members who are not resident with the household for other reasons (Posel, 2009). Using data from the national 2002 General Household Survey (GHS), Posel and Devey (2006) estimated that 55% of rural Black African children (age 15 years and younger) were reported by a household respondent to have 'absent' fathers. The GHS did not distinguish whether 'absent' fathers were co-members of the household.

In South Africa, the long and well-established decline in marriage (Budlender et al., 2005; Locoh, 1988; Udjo, 2001), together with cultural norms related to household formation and childbearing, have also contributed to the social and residential separation of fathers and children. In turn, the processes of labour migration, family separation and economic insecurity have further acerbated declines in marriage (Preston-Whyte, 1974; Preston-Whyte, 1978; Preston-Whyte, 1993). In 2006, 55% of women aged 40-44 years in rural KwaZulu-Natal had never been married (Hosegood et al., 2009). In the context of high rates of childbearing outside marriage, the extent to which children live with their fathers will be influenced by the cultural norms and practices related to non-marital cohabitation and the care and responsibility for children by maternal and paternal kin (Preston-

Whyte, 1978; Preston-Whyte, 1993; Russell, 2003). While non-marital cohabitation rates have risen in the last decade, the practice is much more common in urban communities, with family and household formation in rural communities typically restricted to individuals related through kinship or marriage.

The study of fathers raises many theoretical, methodological, measurement and study design issues (See for example, (Lamb et al., 2004; Roggman et al., 2002)). Few large longitudinal population-based studies or cohorts in South Africa where father-child pairs are consistently identified and followed, in which changes in living arrangements of children and their fathers are recorded, and where the effect of fathers on the health and wellbeing of children can be investigated. The main challenges in using existing survey and census data for the study of fathers lie in the way that surveys identify fathers and the amount of information they collect about non-resident fathers. The importance of distinguishing household membership and residency for social and demographic research in South Africa has been noted by many authors (Hosegood et al., 2005a; Russell, 2003; Spiegel, 1986). Avoiding the need to rely on simplistic categorisations of all non-resident fathers as 'absent' by distinguishing social and residential dimensions within the living arrangements of fathers and children represents a conceptual advance in several South African longitudinal population studies over co-residential household definitions. The second challenge relates to the extent that household surveys collect information about fathers who are not co-members of the household. The importance of understanding intra-household relationships and events in the context of a 'web' of relationships between inter-connected households (Hosegood et al., 2007b; O'Laughlin, 1998; Townsend, 2001; Townsend, 1997). The minimum information needed is whether a childs' father is alive or dead - surprisingly this information is not collected in many surveys (Floyd et al., 2005). The next level of information - about the type, amount and quality of father involvement, is where the least data are available in large South African surveys. Setting aside the complexities and challenges of how such involvement would be defined and measured, none of the national surveys have consistently sought to collect such data from household respondents about the involvement of fathers for all children in the survey. A further methodological step – to collect detailed data from fathers themselves regarding their involvement with children – has not been attempted in a South African survey.

Most research about fathers and men's involvement in families in southern Africa has used data from qualitative studies or small sample surveys. Qualitative methods are more readily adapted than population studies to the collection of detailed information about family relationships in a context of complex, fluid and dispersed social and residential arrangements. Only recently have researchers begun to collect and utilise empirical data in order to test widely held assumptions about the correlation between the 'absence' of fathers and their involvement in the care and support of children. The Children's Well-Being and Social Connections

(CWSC) study conducted in the rural Agincourt sub-district, Limpopo province, South Africa, used lifetime residential histories of 297 children aged 10-20 years to examine the level of material support provided by fathers with different social and residential connections to their children (Madhavan et al., 2008). Co-residence and co-members were not significant predictors of financial support for children. Children with co-resident fathers had the same likelihood of receiving financial support than children who fathers lived elsewhere and were not members of the same household. Where longitudinal survey data on fathers and child outcomes are available, the most widely studied aspects have been between fathers 'absence' and outcomes in older children: age at first sex for girls, teenage pregnancy, school enrolment and educational attainment (Anderson, 2004; Timaeus et al., 2007).

One population study with longitudinal information about the living arrangements fathers and young children, albeit not measures of fathers' involvement, is the Africa Centre demographic surveillance system in rural KwaZulu-Natal, South Africa. Using these data we address four questions in this paper: What are the living arrangements of young children and their fathers at the time of birth? What maternal and household factors are associated with fathers' social and residential arrangements with biological children at birth? A considerable evidence-base has built up about the effects of father absence on young children's psychological and physical development primarily using data collected in European and North American family surveys and cohort studies. However, many of these studies were designed specifically to answer questions about family structure, parental involvement and outcomes for children (for example, the Fragile Families and Child Wellbeing Study). In ACDIS, information is available for children under 5 years for only a limited number of outcomes that may be markers of child vulnerability. We examine the migration patterns of young children in the first five years of life and examine the question of whether the social and residential arrangements of fathers are associated with the mobility of their children? Last, whether father-child living arrangements in the first five years of life are associated with child survival?

The main reason for focusing on fathers and young children (under 5 years) is that this age group has received little attention beyond the consequences of paternal orphanhood. An advantage of this age group for longitudinal study is also that we know that fathers were alive prior to birth and changes in the residency arrangements are more closely linked to the circumstances of their parents and caregivers rather than due to schooling. Although the focus of this paper is on children and fathers, in all descriptive and analytical results we also include information about mothers and households.

DATA

The study was conducted using data collected by the Africa Centre Demographic Information System (ACDIS), a longitudinal demographic surveillance system conducted in part of the Umkhanyakude district, northern KwaZulu-Natal, South Africa. The study population is almost exclusively Zulu-speaking. The demographic surveillance area (DSA) is typical of many rural areas of South Africa in that while predominantly rural, it contains an urban township and informal peri-urban settlements. The 438km^2 area is characterized by large variations in population densities (20–3000 people/km^2). In the rural areas, homesteads are scattered rather than grouped. Most households are multi-generational with an average size of 7.9 (SD±4.7) members. In 2006, approximately 77% of households in the surveillance area had access to piped water and toilet facilities (Case et al., 2004). Despite being a predominantly rural area, the principle source of income for most households is waged employment and state pensions.

Started in January 2000, the ACDIS population consists of approximately 89,000 members of 11,000 households in the DSA. The conceptual framework and ACDIS design have been described in detail elsewhere (Hosegood et al., 2005a; Hosegood et al., 2005b; Tanser et al., 2007). Socio-demographic data is collected twice yearly routine household surveillance visits. The ACDIS conceptual model is organized in relation to individuals (person), household (social group) and homesteads (place). All registered individuals in ACDIS must be a member of at least one household within the DSA. Upon meeting eligibility criteria, these subjects are 'registered' in ACDIS and followed-up at subsequent routine visits. During routine household visits, fieldworkers interview household informants to verify and update previously collected information and record new events and status changes. This includes updating information about changes in the number of resident households at the homestead due to dissolution or household migration; changes in household composition due to births, deaths, intra-household relationships, living arrangements and individual migration; and changes in individual characteristics (e.g. parental vital status and marital status). In addition to routine data collection, the ACDIS Household Socio-economic (HSE) surveys have been conducted annually with the exception of 2000 and 2002. The HSE surveys collect detailed information about the socio-economic characteristics of households (e.g. ownership of assets, expenditure) and household members (e.g. education attainment and employment).

The analyses presented in this paper are based on all children registered in ACDIS who at the time of their birth between 1st Jan 2000 and 30th June 2003 became resident members of a household in the surveillance area (N=5,872). The observation period in this study is five years - from birth until the 5th Birthday. The years of birth 2000-2003 were selected so that complete years of ACDIS data were available for observation period.

Forty-nine percent of the study children were female. Five percent of children were members of more than one household at birth. An additional sixty children who although resident at birth were members of more than one household at the same homestead are not included in these analyses because it was felt that arbitrarily assigning them to one household would not represent the very specific set of arrangements in which these children live.

MEASURES

Resident and non-resident household members

In ACDIS, a distinction is made between social membership of a household and physical residency at the same place (homestead) with the household (Hosegood et al., 2005b). Households are not defined in terms of residency or eating from the same pot but rather are based on respondents' own perception that they belong to a social group which has a distinct identity and a recognized head of household (Hosegood et al., 2005a). All household members are followed in ACDIS irrespective of whether the member is resident with the household (resident member) or not (non-resident member). Residency status is self-defined by household respondents but typically will be the place that they consider their primary base and where they have been, or intend to, spend the majority of nights. ACDIS allows any individual to report concurrent membership of more than one household but only residency at one homestead at any point in time.

Child-parent linkages

In ACDIS, where the biological father and mother of any individual is or has been, is a registered individual, the parent's unique ACDIS identifier is linked to that of his or her child. Child-parent record linkage is part of the routine household visit where parents can be identified readily from the household rosta. Linkages are established between individual rather than household member child-parent records. Consequently, although ACDIS does not actively seek to link children to registered parents who are only members of different households within the DSA, the information will often be available.

If a father is not identified as having been registered in ACDIS, no information is available about him with the exception of his vital status (discussed below). However, based on the ACDIS design, we are however, able to derive some indicators about him. For example, that unregistered fathers were not members of the same households as their child within the DSA.

LIVING ARRANGEMENTS AT BIRTH

In Table 1, we describe the children by their parental living arrangements. For children with multiple memberships at birth, the living arrangement represents those in the household where the child was a resident member. We use the term 'co-member' to describe parents who were members of the same household as their child (rows and columns I and II). In total, only 34% of fathers were co-members (1,260+744/5,872) compared with 97% (5,094+581/5,872) of mothers. Among parental co-members at birth we are able to use the additional information on individual and household residencies to identify resident co-members (row and column I) and non-resident co-members (row and column II). A higher proportion of co-member fathers were non-resident (37%=744/1,260+744) than co-member mothers (13%=581/5,094+581). As shown in row and column IV, only 62 mothers (1%) were not identified as registered individuals, in comparison with 3,300 fathers (56%). Given the ACDIS design, it is reasonable to assume that the parents who have not been registered were not co-members with their child in any household in the surveillance area at birth or at any subsequent time. A small proportion of mothers and fathers, 2% and 10% (row and column III) were identified as registered individuals but were not co-members at the time of birth[i]. A minority - one third of all children (32%) – were co-members at birth with both parents and only 20% were co-resident with both parents. For children where parents were both co-members at birth, the median difference between fathers' and mothers' ages was 6 years (IQR 3-10).

Characteristics of fathers at birth

Focusing on the characteristics of fathers at birth, Table 2 shows descriptive information from ACDIS routine visits and HSE survey closest in time to the child's birth (observations preceding the birth were given preference). Among registered fathers, the mean age was 37.1 years (SD 9.1), half had never been married (51%), the majority had completed primary school and 22% had matriculated (i.e. passed secondary school exams). Unemployment among fathers was high (30%). Only 5% of the children were resident in a household headed by their father at birth.

FACTORS ASSOCIATED WITH FATHER'S CO-MEMBERSHIP AT BIRTH

With only one-third of fathers of resident children belonging to the same household, we examined whether particular child, maternal and household factors are significantly associated with fathers' co-membership at birth – an outcome that represents one dimension of the social connectedness between fathers and children (Madhavan et al., 2008). We used logistic regression with an adjustment for clustering due to multiple observations per household. The Huber-White sandwich method was used to adjust the standard errors

(Williams, 2000; Wooldridge, 2002). All independent variables were examined in univariate and multivariate models. Analyses were conducted using Stata Version 10.0 (StataCorp, Texas, USA).

Table 3 shows the univariate and multivariate odds ratios and 95% confidence intervals from the logistic regression models. An odds ratio greater than 1 indicates a higher probability of father co-membership. In column 3, the number of observations in each variable level is shown, with the proportion of each level whose father was a co-member at birth in parentheses. The multivariate model suggests that fathers are significantly more likely to be co-members at birth when a child's mother has been married, is older, less educated, and not currently employed. When mothers themselves did not belong to the household, fathers were significantly more likely to be a co-member. The likelihood of fathers being a co-member was significantly higher for children living in wealthier, smaller, urban households.

CHANGES IN LIVING ARRANGEMENTS IN THE FIRST 5 YEARS OF LIFE

Changes in children's living arrangements and vital status during follow-up

In ACDIS, household membership and residency are recorded as episodic data with exact dates and identified start and end events. Household membership may be ended for several reasons including death, household dissolution, or upon the household itself migrating outside the DSA. Ongoing episodes are censored at the date of the last routine visit to the household. Thus, the episode data available in ACDIS can be used to represent membership and residency status and patterns for any time point or period. In this study, the period of observation was from birth until the child's 5th Birthday, death or end of all household membership in the DSA; whichever occurred earliest. For all 5,872 resident children, the first membership episode and first residency episode started at birth.

Within five years of their birth, nearly one in five children (18%) had been recorded as having more than one episode of household membership in the surveillance area[ii], whether concurrently or serially with different households, or rejoining the same household after a break in membership. Table 4 shows the changes in children's vital status and household membership by the end of the follow-up period. Of the 5,872 children, 76% survived to their 5th birthday, 10% were reported to have died[iii]. Fourteen percent of the children ended all household membership in the DSA before their 5th Birthday but were reported to be alive at the date the last membership ended.

ACDIS collects information about the residency episodes and migration events for all household members. At each routine household visit, information is collected about individual and household migrations. Individual out-migration refers to a situation in which the household continue to be resident but one or several household members (for example, a young mother and her child) migrated to live in a different homestead. Household migration involves all resident members migrated to a different homestead. Internal migration is defined as a change in residence between two homesteads within the surveillance area, whereas for external migration one homestead (source or destination) is located outside the area.

All the children described in this study were resident household members at birth. Forty-two percent of the children out-migrated at least once in their first 5 years (Table 4). One quarter of the children were subsequently recorded as resident in a different homestead within the surveillance area. Table 4 also shows among all children that migrated at least once during the period of follow-up, the type and destination of their first migration event. Roughly equal proportions of children internally and externally migrated. Only a minority of children (14%) migrated as part of a household migration, of these, the destination was most commonly (70%) a place within rather than outside the DSA.

Parental vital status and living arrangements during follow-up

In order to identify whether a child's parents were dead or alive at the end of follow-up we use direct and indirect observations of parental survival provided by ACDIS. For registered parents followed by ACDIS, the last known survival date and date of death can be established directly. However, ACDIS also routinely updates information about the survival status of the biological parents of each household member, regardless of whether the parent is registered or not[iv]. Table 5 describes the vital status of parents during the period from birth to the child's 5th Birthday, death or loss to follow-up whichever occurred first. Therefore, in cases where a child also died in the first 5 years, we classify the parental outcome as a death if parent died before or on the same day as the child, otherwise the parent is classified as having survived (the period from birth until the child's death). 9% of fathers and 4% of mothers were reported to have died during the children's follow-up period. In only a small number of cases we were unable to ascertain the survival status of children's parents after birth; for 1.3% of the mothers and 4.7% of the fathers).

For many young children living arrangements are dynamic involving multiple households and residencies in different homesteads over time. Complex situations often arise when parents are unmarried and belong to different households or when a parent is not the child's primary care giver. In order to describe the living arrangements of children with their parents during follow-up, we classify parents on the basis of the extent of

overlap between their own residency episodes and those of his or her child's membership of households in the surveillance area during the period of follow-up (Table 6). Parents that were resident members of the same household as their child for all or some of the period are shown in rows and columns I and II[v]. Where a parent was not identified as having been resident in the same household as his or her child, we examined the extent to which the parent and child had been co-members of households during the period (rows and columns III, IV and V). For a minority of children, fathers (10%) and mothers (37%) were always resident during the follow-up period. Less than one third of all children (29%) had both parents resident for all or some of the time that they were members of households in the DSA. Among children with registered parents, the most common arrangement was that the registered parent would be resident for part of the period.

ASSOCIATION BETWEEN FATHERS' CHARACTERISTICS AND CHILD MOBILITY

We use survival analysis methods to investigate the impact of fathers' social and residential arrangements on the migration of their children in the first five years. We defined a child migration event as the first outmigration during follow-up from the homestead at which a child was resident at birth. Analysis-time was calculated from birth until first migration, death, ending of all household membership (equivalent to loss to follow-up) or 5th Birthday whichever was earliest. Among the 5,872 children, 2,474 (42%) were reported to have had a first migration event during 19,102 person-years of follow-up. Parental variables for education, employment and marital status at birth were considered[vi]. Analayses were conducted using Cox proportional hazard models with the Breslow method for ties (Breslow, 1974). Given our focus on children and fathers all variables describing the characteristics of fathers' at birth or during follow-up were included in the univariate and multivariate models. Child, maternal and household variables at birth significant in the univariate analyses, as well as other variables previously indicated in the literature as important, were considered in the multivariate analyses. Hazard ratios and standard errors were adjusted for clustering due to multiple observations per household. Statistical significance was considered to be an alpha level of 0.05. For both the univariate and multivariate models, hazard ratios >1 indicate that a child in the category is more likely to migrate from the homestead where they were living at birth than a child in the referent category. The assumption of proportional hazards for each variable was tested by examining the scaled Schoenfeld residuals for a trend with child's age (Schoenfeld, 1982).

Tests suggested that the underlying hazard of migration in children whose fathers were or were not registered in ACDIS violated proportional hazard assumptions (global χ^2 9.39, p=0.025, 3df). Table 7 shows the Kaplan-Meier estimates for the time to first migration by father's living arrangements at birth. Stratifying by registration

of fathers was not used because information about many more covariates is available when fathers are registered. Using the same analytical approach we present separate models for children with registered and unregistered fathers.

Registered fathers and child mobility

Given our primary interest in investigating the association between child migration and changes in the co-residential status of children and their fathers, we excluded 139 children whose registered fathers who had not been a co-member with them at any time during follow-up. The variable indicating whether the child's father had died prior to the date that the child migrated or follow-up ended violated the proportional hazards assumption (global χ^2 6.68, p=0.035, 2df). Therefore, we divided the deaths of fathers into first and second observation periods and included both variables in the models. The univariate and multivariate results are shown in Table 8.

Controlling for household and maternal characteristics at birth and during follow-up, the socio-economic characteristics of fathers at birth were not significantly associated with the hazard of child migration. However, children were significantly more likely to have migrated if their fathers were recorded by ACDIS as having migrated prior to the child's first migration or end of follow-up compared with children whose fathers were not reported to have migrated between households in the surveillance area. Independently, children had a higher risk of migration is their father was co-resident only part of the time compared with children always co-resident with their father (regardless of whether this was at the same or different homesteads). There was no significant difference in child migration by fathers' vital status during follow-up. Holding fathers' attributes constant, mother's living arrangements, mobility and mortality during the follow-up period were significantly associated with child migration.

From these findings, two parental behaviours appear to independently increase the mobility of children. The first is the high mobility of parents. Children may accompany parents as they migrate. Adult migration may also trigger migration by a child at a later date (e.g. to join his or her parent) or to a different household (e.g. for caregiving). However, social separation of parents also creates an environment in which children have a high propensity for migration. Using proportional hazards models we explored the relative effects of parental migration and dual or single parent co-membership. Table 9 shows that the likelihood of a young child migrating was six times higher among children were one or both parents had migrated. Controlling for parental migration, children in single parent households with co-member mothers were also significantly more likely to migrate (hazard ratio 1.15; 95% CI 1.06-1.26).

Unregistered fathers and child mobility

We turn now to the analyses of child migration among children whose fathers were unregistered by ACDIS. In this sub-group of children, apart from the assumption that these fathers were not co-members of the household, the only paternal information available at birth or during follow-up is that of their vital status. In order to control for maternal characteristics, we also excluded 77 children whose mothers had not been a co-member at any time during follow-up. Testing the proportional hazards assumptions in this group indicated that it was necessary to stratify analysis by whether a child's mother had died before the end of each child's period of follow-up (global χ^2 7.82, p=0.02, 2df). Children whose mothers' vital status was unknown were therefore not included. Table 10 shows the results of the univariate and multivariate models (N=3,153). The hazard of child migration was not significantly different according to father's survival during follow-up. However, controlling for maternal and household factors, children whose father's vital status could not be ascertained had a statistically significantly higher risk of migrating (hazard ratio = 3.74; 95% CI = 3.13, 4.49). In the multivariate model, children whose mothers were not always resident or lived in a peri-urban or urban area had a significantly higher risk of migration.

ASSOCIATION BETWEEN FATHERS' CHARACTERISTICS AND CHILD SURVIVAL

Using analysis-time calculated from birth until death, end of all household membership or 5th Birthday whichever was earliest, 559 children died (9.5%) during 24,939 person-years of observation. Although longitudinal data is available in ACDIS to model survival time, exploration of mortality hazards during follow-up using Cox's models significantly violated proportional hazards assumptions for all variables representing changes in fathers' vital status and living arrangements over the period. Table 7 presents the Kaplan-Meier estimates for the time to death by father's living arrangements at birth. The same violation was observed with mothers' vital status and living arrangements. We tested several strategies to account for the lack of proportionality in the hazards including dividing the observation period to create periods in which the odds were proportional, stratifying the proportional hazards analyses, and constructing the model with time-dependent covariates; however, none of these approaches were able to adequately overcome the lack of proportionality in the hazards. We therefore used logistic regression models to examine whether indicators of fathers' status at birth and during follow-up are associated with the risk of child mortality controlling for maternal and household characteristics. The univariate and multivariate odds ratios of child mortality in the first five years of life were modeled using logistic regression models accounting for clustering due to multiple observations per household.

Separate analyses were conducted for children whose fathers were registered and co-members at some point during follow-up, and for fathers who not registered.

Registered fathers and child survival

Initially when we considered only parental deaths occurring before the end of each child's follow-up, we found a significantly negative association between maternal mortality and child survival in multivariate models. Maternal mortality has been shown elsewhere to significantly increase the risk of child mortality (Newell et al., 2004). Therefore, while acknowledging temporal limitations[vii], we used a parental mortality variable with a broader time period – representing parental deaths occurring between birth and end of follow-up, or in the case where a child died, within one year of the child's death. In addition, because we were interested in exploring whether child migration was independently associated with child survival and therefore included separate indicators for child and parental migrations prior to the child death or the end of follow-up.

Table 11 shows the results of univariate and multivariate models for children whose fathers were co-members of their household at some point during the first five years of life (n=2,433). No paternal or maternal characteristics at birth were associated with the risk of child survival in multivariate models. The only characteristic of father found to be significantly associated with child survival was fathers' migration prior to the child's death or the end of follow-up period (odds ratio = 0.29; 95% CI 0.18-0.47). The mobility of children was independently associated with a lower risk of mortality (odds ratio = 0.23; 95% CI 0.12-0.43). The mobility of mothers was not significantly associated with child survival after controlling for father and child migration. We sought to examine to what extent the negative association between father mobility and child survival might be due to an increase in children being lost to follow-up among mobile children. Among children with registered fathers, the proportion of children ending all household memberships prior to 5th Birthday was not significantly different between those with mobile and non-mobile fathers (chi^2 =0.7). However, there is a suggestion that the estimates for the protective effect of child mobility on child survival might be elevated somewhat by the design of ACDIS. The proportion of mobile children lost to follow-up was four times higher (25%) than among non-mobile children (chi^2 =<0.01).

Keeping fathers' characteristics constant, child survival was lower among children whose mothers who were never co-resident compared with those whose mothers were always co-resident, and whose mothers died during follow-up compared to those whose mothers were alive at the end of follow-up.

Unregistered fathers and child survival

Separate logistic regression models were also conducted to examine factors associated with child survival among children whose fathers were not registered. The only paternal indicator which we have from ACDIS for these fathers during the period of follow-up i.e. fathers vital status, was not significantly associated with child survival in univariate or multivariate models.

Discussion

Using data from the Africa Centre surveillance system in KwaZulu-Natal, South Africa, we examined the living arrangements of children and their fathers in the first five years of life. We show that a minority (34%) of the 5,872 children resident in the area were co-members of households with their fathers at the time of their birth in 2000-2003, and for only 22% was he co-resident. The findings are similar, albeit somewhat higher, than other studies estimating the prevalence of 'absent' fathers from national surveys (Posel et al., 2006). The findings are very similar to those shown for non-orphans in other studies of living arrangements of in the same population (Hill et al., 2008; Hosegood et al., 2007a). Historically researchers considering the factors contributing to the dispersal of children and parents have commonly focused on the influence of poverty or Apartheid-era state policies (Murray, 1981; Spiegel, 1986). Certainly like other poor rural communities living in former bantustan homeland areas close to urban centres of employment, the study population has very high rates of adult and child migration (Ford et al., 2005; Muhwava et al., 2009). The level of father-child household co-membership in this area may be being further exacerbated by particularly low rates of marriage and cohabitation (Hosegood et al., 2009), and Zulu cultural norms unfavourable to the social recognition of unmarried partners within the same household (Preston-Whyte et al., 1992). Most Zulu families place great value on patrilineal descent legitimized by bridewealth and marriage. The majority of young children born to unmarried parents live with their mothers, often in extended households headed by maternal kin (Preston-Whyte, 1974, 1993; Russell, 2003). Child whose mothers had ever married were significantly much more likely to be co-members of the same household with their father than children of never married mothers. However, most mother who were co-members with their child at birth had never been married (64%), and 10% were younger than 18 years. Unless unmarried parents have established their own household in the surveillance area, the child's unmarried father will be extremely unlikely to be considered as a member. Resident children born to married parents in which both fathers and mothers are co-members constitute a small and distinctive group of children whose parents are generally older, and more likely to belong to wealthier and urban households.

ACDIS provides insights into the dynamic and often highly complex social and residential arrangements of young children. Young children are extremely mobile: 42% of children were recorded as migrating at least once during the first five years of life within and outside the surveillance area. While the mobility of young children has been well-described in qualitative studies (See for example, (Jones, 1992, 1993)), few empirical studies have described the level and patterns of child migration in South Africa. We show that even amongst children who are co-members with both parents, the co-residential arrangements in the first five years of life can be

very dynamic. Of the fathers (44%) and mothers (99%) registered in ACDIS, 55% and 51% respectively were observed to have migrated at least once during the first five years of their child's life. Parental mobility, together with the high rate of parental deaths in early childhood, resulted in only a minority of young children (10% and 37%) who were always co-resident with their fathers and mothers respectively. The nuclear, co-residential family unit is far from a common arrangement for young children. Less than one in ten children were co-resident with both their father and mother at all times during their first five years of life.

Our study shows that factors related to fathers' living arrangements with children, fathers' mobility and fathers' vital status were significantly associated with early life experiences for children. The risk of child migration and child survival were significantly different between the group of children whose fathers were co-members at some period during follow-up and the group of children whose fathers were not registered in ACDIS (56%). We examined the risk factors associated with child outcomes in each group separately because of non-proportional hazards and that less information was available from ACDIS about unregistered fathers.
The mobility of children in the first five years of life was independently and positively associated with the residential status and migration of their fathers. Controlling for maternal and household factors, children whose fathers were always resident were less likely to migrate than children whose fathers were non-resident for all or part of the period. Children had an independent risk of migrating themselves if their father had been recorded by ACDIS as migrating. The independent associations between child mobility and paternal non-residency and paternal migration are important in context of rural South Africa communities with well established patterns of labour migration. Long-term labour migration can in some circumstances be a relatively stable living arrangement. One in which, after an initial migration, a child's father may remain a non-resident member for many years without further changes in residence. Alternatively, fathers may frequently migrate between different households, the reasons being associated with positive reasons such as work or improved housing, or less positively with loss of work or illness (Welega, 2006). Although the association of both parental co-residential instability and parental migration is to increase the mobility of children, we are unable to examine whether they have differential impacts on other health and wellbeing outcomes for children.

When migrating, children do not merely accompany their parents. For many children the dispersal of their fathers and mothers across different households maps out a migration 'route' for the child along which he or she may migrate independently and repeatedly. Indeed, the migration routes of their fathers will often be quite different to those of their children. Fathers may migrate frequently because of work and work-seeking, or live for periods in areas or domestic arrangements not considered appropriate for a young child.

The multivariate models suggest that among children whose fathers were co-members during follow-up, paternal death was not significantly associated with child mobility. A negative association was observed with maternal deaths during the period. Among children whose fathers were not registered, children whose fathers' vital status was not known had a significantly higher likelihood of migrating during follow-up than children whose fathers were known to survive until the end of follow-up. There are few studies of child mobility with which to compare these findings. An earlier study using data from ACDIS investigated whether parental AIDS mortality was associated with the mobility of children aged 0-17 years in 2000 and 2001 (Ford et al., 2005). The study showed that controlling for age, gender of the child and household characteristics, the death of a child's father or mother significantly increased the risk of a child migrating in the follow-up period. Younger children and children whose mothers or fathers were resident members of the children's household at the start of observations were less likely to move. However, the results of the previous study however, are not directly comparable with those presented in this paper because estimates were age adjusted rather than in children under 5 years, and for a shorter follow-up period.

Child survival

Very different levels and patterns of child mortality were observed in relation to fathers' membership, residency and survival status in the first five years of life. Using logistic regression models controlling for maternal and household factors, we found that fathers' membership and residency was associated with the risk of child mortality. Among children whose fathers were co-members, those whose fathers had never been resident had a 1.79 (95% CI 1.02,3.12) higher odds of dying than children whose fathers had been always resident in the first five years of life.

Controlling for household socio-economic status, mortality was significantly lower among children whose co-member fathers were recorded as having migrated. Migration involves a change in residence and may be more common among fathers who are starting or changing jobs, starting their own household, building a new house – all events signifying a degree of upward mobility which may be attendant with a better health status for their children. The mobility of children themselves was also significantly associated with lower mortality. We also considered, and are unable to rule out, that lower mortality among children who are mobile themselves or have mobile fathers may be an artifact due to higher loss to follow-up.

In South Africa, there is little data with which to explore the hypothesized pathways through which a fathers' physical presence may have protective effect on the health of young children over and above the protection afforded to children by his social connectedness (Richter, 2006). Data from the South African Time Use

Survey) has been used to compare the the difference in childcare tasks between men and women in the same household (Budlender et al., 2001), but does not provide information with which to compare childcare by resident and non-resident fathers, or with fathers who are not co-members. Findings from the CWSC study conducted in the Agincourt sub-district provide perhaps the most interesting body of comparative data to our own study. While the CWSC was not a population-based study but a purposeful and small selected sample, the conceptual approach used to classify the dimensions of father's social and residential arrangements were very similar to those used in ACDIS. Papers reporting findings from CWSC have examined the association between fathers social and residential presence with financial support for children (Madhavan et al., 2008) and nutritional status, measured by weight-for-height and height-for-age (Madhavan et al., 2007). In univariate analyses of data for 297 children aged 10-20 years, fathers co-residence and co-membership was not significantly associated with fathers' financial support towards the child. Bivariate analyses adjusting only for child's age, showed that compromised nutritional status in 202 children aged 0-21 years was positively associated with a history of financial support by the father. While different in size, design and statistical methods, the results of our longitudinal analysis of child survival and the findings by Madhavan and colleagues, when considered together the body of results from these rural communities strongly suggest that fathers are a playing a role in the health of their children. However, much more detailed data and analysis will be needed to elucidate exactly how.

One of the major limitations of our ability in this study to describe the pattern of father-child relationships is that 56% of all fathers were not themselves registered and linked to their child in ACDIS. Because ACDIS only follows households in one defined geographical area, any social or residential connections between the child and these fathers are undocumented. For example, we are unable to ascertain whether children share membership of households outside the area or if children were migrating to join paternal households when ending all memberships in the surveillance area. In terms of investigating how fathers influence their children's mobility and survival, the lack of information about non-resident fathers necessarily required us to crudely represent them by their lack of co-membership (or 'absence' as they might be described in other surveys) and their vital status. We clearly see that resident children whose fathers were not co-members have quite different vulnerabilities and behaviours than children with co-member fathers (i.e their significantly higher risk of migration and under-5 year mortality). However, the findings of Madhavan et al (2007) caution us against reducing fathers non-membership to a lack of connectedness or lack of material provision towards their children. Thus, in order to understand how such fathers are shaping the differential risk of their children we require new data that represents not only the characteristics of fathers outside the surveillance area but tells us

something about the nature and quality of the fathers' relationships with his child and with the other people involved in the health and wellbeing of the child.

Another issue which is not explored in the current study is the role that HIV and AIDS may play in determining living arrangements with parents or may moderate the relationship between parental and household factors and child mobility and survival. The impact of adult HIV and AIDS mortality on child outcomes (mobility), adult migration and households (composition, migration, dissolution) have been examined in previous studies (Ford et al., 2005; Hill et al., 2008; Hosegood et al., 2004). For more than a decade, HIV and AIDS illness and death have been an influence on family life in this population, and one may postulate a number of ways in which HIV and AIDS might influence the living arrangements of fathers and their children (Hosegood, 2009). However, we did not include data on paternal HIV status for several reasons. ACDIS HIV surveys started in 2003/4, towards the end of the observation period considered in this study. No information about HIV would be available for the large number of unregistered fathers, however, even among registered fathers who were eligible to participate in the survey, the extent of missing data will be high due to low contact and high refusal rates (Welz et al., 2007).

Another possible limitation of the study is the extent to which father-child pairs were under-reported in the households. Many studies have shown that cross-sectional and longitudinal surveys under-report fathers, particularly never-married, divorced and non-resident fathers (Cabrera et al., 2002). ACDIS does not seek to identify fathers who are not members of the same household and therefore, the extent of under-reporting in ACDIS will be determined by the extent to which men who are fathers of children in the household are listed on the household rosta, and whether the father-child record linkage is correctly established by the fieldworkers. Issues such as fathers refusing to acknowledge their children or do not know that they fathered a child are less likely in a household survey design. Households are visited repeatedly and its membership routinely updated with a variety of different household respondents rather than only mothers of young children. Some fathers listed as household members may have effectively separated themselves from their partners or children, however, qualitative research in the same community suggests that even in such circumstances, respondents would continue to report such men as household members for a long period afterwards (Hosegood et al., 2005a). Fieldworkers are prompted to continually check and update the father-child linkages within the household. Data validation also routinely identifies and queries possible errors in linkage, e.g. on the basis of age differences. We feel therefore confident that the ACDIS data about father co-membership and co-residency is very reliable. A potentially more problematic issue is that of reports of vital status by household informants for fathers who are not co-members. Again, studies elsewhere have shown that mothers'

knowledge about nonresident fathers may be limited. From the direct and indirect reports we were unable to identify the vital status of 5% of fathers and 1% of mothers. The percentage of fathers for whom this information was not known is surprisingly small given that that 56% of fathers were never identified as having been registered in ACDIS. The knowledge about fathers who are not part of the household may partially reflect the fact that the non co-membership by many of these fathers does not necessarily equate to a contentious relationship with the child's mother or other members of her household (e.g. following divorce or separation) (Russell, 2003) or non-involvement by fathers (Madhavan et al., 2008). Also that in rural Zululand information is widely shared about the deaths of adults with connections to the community.

Another substantial limitation of the study is that no information is available specifically about the type or level of involvement for every father from ACDIS. A question is routinely asked at each household visit about the identity of each child's primary caregiver. Information about caregivers was collected in the first round of 2005 for 4,613 of the 5,872 children included in our study. These children were aged between one and five years at the household visit. Biological fathers were reported as the primary caregiver for 5% of the children. This small percentage is not surprising in the light of strong cultural and gender norms related to the inappropriateness of men in the physical care of very young children. However, the data collected by ACDIS does not tell about whether fathers of the other 95% of children had some role in providing care nor what other types of involvement they might have. Empirical data on father involvement specifically with young children is very limited. The study by Madhavan et al (2008) and colleagues of financial support included only children aged 10-20 years. No studies have been published using data from South African population-based studies that specifically describe measures of father involvement with very young children.

South African families: Design challenges for longitudinal studies

The design of ACDIS has some considerable strengths in providing empirical population-based data for family studies in the context of highly dynamic and complex family relationships. The distinction between the social and residential connections of fathers and their children is clearly an important one. Recognition in the data collection design that children may belong to multiple households at the same time, be highly mobile, and migrate independently of adults has also been shown to be important representations of the lives of young children in this population. As have the routine updates about the vital status of fathers as well as mothers, who are not co-members of the same household as their child.

However, this study highlights a number of substantive limitations with ACDIS both in its design as a surveillance system and in the data that are currently available. We have referred earlier to the inherent problem of loss to follow-up in surveillance system designs based on eligibility for registration and follow-up through membership of households in a contiguous area. The largest gaps in the ACDIS data collection are first the absence of data about fathers who are not registered in ACDIS, and second, information about locally appropriate measures of father involvement, perhaps along the lines of the engagement, availability and responsibility dimensions suggested by Lamb et al (1987) (Lamb et al., 1987).

Roggman et al (2002) in their review 'Methodological, Measurement, and Design Issues in the Studying Fathers' suggest that to understand more about fathers and fathering, methodological approaches that are appropriate to study fathers directly and as part of a family system are needed. In addition to the measurement, methodological and conceptual issues that large surveys and population studies such as ACDIS, face in collecting data about father involvement in South Africa, researchers and participants themselves also present their own challenges for studying fathers. Madhavan et al (2008) have suggested that inadequate conceptualisation and measurement of fathers and involvement has contributed to the dominant but unsubstantiated image of South African fathers as disinterested and uninvolved. Montgomery et al (2007) have described how cultural norms, beliefs and attitudes of researchers, as well as participants, influenced the type of information collected in a study of men's involvement with families affected by HIV and AIDS in rural South Africa (Montgomery et al., 2005).

In conclusion, this study contributes empirical findings from a population-based study to the growing body of work on fathers and the role of fathers in the lives of children in South Africa. The results suggest that identifying and collecting social and health data about, or even more importantly from, fathers in South Africa presents a considerable challenge for researchers. In this population, less than one in ten children are co-resident with their fathers at all times during the first five years of live. Therefore, creative ways of collecting data about the influence and involvement of fathers occurring between as well as within households are necessary to increase understanding and strengthen efforts to support men's involvement in the lives of young children and families.

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ENDNOTES

[i] The identification of registered fathers and mothers who are not co-members at birth will have been by ACDIS later on. For example, a father might have joined his child's household although more common scenarios would be that the child became a member of his fathers' household or that the father established a new household. Compared with 568 registered fathers who were not co-members at birth, only 139 registered fathers who were not a co-member with their child at any period in the first five years of life.

[ii] ACDIS registers all households that are resident in the surveillance area. When a new individual is registered in ACDIS, specific questions and tracking activities are conducted in order to verify whether an individual has already been registered in ACDIS. Thus, ACDIS provides detailed information about the living arrangements of children and their parents in relation to any of their households within the surveillance area. However, ACDIS has little information about social or residential arrangements that individuals have with households outside the surveillance area. No information is available in ACDIS about whether the child is also considered to be a member of a household outside the DSA to which a child might also belong. For children or parents who are resident members living outside the surveillance area, information is collected about the general area in which they live.

[iii] In ACDIS, only the deaths of children who were followed-up (i.e. a member of at least one household in the DSA) will have been recorded. No routine information is collected about the vital status of former household members. Prospective survival data would be available in cases where a former household member is a biological parent of a current household member.

[iv] The indirect observations of parental status are made every six months and do not record a precise date of death. To avoid creating inconsistency with episodic data, we assigned the date of death from these parental vital status observations as the first date the parent was reported to have died rather than a point in time between two routine household visits.

[v] Parents classified as always being co-resident may have been resident together with their child in just one homestead throughout the period, resident together in several homesteads having migrated together between homesteads, or the parent may have been resident even when the child became a non-resident member for a period of time.

[vi] While the use of time-varying indicators of parental and household socio-economic characteristics was considered, considerable complexity is introduced by the large number of children with simultaneous memberships of more than one household during follow-up. Furthermore, the lack of an HSE survey in 2002 and high parental mobility meant that repeated measures were often not available during the period. We therefore examined indicators of for only the household in which the child was first resident, as well as, an indicator the child was already a member of more than one household at birth. We therefore examined indicators of for only the household in which the child was first resident, as well as, an indicator that the child was already a member of more than one household at birth. Data on parental marital status was also included only for status at birth because changes in marital status observed were relatively modest.

[vii] The limitation of representing a parent as having died if the death occurred within one year of the child's death is that temporality of association is inconsistent when independent events modeled (parental death) occurred after the date of outcome

(child's death). For none of the children who died in their 4th year did the parental death occur later than 5 years after the child was born.

__TABLES AND FIGURES __

Fathers and the living arrangements, mobility and survival of young children in rural South Africa

Hosegood, McGrath, Bland & Newell

Table 1. Parental household membership and residency status at birth for children who were resident in the DSA

	Father's Status				
Mother's Status	I Household member, resident with child	II Household member, not resident with child	III Not household member, registered by ACDIS	IV Not household member, not registered by ACDIS	V Row totals (% of mothers)
I Household member, co-resident	1,168	652	465	2,809	5,094 (86.8)
II Household member, not resident	37	46	74	424	581 (9.9)
III Not household member, registered by ACDIS	43	24	21	47	135 (2.3)
IV Not household member, not registered by ACDIS	12	22	8	20	62 (1.1)
V Row totals (% of fathers)	1,260 (21.5)	744 (12.7)	568 (9.7)	3,300 (56.2)	5,872

Table 2. Characteristics of fathers at birth for children resident in the DSA

Characteristics at birth		% or Mean	*SD*
Father's membership and residency	Father resident co-member	21.5	
	Father non-resident co-member	12.7	
	Father is not a co-member	65.9	
Household headed by father or others	Headed by father	4.5	
	Headed by mother	22.9	
	Headed by a non-parent	72.6	
Among children with father co-member at birth (n=2,004):			
Father's age at baby's birth (mean)		37.1	9.1
Father's marital status at baby's birth	Never married	51.05	
	Ever married	48.1	
	<18 years or missing data	0.9	
Father's education at baby's birth	Matriculated	22.7	
	7-11 years	35.1	
	<7 years	39.5	
	Missing data	4.4	
Father's employment status at baby's birth	Full- or part-time employed	66.1	
	Not employed	30.6	
	Missing data	3.3	

Notes:
N=5,872. Co-membership or resident co-membership by fathers refers to his membership and residency status in the household with which the child was a resident member at birth. Fathers classified as non co-members at birth include i) fathers registered by ACDIS but known not to be a co-members with their child at the time of the child's birth, and ii) fathers who are assumed to never have been registered in ACDIS given that no link with their child was recorded.

Table 3. Logistic regression models for the effects of maternal and household factors on fathers' co-membership with children resident in the DSA at birth

			Unadjusted			Adjusted		
Characteristics at birth	**Variable**	**n (%)**	**Odds Ratio**	**95% CI**	***p value***	**Odds Ratio**	**95% CI**	***p value***
Mother Characteristics								
Mother's status	Resident co-member (r)	5,094 (35.7)	1.0	-		1.0	-	
	Non-resident co-member	581 (14.3)	0.30	0.23-0.38		0.47	0.34-0.66	
	Not a co-member (registered)	135 (49.6)	1.78	1.24-2.54		3.89	2.05-7.37	
	Not co-member (not registered)	62 (54.8)	2.18	1.31-3.64	<0.01	20.40	10.48-39.71	<0.01
Birth order	1 (r)	2,402 (11.4)	1.0	-		1.0	-	
	2+	3,237 (50.4)	7.90	6.82-9.14	<0.01	2.80	2.29-3.44	<0.01
Mother's age	<20	1,366 (8.9)	0.16	0.13-0.20				
	20-24	1,606 (17.8)	0.36	0.30-0.43				
	25-29 (r)	1,217 (37.6)	1.0	-				
	30+	1,621 (68.2)	3.55	1.19-3.40	<0.01			
Mother's marital status	Never married (r)	3,815 (25.1)	1.0	-				
	Ever married	1,007 (92.5)	36.53	28.12-47.46				
	<18 years or missing data	988 (8.2)	0.27	0.21-0.34	<0.01			
Mother's age and marital status	<18 years	587 (7.3)	0.35	0.25-0.49		0.32	0.20-0.52	
	18-29_never married (r)	2,945 (18.4)	1.0	-		1.0	-	
	18-29_ever married	259 (94.6)	77.76	43.40-139.35		77.87	40.55-149.52	
	30+_never married	870 (47.9)	4.10	3.44-4.87		2.32	1.87-2.88	
	30+_ever married	748 (91.7)	49.17	36.63-65.99		33.27	23.64-46.81	
	18+_marriage data missing	401 (9.5)	0.47	0.33-0.66	<0.01	0.62	0.42-0.92	<0.01
Mother's education	<7 years	1,322 (57.0)	3.07	2.59-3.64		3.07	2.37-3.98	
	7-9	1,504 (29.0)	0.94	0.80-1.12		1.60	1.25-2.04	
	10-11 years	1,397 (21.4)	0.63	0.52-0.76		0.94	0.73-1.22	
	Mother matriculated (r)	1,425 (30.2)	1.0	-	<0.01	1.0	-	<0.01
Mother's employment status	Full- or part-time employment (r)	1,143 (39.2)	1.0	-		1.0	-	
	Not employed	4,263 (33.9)	0.80	0.69-0.92	<0.01	1.66	1.33-2.06	<0.01
Mother household head	Mother is not head (r)	5,607 (34.3)	1.0	-		1.0	-	
	Mother is head	265 (30.9)	0.86	0.64-1.15	0.31	0.13	0.08-0.23	<0.01
Household Characteristics								
Household size (adults)	1-2	940 (66.0)	4.0	3.38-4.70		4.60	3.57-5.93	
	3-5 (r)	2,424 (32.7)	1.0	-		1.0	-	
	6+	2,508 (23.6)	0.64	0.55-0.73	<0.01	0.73	0.61-0.87	<0.01
Household assets	Poorest	1,565 (31.9)	0.67	0.56-0.79		0.64	0.49-0.84	
	Second quartile	1,469 (30.2)	0.61	0.52-0.73		0.63	0.49-0.83	
	Third quartile	1,632 (34.1)	0.74	0.62-0.87		0.83	0.65-1.06	
	Wealthiest (r)	1,112 (41.3)	1.0	-	<0.01	1.0	-	<0.01
Homestead area	Rural (r)	3,798 (34.6)	1.0	-		1.0	-	
	Peri-urban	1,771 (65.4)	1.08	0.95-1.23		1.32	1.09-1.59	
	Urban	303 (65.9)	1.88	1.45-2.43	<0.01	1.36	0.94-1.96	<0.01

Notes:

N=5,872. n= number of children in each indicator level, the percentage(s) of children in each level whose father was a co-member at birth are shown in parentheses. Standard errors were adjusted for clustering owing to multiple observations per household. In all models, p values from a Wald test indicate the significance of the overall variables' contribution to the model. Models included indicators that data on mother's education, employment, birth order and household asset ownership are missing. Significant interaction was found between the age of mothers at birth and their marital status, therefore we used a variable combining age and marriage in the final multivariate model. An indicator that the mother was younger than 18 years (the minimum legal age of marriage in South Africa) was included. Homestead areas are classified as urban if lying within the municipal authority boundaries or peri-urban as having a population density of more than 400 people per km^2. Sex of child and year of birth were considered in univariate and multivariate models but were not significant (data not shown) and therefore are not included in the final multivariate model.

Table 4. Changes in children's vital status, household membership and residency between birth and their 5th Birthday

Indicator		n (%)
Child outcome before 5th birthday	Survived	4,496 (76.6)
	Died	559 (9.5)
	Ended all household memberships in DSA	817 (13.9)
Child migration before 5th birthday	Never migrated	3,398 (57.9)
	Migrated at least once	2,474 (42.1)
Among children that migrated (n=2,474):		
Destination of first out-migration	Internally within DSA	1,250 (50.5)
	Externally outside the DSA	1,182 (47.8)
	Not specified	42 (1.7)
Type of first out-migration	Individual	2,068 (83.6)
	Household	356 (14.4)
	Not specified	50 (2.0)
Number of out-migrations recorded during follow-up period	1	1,989 (33.9)
	2	414 (7.1)
	3+	71 (1.2)

Notes:
N=5,872. The indicator that a child ended all household memberships in the DSA is analogous to loss to follow-up in other cohort studies given that no further information is collected by ACDIS after that point. The 'not specified' indicator for the migration destination variable are mainly reports of a child's residency ending due to household dissolution rather the specific external or internal destination to which the child migrated. The absence of information about the destination or type of first migration events did not preclude the inclusion of the event in the analyses of child migration and child survival.

Table 5. Vital status of fathers and mothers before child's 5th Birthday

	Father's Status			
Mother's Status	I Survived	II Died	III Status unknown	IV Row totals (% of mothers)
I Survived	4,839	470	265	5,574 (94.9)
II Died	177	43	0	220 (3.8)
III Status unknown	64	5	9	78 (1.3)
IV	5,080	518	274	5,872
Row totals (% of fathers)	(86.5)	(8.8)	(4.7)	

Notes:
N=5,872. Vital status of parent represents survival over the period between child's birth and the end of follow-up (5th Birthday), child's death or end of all household memberships whichever is the earliest. Vital status is unknown where there was insufficient information available in ACDIS from direct follow-up of parent or indirectly from routine questions about parental vital status.

Table 6. Living arrangements of parents with children before child's 5th birthday

	Father's Status					
Mother's Status	I Always resident with child	II Sometimes resident with child	III Never resident, co-member	IV Never resident, never co-member Registered by ACDIS	V Never resident, never co-member Not registered by ACDIS	VI Row totals (% of mothers)
I Always resident with child	462	347	275	27	1,043	2,154 (36.7)
II Sometimes resident with child	135	771	327	100	2,061	3,394 (57.8)
III Never resident, co-member	7	31	28	8	173	247 (4.2)
IV Never resident, never co-member Registered by ACDIS	3	6	3	0	3	15 (0.3)
V Never resident, never co-member Not registered by ACDIS	6	16	16	4	20	62 (1.1)
VI Row totals (% of fathers)	613 (10.4)	1,171 (19.9)	649 (11.1)	139 (2.4)	3,300 (56.2)	5,872

Notes:
N=5,872. Parental co-membership and co-residency represents the extent to which parental episodes overlap with children's membership episodes in the follow-up period. For example, a mother classified as 'always resident' will have at all times been a resident member of a household in which the child was a member during the period between birth and the end of follow-up for the child (5th Birthday, child's death or end of all household memberships whichever was the earliest).

Table 7. Kaplan-Meier estimates for first child migration and child mortality by fathers' living arrangements at birth and year of follow-up

	Child migration					Child mortality				
Fathers' living arrangements during period	Period (yrs)	No. of children starting period	No. of children migrating during period	Survivor Function	95% CI	Period (yrs)	No. of children starting period	No. of children dying during period	Survivor Function	95% CI
Co-member, co-resident	1	1061	117	0.90	0.88-0.92	1	1149	63	0.95	0.94-0.96
	2	905	124	0.79	0.77-0.82	2	1077	23	0.93	0.91-0.94
	3	806	85	0.72	0.69-0.74	3	1036	7	0.92	0.91-0.94
	4	743	46	0.68	0.65-0.70	4	999	4	0.92	0.90-0.93
	5	672	53	0.63	0.60-0.66	5	945	4	0.92	0.90-0.93
Co-member, non-resident	1	647	57	0.92	0.90-0.94	1	698	37	0.95	0.93-0.96
	2	568	70	0.82	0.79-0.85	2	669	10	0.94	0.92-0.95
	3	507	51	0.75	0.71-0.78	3	644	3	0.93	0.91-0.95
	4	469	30	0.70	0.67-0.73	4	628	1	0.93	0.91-0.95
	5	430	30	0.66	0.62-0.69	5	604	1	0.93	0.91-0.95
Not co-member, registered by ACDIS	1	404	142	0.74	0.70-0.78	1	541	20	0.96	0.95-0.98
	2	261	137	0.49	0.44-0.53	2	527	8	0.95	0.93-0.97
	3	180	79	0.34	0.30-0.38	3	516	2	0.95	0.92-0.96
	4	137	41	0.26	0.22-0.30	4	507	4	0.94	0.92-0.96
	5	103	33	0.20	0.16-0.23	5	497	0	0.94	0.92-0.96
Not co-member, not registered by ACDIS	1	2603	426	0.86	0.85-0.87	1	2934	248	0.92	0.91-0.93
	2	2104	422	0.72	0.70-0.74	2	2751	74	0.90	0.89-0.91
	3	1841	227	0.64	0.62-0.66	3	2616	28	0.89	0.88-0.90
	4	1653	175	0.58	0.56-0.60	4	2540	13	0.89	0.88-0.90
	5	1497	129	0.53	0.52-0.55	5	2450	9	0.88	0.87-0.89

Table 8. Proportional hazards models for the factors associated with the migration between birth and their 5th Birthday among children whose father was a household co-member at some time during follow-up

Characteristics at birth	Variable	n (% migrated)	Unadjusted			Adjusted		
			Hazard Ratio	95% CI	p value	Odds Ratio	95% CI	p value
Father's characteristics at birth								
Father's age	<20	58 (70.69)	2.22	1.61-3.06		1.03	0.66-1.62	
	20-29	583 (65.35)	2.10	1.82-2.42		1.03	0.86-1.23	
	30-39 (r)	1,034 (40.43)	1.0	-		1.0	-	
	40+	758 (26.12)	0.57	0.48-0.69	<0.01	1.04	0.87-1.25	0.97
Father's marital status	Never married (r)	1,380 (52.83)	1.0	-		1.0	-	
	Ever married	1,011 (27.99)	0.41	0.36-0.48		1.18	0.92-1.5	
	<18 years[a] or missing data	42 (61.90)	1.26	0.85-1.84	<0.01	0.90	0.56-1.45	0.38
Father's education	<7 years	867 (31.95)	0.55	0.47-0.66		0.89	0.73-1.09	
	7-9	491 (42.77)	0.81	0.67-0.97		1.09	0.89-1.32	
	10-11 years	394 (50.51)	1.03	0.86-1.25		1.21	1.01-1.46	
	Matriculated (r)	587 (50.09)	1.0	-	<0.01	1.0	-	<0.05
Father's employment status	Full- or part-time employment (r)	1,558 (40.95)	1.0	-		1.0	-	
	Not employed	767 (43.81)	1.07	0.93-1.23	<0.01	0.94	0.79-1.05	0.45
Father household head	Father was not head (r)	1,088 (61.03)	1.0	-		1.0	-	
	Father was head	1,345 (27.81)	0.36	0.31-0.41	<0.01	0.85	0.73-1.0	<0.05
Father's characteristics during follow-up								
Father's mobility	Did not migrate (r)	1,021 (28.01)	1.0	-		1.0	-	
	Migrated	1,412 (53.26)	2.05	1.77-2.36	<0.01	1.46	1.22-1.74	<0.01
Father's living arrangements	Always resident (r)	613 (16.64)	1.0	-		1.0	-	
	Sometimes resident, co-member	1,171 (57.30)	4.30	3.45-5.37		1.36	1.03-1.81	
	Never resident, co-member	649 (40.83)	2.70	2.12-3.45	<0.01	0.96	0.71-1.31	<0.01
Father's vital status	Survived first period of follow-up (r)	2,266 (42.06)	1.0	-		1.0	-	
	Died during first period	147 (48.30)	1.13	0.90-1.44		1.19	0.93-1.53	0.23
	Survived second period of follow-up (r)	2,348 (42.38)	1.0	-		1.0	-	
	Died during second period	65 (44.62)	0.93	0.65-1.34	<0.01	0.94	0.67-1.31	0.72
Mother's characteristics at birth								
Mother's age and marital status	<18 years	102 (78.43)	1.20	0.94-1.53		0.97	0.73-1.29	
	18-24_never married (r)	442 (66.29)	1.0	-		1.0	-	
	18-24_ever married	62 (43.55)	0.50	0.33-0.74		0.66	0.43-1.02	
	25+_never married	826 (43.95)	0.51	0.43-0.27		0.88	0.72-1.07	
	25+_ever married	890 (23.15)	0.22	0.18-0.27	<0.01	0.58	0.43-0.80	<0.01
Mother's education	<7 years	836 (32.18)	0.60	0.50-0.73		0.87	0.71-1.07	
	7-9	565 (45.31)	0.97	0.81-1.17		1.03	0.84-1.25	
	10-11 years	413 (52.06)	1.16	0.96-1.40		1.06	0.87-1.28	
	Matriculated (r)	520 (47.12)	1.0	-	<0.01	1.0	-	<0.01
Mother's employment	Full- or part-time employment (r)	520 (39.23)	1.0	-		1.0	-	
	Not employed	1,772 (42.49)	2.84	2.13-3.79	<0.01	0.84	0.71-0.99	0.08

Mother's characteristics during follow-up								
Mother's vital status	Survived (r)	2,305 (41.52)	1.0	-		1.0	-	
	Died	73 (50.63)	1.22	0.88-1.69	<0.01	0.69	0.49-0.98	<0.05
Mother's living arrangements	Always resident (r)	1,084 (7.38)	1.0	-		1.0	-	
	Sometimes resident, co-member	1,233 (73.48)	16.90	13.38-21.36		12.45	9.67-16.02	
	Never resident, co-member	66 (51.52)	12.38	8.06-19.0		6.79	4.08-11.30	
	Not a co-member: mother registered	12 (16.67)	2.65	0.63-11.25		1.27	0.34-4.78	
	Not a co-member: mother not registered	38 (42.11)	7.19	4.28-12.07	<0.01	3.86	2.17-6.88	<0.01

Notes:
N=2,433. n= number of children in each indicator level, the percentage(s) of children in each level recorded as having a first migration event are shown in parentheses. Standard errors were adjusted for clustering owing to multiple observations per household. In all models, p values from a Wald test indicate the significance of the overall variables' contribution to the model. Models included indicators that data on mother's education, employment, marital status, parental vital status are missing. Significant interaction was found between the age of mothers at birth and their marital status, therefore we used a variable combining age and marriage in the final multivariate model. An indicator that the mother was younger than 18 years (the minimum legal age of marriage in South Africa) was included. Homestead areas are classified as urban if lying within the municipal authority boundaries or peri-urban as having a population density of more than 400 people per km^2. Sex of child, year of birth, mother's mobility, household size (all members), household size (adults), household asset ownership, homestead area were considered in univariate and multivariate models but were not significant (data not shown) and therefore are not included in the final multivariate model. Univariate and multivariate models are stratified by an indicator representing whether mothers had been recorded by ACDIS as migrating during follow-up.

Table 9. Proportional hazards models testing the effect of dual parental co-membership and parental migration on the migration of children between birth and 5th Birthday

Characteristics	Variable	n (migrated)	Model 1			Model 2			Model 3		
			Hazard ratio	95% CI	p value	Hazard ratio	95% CI	p value	Hazard ratio	95% CI	p value
Parental membership status at birth	Both parents co-mbrs(r)	2,333 (42.43)	1.0	-					1.0	-	
	Mother only co-mbr	3,368 (41.54)	1.03	0.94-1.12	0.07				1.15	1.06-1.26	<0.01
Parental migration	No parent migrated	2,095 (12.60)				1.0	-		1.0	-	
	Parent migration	3,606 (58.93)				5.64	1.06-1.26	<0.01	5.71	4.99-6.53	<0.01

Notes:
N=5,701. n= number of children in each indicator level, the percentage(s) of children in each level recorded as having a first migration event are shown in parentheses. Standard errors were adjusted for clustering owing to multiple observations per household. In all models, p values from a Wald test indicate the significance of the overall variables' contribution to the model. The multivariate model included variables for household asset ownership and homestead area. All other paternal and maternal characteristics at birth and during follow-up, and household size were considered in univariate and multivariate models but were not significant (data not shown) and therefore are not included in the final multivariate model. Mother and father mortality were not included because tests for proportional hazards assumptions were violated.

Table 10. Proportional hazards models for the factors associated with the migration between birth and their 5th Birthday among children whose fathers were not registered in ACDIS

			Unadjusted			Adjusted		
Characteristics	**Variable**	**n (% migrated)**	**Hazard Ratio**	**95% CI**	**p value**	**Odds Ratio**	**95% CI**	**p value**
Father's characteristics during follow-up								
Father's vital status	Survived (r)	2,651 (39.80)	1.0	-	<0.01	1.0	-	
	Died	279 (38.71)	0.85	0.70-1.04		0.83	0.68-1.02	
	Father vital status unknown	223 (57.40)	3.72	3.10-4.48		3.74	3.13-4.49	<0.01
Mother's characteristics at birth								
Mother's age_marital status	<18 years	457 (43.33)	1.06	0.90-1.25		0.92	0.77-1.10	
	18-24_never married (r)	1,377 (40.74)	1.0	-		1.0	-	
	18-24_ever married	2 (50.0)	1.08	0.18-6.34		1.72	0.87-3.42	
	25+_never married	46 (39.90)	0.99	0.88-1.14		1.02	8.94-1.17	
	25+_ever married	46 (39.96)	0.97	0.58-1.62	0.96	1.16	0.70-1.92	0.49
Mother's education	<7 years	460 (44.57)	1.34	1.11-1.60		1.44	1.20-1.74	
	7-9	887 (44.76)	1.28	1.100-1.50		1.44	1.23-1.70	
	10-11 years	950 (38.32)	0.99	0.84-1.15		1.06	0.90-1.23	
	Matriculated (r)	856 (37.97)	1.0	-	<0.01	1.0	-	<0.01
Mother's characteristics during follow-up								
Mother's living arrangements	Always resident (r)	997 (15.85)	1.0	-		1.0	-	
	Sometimes resident, co-member	1,993 (53.09)	4.23	3.56-5.02		4.53	3.82-5.38	
	Never resident, co-member	163 (46.01)	4.52	3.41-5.99		4.9	3.68-6.54	
					<0.01			<0.01
Household characteristics at birth								
Homestead area	Rural (r)	2,088 (39.75)	1.0	-		1.0	-	
	Peri-urban	932 (43.13)	1.13	0.99-1.28		1.26	1.11-1.42	
	Urban	133 (44.36)	1.25	0.93-1.68	0.08	1.47	1.09-1.97	<0.01

Notes:
N=3,153. n= number of children in each indicator level, the percentage(s) of children in each level recorded as having a first migration event are shown in parentheses. Standard errors were adjusted for clustering owing to multiple observations per household. The model excluded children for whom information was missing about household asset ownership, maternal vital status, and maternal education. In all models, p values from a Wald test indicate the significance of the overall variables' contribution to the model. Models included indicators that data on mother's marital status was missing. Sex of child, year of birth, mother's employment status at birth, maternal vital status, household size (all members), household size (adults), and household asset ownership, were considered in univariate and multivariate models but were not significant (data not shown) and therefore are not included in the final multivariate model.

Table 11. Logistic regression models for the effects of paternal factors on child survival before 5th Birthday among children whose father was a household co-member at some time during follow-up.

			Unadjusted			Adjusted		
Characteristics at birth	**Variable**	**n (% died)**	**Odds Ratio**	**95% CI**	**p value**	**Odds Ratio**	**95% CI**	**p value**
Father's characteristics at birth								
Father's age	<20	58 (6.90)	1.04	0.36-2.96		2.08	0.35-12.40	
	20-29	583 (7.38)	1.11	0.74-1.67		1.37	0.77-2.45	
	30-39 (r)	1,034 (6.67)	1.0	-		1.0	-	
	40+	758 (6.46)	0.97	0.65-1.43	0.93	0.83	0.54-1.30	0.47
Father's marital status	Never married (r)	1,380 (7.39)	1.0	-		1.0	-	
	Ever married	1,011 (5.93)	0.79	0.56-1.12		0.73	0.48-1.10	
	<18 years[a] or missing data	42 (7.14)	0.96	0.29-3.17	0.41	1.18	0.20-6.94	0.31
Father's education	<7 years	867 (7.50)	1.41	0.90-2.19		1.09	0.63-1.89	
	7-9	491 (6.31)	1.17	0.68-2.01		1.05	0.57-1.93	
	10-11 years	394 (7.11)	1.33	0.77-2.29		1.23	0.67-2.25	
	Matriculated (r)	587 (5.45)	1.0	-	0.46	1.0	-	0.86
Father's employment status	Full- or part-time employment (r)	1,558 (6.55)	1.0	-		1.0	-	
	Not employed	767 (6.91)	1.06	0.74-1.51	0.56	1.01	0.66-1.53	0.74
Father household head	Father was not head (r)	1,088 (6.25)	1.0	-		1.0	-	
	Father was head	1,345 (7.21)	1.17	0.84-1.62	0.36	0.84	0.52-1.35	0.47
Father's characteristics during follow-up								
Father's mobility	Did not migrate (r)	1,021 (11.26)	1.0	-		1.0	-	
	Migrated	1,412 (3.54)	0.29	0.20-0.41	<0.01	0.29	0.18-0.47	<0.01
Father's living arrangements	Always resident (r)	613 (11.26)	1.0	-		1.0	-	
	Sometimes resident, co-member	1,171 (3.76)	0.31	0.21-0.46		0.76	0.44-1.31	
	Never resident, co-member	649 (8.01)	0.69	0.46-1.02	<0.01	1.79	1.02-3.12	<0.01
Father's vital status	Father survived (r)	2,148 (6.94)	1.0	-		1.0	-	
	Father died before or within 1 year of child	265 (5.28)	0.75	0.43-1.32		0.72	0.39-1.34	
	Father status is unknown	20 (10)	1.19	0.34-6.49	0.51	2.32	0.33-16.24	0.40
Mother's characteristics during follow-up								
Mother's vital status	Mother survived (r)	2,271 (6.34)	1.0	-		1.0	-	
	Mother died	107 (16.82)	2.99	1.74-5.14		2.74	1.46-5.17	
	Mother status is unknown	55 (5.45)	0.85	0.85-2.77	<0.01	1.31	0.37-4.67	<0.01
Mother's living arrangements	Always resident (r)	1,084 (7.84)	1.0	-		1.0	-	
	Sometimes resident, co-member	1,233 (5.03)	0.62	0.44-0.89		1.59	0.95-2.66	
	Never resident, co-member	66 (18.18)	2.61	1.35-5.06		5.37	2.17-13.42	
	Not a co-member: mother registered	12 (16.67)	2.35	0.51-10.91	<0.01	1.22	0.21-7.05	<0.01
Mother's mobility	Did not migrate (r)	1,338 (9.79)	1.0	-		1.0	-	
	Migrated	1,057 (2.84)	0.27	0.18-0.41	<0.01	0.53	0.28-1.01	0.05
Child's mobility	Did not migrate (r)	1,395 (10.25)	1.0	-		1.0	-	
	Migrated	1,038 (2.12)	0.19	0.12-0.30	<0.01	0.23	0.12-0.43	<0.01
Household assets	Poorest	638 (6.11)	1.16	0.68-1.98		1.55	0.83-2.93	
	Second quartile	565 (9.03)	1.77	1.07-2.92	0.08	2.06	1.15-3.67	0.14

Third quartile	653 (6.28)	1.19	0.71-2.0		1.31	0.76-2.27
Wealthiest (r)	527 (5.31)	1.0	-		1.0	-

Notes:
N=2,433. n= number of children in each indicator level, the percentage(s) of children in each level recorded as having died are shown in parentheses. Standard errors were adjusted for clustering owing to multiple observations per household. In all models, p values from a Wald test indicate the significance of the overall variables' contribution to the model. Models included indicators that data on father's marital status, education status at birth, employment status at birth, household asset ownership were missing. The multivariate model included variables fro mother's age at birth and household asset ownership even though both were not significant in the final model because of previous literature showing that maternal age and economic status is associated elsewhere with child survival. Sex of child, year of birth, mother's employment status at birth, mother's education status at birth, household size (all members), household size (adults), and homestead area were considered in univariate and multivariate models but were not significant (data not shown) and therefore are not included in the final multivariate model. The parental vital status variables included in this model represent whether the father or mother died between birth and end of follow-up, or in the case where a child died, within one year of the child's death.