Population Studies, Vol. 64, No. 3, 2010, pp. 229–246

Prenatal development in rural South Africa: Relationship between birth weight and access to fathers and grandparents

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Birth weight is an indicator of prenatal development associated with health in infancy and childhood, and may be affected by the family environment experienced by the mother during pregnancy. Using data from KwaZulu-Natal, South Africa, we explore the importance of the mother's access to the father and grandparents of the child during pregnancy. Controlling for household socio-economic indicators and maternal characteristics, the survival and residence of the biological father with the mother are positively associated with birth weight. The type of relationship seems to matter: married women have the heaviest newborns, but co-residence with a non-marital partner is also associated with higher birth weight. Access to the maternal grandmother may also be important: women whose mothers are alive have heavier newborns, but no additional benefit is observed from residing together. Co-residence with any grandparent is not associated with birth weight after controlling for the mother's partnership.

Keywords: birth weight; child health; family; grandmother; father; partnership; South Africa

[Submitted August 2008; Final version accepted June 2010]

Introduction

Weight at birth is an indicator of foetal health and subsequent survival, development, and health (Hack et al. 1994; Barker 1995; Solis et al. 2000; Behrman and Rosenzweig 2004; Evensen et al. 2004). The family environment can be an important source of support during pregnancy, and this support may improve maternal health and nutrition and consequently also affect birth weight. Studies from the USA and Europe have shown that birth weight is positively associated with the mother's social support, including her marital status and her access to the child's father (Miller 1991; Manderbacka et al. 1992; Reichman and Pagnini 1997; Bird et al. 2000; Dunkel-Schetter 2000; Feldman et al. 2000). The contribution of the study we report here was to explore the importance of the family environment for birth weight in a less developed country. Using data from a longitudinal, population-based data-set in KwaZulu-Natal province, South Africa, we examined the possible impact on birth weight of access to the child's biological father or other partner of the mother, and to grandparents, especially the mother's mother. There is evidence that family and household structure are important for several aspects of child well-being in less developed countries. For example, studies have shown that children who do not live with both parents (Engle and Breaux 1998; Morrell et al. 2003; Richter 2006) or whose parents are deceased (Bishal et al. 2003; Case et al. 2004; Newell et al. 2004; Case and Ardington 2006; Evans and Miguel 2007) have worse outcomes in terms of survival, growth, education, and psychological well-being. There is also evidence that the presence of maternal grandmothers improves child growth and survival (Sear et al. 2000; Duflo 2003).

The family environment may be particularly important to consider in South Africa, where multi-generational households are common, rates

ISSN 0032-4728 print/ISSN 1477-4747 online
DOI: 10.1080/00324728.2010.510201

of marriage are low, and where the social and residential arrangements are a legacy of the labour migration system created during the apartheid era (Preston-Whyte 1993; Niehaus 1994; Russell 2003; Montgomery et al. 2006; Ramphele and Richter 2006; Wilson 2006). In South Africa, only 37 per cent of children lived with both biological parents in 2005 (Budlender 2006), and in the population described here, 15 and 51 per cent of children under 18 years old were not members of the same household as their mother and father respectively (Hill et al. 2008).

We focused on birth weight as a direct measure of prenatal development because it is an indicator both of intrauterine nutrition and growth and of duration of gestation. Unlike mortality, which is the more commonly studied indicator of child health, birth weight, because it is a continuous variable, permits more nuanced analyses of family support and child health.

Social support, family environment, and health at birth

Social support comprises the resources acquired through social contacts to meet both routine and extraordinary needs (Lin and Ensel 1989). It is widely believed to be an important component of mental, social, and physical well-being. Social support may affect health directly, mediate the effects of life events on health, or it may buffer the consequences of negative events (Lin and Ensel 1989). One of the most important institutions within which supportive exchanges occur is the family (Astone et al. 1999).

Studies conducted in the USA and Europe have shown that social support is associated with better child health at birth. These studies highlight the importance of social networks and perceived support from a male partner and to a lesser extent perceived support from family members (Ramsey et al. 1986; Pagel et al. 1990; Mutale et al. 1991; Dunkel-Schetter et al. 2000). Women with multiple sources of support from their family, the child's father, or a social network give birth to heavier babies, with these relationships being as predictive as medically defined obstetric risk factors (Feldman et al. 2000). Social support has been generally shown to be associated with birth weight in the process of foetal growth (Feldman et al. 2000). Thus family support may be of greater benefit in resource-poor settings, where mothers are more likely to be exposed to nutritional insufficiencies that can restrict foetal growth.

Grandparents and child health

A number of studies have examined the importance of grandparents for child survival. In historical Germany and Québéc, infants aged 6–12 months and toddlers whose maternal grandmothers were still alive were more likely to survive, especially if the grandmother lived close by (Voland and Beise 2002; Beise 2005). Among present-day Khasi in North-east India, children whose maternal grandmothers were alive but not co-resident with them had lower chances of dying before the age of 10 than were children with deceased grandmothers (Leonetti et al. 2005). A study in Gambia found that children past infancy who had living maternal grandmothers had significantly lower mortality than those whose maternal grandmothers had died, though co-residence did not increase the benefits (Sear et al. 2002). A recent review of the literature reports that, among 11 statistically valid studies examining the effects of the maternal grandmother on child survival, seven found positive associations, one found negative associations, and three found no associations (Sear and Mace 2008). Most of the statistically valid studies also found positive effects of paternal grandmothers (9 of 15), but among studies estimating the effects of grandfathers, the largest number found no effect for maternal (8 out of 10) or paternal (5 out of 10) grandfathers (Sear and Mace 2008).

Children's health may benefit in other respects from grandparental care. In Gambia, the survival of the maternal grandmother was associated with better nutritional status in early childhood, measured by weight and height, but only if the maternal grandmother was not herself reproductively active (Sear et al. 2000). In KwaZulu-Natal, South Africa, in a population near the one featured in our study, height and weight increased more in children living with grandmothers (but not grandfathers) eligible for the State old-age pension than in children living with ineligible grandmothers, though effects were significant only for granddaughters and not for grandsons (Duflo 2003). Qualitative research from our study population in KwaZulu-Natal found that young mothers sought parenting help from their mothers and grandmothers, though the guidance they received from family with respect to infant feeding was often incompatible with recommended practices (Thairu et al. 2005).

There are reasons to expect that grandparents, and especially grandmothers, may also influence prenatal development. A grandmother may be able to improve prenatal health through financial support

(for example, purchasing more food and more nutritious food or paying for transportation or medical expenses), reducing the mother's workload (for example, caring for her other children, cooking, cleaning, or fetching water), or recognizing health complications. Only one study, from a historical population in Quebec, explored the effect of grandmaternal involvement on prenatal health (Beise 2005). It found that the involvement of grandmothers (maternal and paternal) was associated with survival during the first month of life. Assuming that mortality in that month is primarily determined by prenatal health, this may be evidence that grandmothers improved maternal health during pregnancy, consequently lowering the chances of neonatal mortality. The involvement of grandmothers can be expected to be especially important in a setting like KwaZulu-Natal, where female family networks are among the most stable sources of support (Preston-Whyte 1978).

Men's involvement and child health—Fathers and partners

Another potentially important source of support for the mother is the child's own father. Several studies have examined the importance of fathers for child well-being. The studies focused on child mortality report mixed evidence for paternal support. Fathers were associated with lower under-5 mortality in historical Québéc (Beise 2005) and lower under-10 mortality in modern-day India (Leonetti et al. 2005). A review of the literature reports that of the 15 statistically valid studies examining the effect of fathers on child survival, 7 found positive associations, 1 a negative association, and 8 found no associations (Sear and Mace 2008).

In South Africa, access to fathers has been shown to be beneficial in other domains, such as education and emotional well-being (Johnson 1996; Engle and Breaux 1998; Mboya and Nesengani 1999; Morrell et al. 2003; Richter 2006). Drawing on ethnographic research in our study area, Montgomery et al. (2006) described men's positive involvement in households affected by HIV and AIDS, including caring for children, providing financial support, and participating in household maintenance.

There is some evidence from Europe and the USA that a mother's access to the child's father, or more generally a partner, is associated with higher birth weight. The children of married parents tend to be heavier at birth (Miller 1991; Manderbacka et al. 1992; Reichman and Pagnini 1997). However, being unmarried is not necessarily either detrimental or a marker for risk: the newborns of mothers in long-term non-marital relationships have often been found to be at no greater risk of low birth weight than the newborns of married women (Manderbacka et al. 1992). On the other hand, it is not known to what extent findings from the USA and Europe are applicable in a setting like South Africa, given the differences in household and partnering arrangements. There is evidence from qualitative studies in South Africa that men's contributions are limited by economic circumstances and class divisions, with men who are unemployed, struggling to raise bride-wealth money, or of lower standing in the community, facing both financial constraints and obstacles from family and community in their attempts to contribute to their children's care (Mkhize 2006).

There is some debate, both in the African and Western literature, about whether the term 'father' should be restricted to a child's biological father, or should include other men acting as fathers, such as the mother's partner or other relatives and described in the literature as 'social fathers' (Engle and Breaux 1998; Morrell et al. 2003; Richter 2006). However, there has been little research on the involvement of social fathers, or on the effect of their involvement in child health in less developed countries (Hosegood and Madhavan 2010). In rural KwaZulu-Natal, where marriage rates are low and a large proportion of young married couples do not reside together (Hosegood et al. 2009), the mother's marital status may not be an adequate indicator of her partnership status, nor be an appropriate substitute for the support she might expect from a male partner. A study of the Xhosa population in South Africa found that resident biological fathers contributed the most to children in terms of time and money, but that, by some measures, resident stepfathers were more involved than non-resident biological fathers (Anderson et al. 1999).

Study setting

The study population comprised approximately 90,000 members of 11,000 households residing in northern KwaZulu-Natal, South Africa (Tanser et al. 2007). The area includes within its boundaries a township, rapidly expanding settlements around the township, major roads, and rural areas. Most of the people living in the study area are Zulu speakers (Hall 1984; Monteiro-Ferreira 2005).

Zulu-speaking communities have traditionally placed an 'extreme emphasis on patrilineal principle' (Hammond-Tooke 2008) with the wife moving into the husband's homestead after the payment of bride-wealth but living in her own hut there with her children (Laband 1997) Thus, new mothers were largely isolated from natal kin and social contacts, while not being fully integrated with the husband's kin (Ngubane 1976). While this way of life still exists, family-formation patterns have been changing (Russell 2003). Declines in marriage have been noted since the mid-twentieth century (Gluckman 1950), together with the rise of female-linked families from which men are not absent but in which the enduring and important social ties are between the women (Preston-Whyte 1978). In 2001, less than a quarter of adults aged 18–59 years in our study population were married, and among couples one-third lived apart (Hosegood et al. 2009). Marriage rates are exceptionally low and have continued to decline in KwaZulu-Natal and South Africa as a whole, as a result, at least in part, of the history of apartheid-era economic, political, and social policies, together with continuing labour migration and limited employment opportunities (Preston-Whyte 1993).

Owing to high unemployment, estimated at 22 per cent in 2001 (Case and Ardington 2004), and as a legacy of apartheid, labour migration was common, with almost 40 per cent of adult men and women residing outside the study area but still maintaining membership in households there (Hosegood et al. 2004). Though the average household had almost nine members, only about six were in residence at the same time. Family members still provided support for each other, with remittances being among the most important source of income (Tanser et al. 2000) and children receiving care and resources from a number of relatives (Hill et al. 2008).

In the early 2000s, most households with children were headed by an adult aged 18–59 (70 per cent) and about 40 per cent of children lived in a household headed by a parent, usually the father (32 per cent) (Hill et al. 2008). Because of low marriage rates, union instability, and traditions of collective childrearing, only about 27 per cent of children with two surviving parents resided with both parents (Hosegood et al. 2009). A third of children lived in a household headed by a grandparent, with almost half of these headed by a grandmother. Both fathers and grandmothers were important sources of support for children. Among children aged under 18 years, 18 per cent received their day-to-day care from a grandmother. While the father was not likely to be reported as the primary care provider, fathers did provide for other needs, such as school fees; fathers paid school fees for 47 per cent and grandmothers for 8 per cent of school children (Hill et al. 2008).

Familes are affected by the very severe HIV epidemic. HIV prevalence in the study area was 27 per cent among women aged 15–49 years, and 14 per cent among men aged 15–54 in 2003/2004 (Welz et al. 2007). Twenty-one per cent of households experienced at least one adult death between January 2000 and October 2002 (Hosegood et al. 2004) and many households experienced multiple AIDS deaths (Hosegood et al. 2007). Adult mortality adversely affects household resources in this population, not only through lost income but also through the increased expenditures imposed by illness and funerals (Case et al. 2008).

Access to drinking water, sanitation, and electricity varied considerably across the study area. In 2001, half of the households had electricity and 13 per cent had access to piped water (Muhwava 2008). Although the area is largely rural, most households depended on wage income and State grants (Case and Ardington 2004). In 2001, the population was served by one hospital, 11 fixed clinics, and 31 mobile clinics, all offering family planning, antenatal care, and child immunization (Tanser et al. 2001). Almost half the mothers in this study (44 per cent) reported at least one antenatal care visit. Neonatal mortality among children born in 2000–02 was 43 per 1,000.

Data and methods

Data

We used data from the Africa Centre Demographic Information System (ACDIS), maintained by the Africa Centre for Health & Population Studies (http://www.africacentre.ac.za/). ACDIS has been described elsewhere (Hosegood and Timaeus 2005; Tanser et al. 2007). During bi-annual visits, detailed demographic and health data are collected on all resident and non-resident members of households in the Umkhanyakude district of KwaZulu-Natal. Household membership is distinguished from residence in the homestead. In this report, when we refer to household and homestead we are referring to the household (group of individuals) and homestead (compound) with which an individual was most closely associated by membership and residence at the time of the child's birth.

At each household visit, information is collected about all current and recently ended pregnancies. For live births, information about birth weight and other health indicators is recorded from the clinic Road-to-Health card if available or from recall by a parent or a care-giver.

Our sample consisted of 3,993 children born between 2000 and 2003. The following were excluded: (i) multiple births, which have different patterns of birth weight (Garite et al. 2004), (ii) children whose mothers were not resident in the study area at the time of the birth, because no information about family and household exposures at their residence outside the surveillance area was available from ACDIS, and (iii) children for whom valid information on birth weight was not available. Our sample represented about half of all births to resident women during the period. Information on birth weight was missing for 4,404 births, including 148 cases of biologically impossible birth weights that were re-coded to 'missing'. An examination of potential selection bias showed that children from the wealthiest households, those who would survive infancy, and those whose mothers were younger or married were more likely to be included. The main reasons for birth weight not being available is that the information was not recorded on the health card, the card was not available, or the informant did not know the birth weight. This was often the case if the mother did not deliver with an attendant or did not take the newborn to a clinic soon after the birth. We found that the likelihood of birth weight being recorded was associated with the proximity of a clinic or hospital and the mother's use of antenatal care. Sensitivity analyses showed that the results were robust to different specifications and to estimation with a selection correction. Additionally, the observed distribution of birth weights is similar to that reported by a clinic-based study with more complete data from the same population (Rollins et al. 2007).

Measuring access to family support

The first time a child or adult is registered by ACDIS, information is collected on his or her biological parents, including their survival status, household membership and residency, and whether the parent has also been registered in ACDIS. Where parents are members of the same household as their child, their ACDIS records are linked together. Parents' survival status is also recorded for each child at routine visits. Thus even though only 30 per cent of births were linked to a father registered in ACDIS and 60 per cent to a maternal grandmother, information on father's and grandmother's survival and co-residence with the child's mother was available for most children.

Using the above information, we classified the status of fathers, maternal grandmothers, and mother's partners as follows: 'co-resident' if he or she was a resident of the same homestead as the mother at the interview round closest to the child's birth; 'residing elsewhere' if he or she was alive but not identified with the same homestead as the mother; and as 'deceased' if his or her death had been directly or indirectly reported in ACDIS. In addition, we combined information on the mother's partnership status (married, no partner, etc.) with the partner's (if applicable) household and homestead information. Thus, for non-marital partners, we distinguished between those who were members of the same household and, presumably, subject to the obligations and transactions entailed in membership, and those who were also co-resident and thus in frequent, even daily contact with other members.

We also took into account access to the maternal grandfather and the paternal grandparents. Where mothers were not members of the same households as these relatives no additional information was available about the characteristics of the grandparent in ACDIS. Furthermore, if a child's record was not linked to that of the father, we could not link to the father's regular updates about his parents' survival, and therefore would not have data on those who had died. Consequently, other grandparents could be classified only as 'co-resident' or 'not co-residing', which meant assuming that a grandfather or paternal grandmother could not provide substantial help to the mother unless he or she resided in the same homestead.

Other social and economic characteristics

One of the challenges of understanding the effects of social support is that it is intertwined with other characteristics (Portes 2000), such as social and economic status. Studies from the USA have shown that low socio-economic status is associated with risk of low birth weight (Rutter and Quine 1990; Parker et al. 1994; Rini et al. 1999). This may be because wealthier households can provide a healthier environment, including better nutrition and less poverty-induced stress for the mother. We used information on the resources owned by the household in 2000/2001, at the time of or shortly before the pregnancy, as

indicators of household wealth (house construction materials, household amenities, ownership of commodities) and ranked households into quintiles according to their relative long-term wealth, using principal components analysis (PCA) (following Dunteman 1989; Filmer and Pritchett 2001). Mother's level of education was included as it has been shown to correlate with child health, including birth weight (Warner 1998; Rini et al. 1999; Feldman et al. 2000). A variable that had not been previously explored but that seemed likely to be important in a highly mobile population was the frequency of periods away from the homestead. This was seen as an indicator of the mother's exposure to the household environment, access to family support, and also indicative of access to sources of income. Because negative financial shocks and health shocks may cause maternal stress, which may affect foetal development (Hoffman and Hatch 1996), we included indicators of whether the household had recently experienced a major financial shock (job loss or major loss of property owing to theft, fire, or flood) and an indicator of whether the household had reported recent experience of a major health shock (death or serious illness).

Statistical methods

The first set of analyses focused on the association between birth weight and the survival and residency status of the child's biological father and maternal grandmother. We used ordinary least squares (OLS) regressions with robust standard errors. The dependent variable was weight in grams, measured as a continuous variable:

$$\mathrm{BW} = \beta_0 + \beta_1 v_g + \beta_2 t_p + \beta_2 W_c + \beta_3 X_m + \beta_4 Y_h + \beta_5 Z_i + \beta_6 U_y + e \quad (1)$$

On the right-hand side, categorical variables indicate the mother's access during pregnancy to her own mother (v_g) and to the child's biological father (t_p), each coded as follows: deceased; alive but not co-residing with the mother (omitted category), and co-residing with the mother at the child's birth. In models examining the role of partnership patterns, we re-coded t_p to indicate the mother's partnership arrangement at the child's birth as follows: married to partner; co-resident with non-marital partner who is also a household member; non-marital partner is a member of the same household but resides elsewhere; non-marital partner neither resides with mother nor is a member of the same household; and no partner (omitted category). In models estimating the effects of access to the other grandparents, we re-coded v_g to indicate co-residence as follows: co-residing with the mother at the child's birth, not co-residing with the mother, including deceased (omitted category).

We included bio-demographic variables known to affect birth weight: the mother's age at birth, whether this was her first live birth, and the child's sex. These are denoted as W_c. Similarly, X_m captures the socio-economic characteristics of the mother: education and whether she was regularly away from home overnight. Y_h is a vector of household characteristics, including the wealth quintile, the indicator of any financial shocks, and the indicator of any health shocks. Since residents in some locations, because of disease environments or lack of access to resources, may be more prone to poor health, we included Z_i, a vector of dummy variables for each of the 24 traditional administrative units called isigodi. Finally, we included a series of dummy variables indicating the child's year of birth, U_y, to capture secular trends in birth weight.

In additional models, we added interactions to test the importance of the family environment in particular circumstances. We investigated whether grandchildren of grandmothers eligible for State old-age pensions (those aged 60 years and older) had a higher birth weight than those with younger grandmothers. To test this, we added a dummy variable indicating whether the grandmother was of pensionable age. We also investigated whether the importance of pension was affected by co-residence. In another test, we investigated whether access to the grandmother was more beneficial for inexperienced (first-time) mothers. Finally, we tested whether the role of family environment differed by wealth status.

Because many observations did not have information on birth weight, we re-estimated all models as Heckman selection correction models. In these, the non-selection hazard was estimated in the first stage on all covariates used in the study plus two exclusion variables to test the effect of two influences on whether birth weight data were obtained or retained by the family. The exclusion variables were (i) distance to the nearest clinic or hospital, and (ii) whether the child subsequently died.

Results

Descriptive statistics from the interview round closest to the child's birth are shown in Table 1. The average birth weight is 3,110 grams and the median is 3,100 grams, with less than 10 per cent of the sample falling below the 2,500-gram low-birth-weight

Table 1 Characteristics of children and their families used for a study of the relationship between birth weight and access to father and grandparents, KwaZulu-Natal, South Africa, 2000–2003

	N (mean)	% (SD)
Birth weight in grams (mean, SD)	3,109.7	519.1
Father's survival and residence[1]		
Not co-residing with mother	3,218	80.6
Co-residing with mother	635	15.9
Deceased	140	3.5
Mother's partnerships		
Married	676	16.9
Partner co-resident and is a household (HH) member	390	9.8
Partner not co-resident but is a HH member	344	8.6
Partner not co-resident and not a HH member	1,499	37.5
No partner	869	21.8
Information on marital status/ partnerships missing	215	5.4
Maternal grandmother's survival, residence, and pension[1]		
Not co-residing with mother	1,858	46.5
Co-residing with mother	1,484	37.2
Deceased	651	16.3
Grandmother is eligible for pension	719	18.0
Grandparents co-residing with mother[1]		
Maternal grandmother	1,484	37.2
Maternal grandfather	483	12.1
Paternal grandmother	136	3.4
Paternal grandfather	31	0.8
Bio-demographic characteristics		
Sex		
Male	1,966	49.2
Female	2,027	50.8
Parity		
First-born child	1,790	44.8
Higher order birth	2,203	52.7
Information on birth order missing	99	2.5
Mother's age at child's birth		
<20	1,011	25.3
20–24	1,182	29.6
25–29	820	20.5
30–34	555	13.9
35+	425	10.6
Social and economic characteristics		
Mother's education		
No education	214	5.4
Primary school	787	19.7
High school	2,176	54.5
Higher education	170	4.3
Information on mother's education missing	646	16.2
Mother's travel		
Most nights in the homestead	3,556	86.0
Spends time away regularly	437	10.9
Information on mother's presence missing	123	3.1
Household wealth and shocks		
Wealth index (mean, SD)	0.03	1.9
Household experienced a severe economic shock	567	14.2
Household experienced a severe health shock	643	16.1
Information on the household missing	408	10.2
N (children)	3,993	

[1]Father's and grandparents' residence with the mother is not mutually exclusive.
Source: Africa Centre Demographic Information System, KwaZulu-Natal, South Africa: children born 2000–2003.

cut-off. Sixteen per cent of the mothers co-resided with the child's father during pregnancy and 37 per cent resided with their own mothers (these categories are not mutually exclusive). Few of the mothers co-resided with their own fathers (12 per cent) and even fewer with their child's paternal grandmother (3 per cent) or grandfather (1 per cent) (again, these categories are not mutually exclusive). Seventeen per cent of the mothers were married at the time of this child's birth, while 22 per cent had no partner. Over half of the women were under 25 years old, had a high school education, and for slightly less than half of them, the index child was their first live birth.

As shown in Table 2, all bio-demographic variables exhibit significant associations with birth weight. Boys are about 99 grams heavier than girls at birth, first-born children are about 100 grams lighter than other infants, and children born to older mothers are heavier than children born to teenagers or mothers in their early 20s.

Birth weight and access to the biological father and partnerships

Table 2 presents results for the association between the biological father's co-residence with the mother, his survival, and the child's birth weight. The co-residence of the biological parents has a significant positive association with birth weight in bivariate estimates. This association is reduced but remains significant in the adjusted model. After controlling for the other explanatory variables, infants whose fathers and mothers co-resided when the infant was born are on average 59 grams heavier at birth than infants whose fathers lived elsewhere. It is the father's

Table 2 Regression of child's birth weight in grams on father's and grandmother's co-residence with mother; coefficients estimated from ordinary least squares (OLS) regression, KwaZulu-Natal, South Africa, 2000–2003

	Bivariate results[1]		Adjusted model results[2]	
Father's survival and residence (not co-residing with mother)				
Co-residing with mother	138.2	(23.1)**	58.6	(25.5)*
Deceased	14.5	(45.9)	23.8	(45.3)
Maternal grandmother's survival and residence (not co-residing with mother)				
Co-residing with mother	−88.1	(17.8)**	−8.9	(20.1)
Deceased	−57.5	(24.4)*	−45.8	(24.2)+
Bio-demographic characteristics				
Male			98.6	(16.3)**
First-born child			−99.8	(22.1)**
Mother's age at child's birth (20–24)				
<20			2.2	(23.1)
25–29			72.3	(24.0)**
30–34			68.7	(29.9)*
35+			100.1	(33.4)**
Social and economic characteristics				
Mother's education (high school)				
No education			7.6	(41.4)
Primary school			−24.6	(22.8)
Higher education			−25.1	(46.8)
Mother's travel (spends most nights in the homestead)			−35.0	(26.8)
Mother spends time away regularly				
Household wealth and shocks				
Wealth quintile (1st—poorest)				
2nd			58.07	(26.4)*
3rd			90.1	(36.1)*
4th			69.3	(28.4)*
5th—wealthiest			83.2	(32.0)**
Experienced economic shock			−45.7	(24.2)+
Experienced health shock			12.39	(23.7)
Constant			3,148.18	(49.12)**
Observations	3,993	3,993		
R^2	0.01	0.05		

[1]Constant terms included (results not shown).
[2]The model includes dummy-variable adjustments for missing values and *isigodi* (traditional administrative unit) and year-of-birth dummy variables.
Notes: Robust standard errors in parentheses. Omitted category given in parentheses. Statistical significance: $+p < 0\ 10$; $*p < 0.05$; $**p < 0.01$.
Source: As for Table 1.

residence in the same homestead, rather than his survival status that seems to matter. In fact, infants born to women who did not reside with the father have a birth weight similar to that of infants whose fathers had died. Further, in Heckman models that adjust for selection, children whose fathers were deceased were born on average heavier than those whose fathers resided elsewhere.

The ACDIS data allow us to examine in greater depth the association between birth weight and the mother's access to a partner. In the models presented in Table 3, we include information about the mother's partnership during pregnancy. All combinations of categories were tested for significant differences from the omitted category (no partner) and from each other. Infants born to women who had no partner at the time of the birth are significantly lighter than infants born to married women or to women with a non-marital partner. The strength of associations is reduced by the inclusion of other explanatory variables in the models, but remains large and significant across specifications. Infants born to mothers who were married at the time of birth are the heaviest. They are 180 grams heavier than infants born to mothers without partners. The next heaviest are infants born to women whose non-marital partner was a member of the same household and who was co-residing with the mother (122 grams heavier than

Table 3 Regression of child's birth weight in grams on mother's partnership arrangement; coefficients estimated from ordinary least squares (OLS) regression, KwaZulu-Natal, South Africa, 2000–2003

	Bivariate results		Adjusted model results[1]	
Mother's partnerships (no partner)[2]				
Married	274.6	(26.5)**	179.6	(36.4)**
Partner co-resident and is a household member	180.8	(32.7)**	121.9	(37.9)**
Partner not co-resident but is a household member	158.2	(31.1)**	107.2	(36.9)**
Partner not co-resident and not a household member	124.3	(21.9)**	84.0	(24.3)**
Constant	2,985.1	(17.7)**	3,064.31	(53.2)**
Observations	3,993		3,993	
R^2	0.03		0.06	

[1]The model includes: child's sex, mother's age at child's birth, parity, mother's education, mother's travel, household wealth, economic and health shocks, grandmother's survival and residence, *isigodi* (traditional administrative unit) and year-of-birth dummy variables, and dummy-variable adjustments for missing values.
[2]Asterisks indicate category is significantly different from omitted category (no partner). In post-estimation tests of linear combinations of estimators, the following categories were significantly different from each other at the 0.05 level or lower in bivariate analyses: married vs. not co-resident household member; married vs. co-resident household member; married vs. not co-resident not household member. The following categories were significantly different from each other at the 0.05 level or lower in multi-variate models: married vs. not co-resident household member; married vs. not co-resident not household member.
Notes: Robust standard errors in parentheses. Omitted category given in parentheses. Statistical significance: $+p < 0.10$; $*p < 0.05$; $**p < 0.01$.
Source: As for Table 1.

infants of mothers without partners). Furthermore, infants born to mothers who had a partner, whether or not the partner was a member of the same household, are also significantly heavier, by 84–107 grams, than infants born to mothers without partners. These results suggest that mothers greatly benefit from having a regular partner, especially if the relationship is marital, and that joint household membership and co-residence can be beneficial even if the relationship is not marital.

In post-estimation tests of linear combinations of estimators, the following partnership arrangements are significantly different from each other at the 0.05 level or lower in multivariate models: married vs. partner who is a household member but not co-residing; and married vs. partner who is neither co-residing nor a member of the same household. In both bivariate and adjusted models, all non-marital partnerships are associated with a significantly higher birth weight than those with no partner. If they are not co-resident, non-marital partnerships are associated with a lower birth weight than for married couples, but birth weight does not differ between co-resident non-marital partnerships and married couples in adjusted models.

Because the potential benefits of support may vary by wealth, we also tested for interactions between mother's partnership status and household wealth. No significant differences were found by wealth quintile or among those living in poorer-than-average households (see Table A2).

Birth weight and access to the maternal grandmother and other grandparents

Table 2 presents the unadjusted and adjusted associations between birth weight and the presence of the maternal grandmother. In bivariate estimates, infants whose maternal grandmothers had died are lighter at birth than those whose maternal grandmothers were still alive but living elsewhere. Newborns whose grandmothers were living in the same homestead as the mother are also significantly lighter than infants whose grandmothers were alive but not co-residing with the mother. However, in the fully adjusted models, the association between grandmother's co-residence and birth weight is reduced substantially and is no longer significant. In the adjusted model, infants with a surviving maternal grandmother are heavier by an average of 46 grams than those whose maternal grandmothers had died, reaching marginal significance. In the Heckman model, the disadvantage of those with deceased grandmothers is greater (63 grams) and significant at the 0.05 level.

We expected that access to a grandmother with a pension might provide the mother with greater

financial support that could be used to purchase better nutrition and care, and therefore be associated with higher birth weight. In fact we find that the coefficient for the grandmother's pension eligibility is not statistically significant and the inclusion of this variable does not materially alter the results for grandmother's co-residence and survival. Since co-residence may affect transfers, we also tested for interactions between grandmother's pension eligibility and co-residence with the mother, but the interaction was also not statistically significant. We also examined whether the presence of the grandmother confers greater benefits for first-time mothers, for mothers who spend time away from home regularly, and for mothers living in households that have recently experienced economic shocks. We did not find evidence that co-residence with the grandmother serves as a buffer in these circumstances (see Table A2). Finally, we did not find evidence that the grandmother can substitute for the father. The coefficients for father's survival status and co-residence are not materially altered by the inclusion of information about the grandmother's co-residence and survival. This suggests that the grandmother and the father have independent effects on birth weight.

Table 4 shows bivariate and adjusted associations between the mother's co-residence with each of the child's four grandparents and the child's birth weight. In bivariate results, mothers who resided with their own parents during pregnancy have significantly lighter newborns, while the newborns are significantly heavier for mothers who resided with the child's paternal grandparents. All of these associations become non-significant when we control for the mother's partnerships and are reduced even further with the inclusion of the other variables. One possible exception is co-residence with the paternal grandfather, which remains significantly associated with birth weight in the Heckman model though not in the OLS model. These patterns indicate that children whose mothers live with the maternal grandparents are born relatively light while those whose mothers live with paternal grandparents are born relatively heavy; however, these results do not necessarily reflect the effects of living with different categories of grandparent. Rather, it is likely that mothers who live with their partners' parents are in longer-term relationships and wealthier households, and that it is partnership, and especially marital status, that affects birth weight. Specifically, 76 per cent of mothers living with the paternal grandfather and 73 per cent of mothers living with the paternal grandmother are either married or have a co-residing partner, compared with less than 2 per cent of those living with maternal grandparents.

Birth weight and other social and economic characteristics

Birth weight is significantly associated with the social and economic environment of mothers during pregnancy, as shown in Table 2. Infants born to mothers in wealthier households are heavier than those in poorer households, though the greatest improvements in birth weight are associated with being in the next-to-poorest rather than the poorest quintile, with no significant increases among wealthier quintiles. Even after controlling for wealth, household-level economic shocks are associated with lower birth weight: infants born in households experiencing an economic shock during pregnancy are about 44 grams lighter than other infants, although this association is only marginally significant. However, birth weight is not significantly associated with household health shocks or with mother's education. Mothers who are regularly away from their homestead tend to give birth to lighter infants, although the association is not statistically significant.

By comparing the results from bivariate results and models with economic controls, we can assess the extent to which the relationships between access to family and birth weight operate through socio-economic circumstances. For example, do fathers and grandmothers appear to be important simply because expectant mothers who co-reside with them are members of wealthier households? The inclusion of economic variables, such as wealth ranking, reduces the negative association between co-residence with the maternal grandmother and birth weight, indicating that these negative associations are partly explained by poverty and economic shocks. However, the positive associations between the mother's access to a partner and birth weight remain large and significant, indicating that the importance of fathers for birth weight is not simply explained by observed socio-economic characteristics, but that there may be additional benefits conferred by established and especially co-resident partnerships.

Discussion

Social support is widely believed to affect health, with the family being among its most important

Table 4 Regression of child's birth weight in grams on each grandparent's co-residence with mother; coefficients estimated from ordinary least squares (OLS) regression, KwaZulu-Natal, South Africa, 2000–2003

	Bivariate: maternal grandmother	Adjusted:[1] maternal grandmother	Bivariate: maternal grandfather	Adjusted:[1] maternal grandfather	Bivariate: paternal grandmother	Adjusted:[1] paternal grandmother	Bivariate: paternal grandfather	Adjusted:[1] paternal grandfather
Grandparent co-residing with mother[2]								
Maternal grandmother	−73.11	3.82						
	(16.78)**	(18.87)						
Maternal grandfather			−61.63	−10.49				
			(25.20)*	(25.57)				
Paternal grandmother					129.40	43.56		
					(43.15)**	(45.54)		
Paternal grandfather							264.84	169.50
							(104.88)*	(107.45)
Constant	3,136.90	3,138.81	3,117.19	3,142.63	3,105.33	3,139.32	3,107.68	3,140.27
	(10.49)**	(48.31)**	(8.75)**	(47.87)**	(8.36)**	(47.82)**	(8.23)**	(47.77)**
Observations	3,993	3,993	3,993	3,993	3,993	3,993	3,993	3,993
R^2	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.05

[1]The model includes: child's sex, mother's age at child's birth, parity, mother's education, mother's travel, household wealth, economic and health shocks, father's survival and residence, *isigodi* (traditional administrative unit) and year-of-birth dummy variables, and dummy-variable adjustments for missing values.
[2]Categories not mutually exclusive—more than one grandparent may be co-resident.
Notes: Robust standard errors in parentheses. Statistical significance: $+p < 0.10$; $*p < 0.05$; $**p < 0.01$.
Source: As for Table 1.

sources. In our study, we examined associations between the mother's access to a partner and to her child's grandparents and the child's weight at birth in rural South Africa. We found that women whose own mothers are still alive gave birth to heavier newborns than women whose mothers are deceased. At the same time, no additional benefits from co-residence with the mother were detected. Nor was co-residence with the paternal grandmother or the grandfathers associated with birth weight after controlling for access to a male partner. Thus, the proposition that co-residence is a primary mechanism through which mothers receive assistance from grandparents is not supported. On the other hand, at least in the case of the maternal grandmother, it seems that support may be provided by grandmothers who reside elsewhere.

Previous studies have found some benefits from grandmother's pension eligibility for grandchildren's access to food and education and for their growth (Case and Deaton 1998; Duflo 2003). We found no evidence that the benefit of an old-age pension extends to grandchildren's prenatal growth, since grandmother's pension eligibility did not correlate significantly with birth weight, nor did it substantially change the correlations between birth weight and the grandmother's presence. It may be that the support received from grandmothers is not strictly financial, but involves in-kind assistance or protection against violence or other threats. The potential benefits of pensions may be confounded by the fact that care is not necessarily unidirectional from older mother to adult daughter: older grandmothers may require substantial care and resources from their daughters, especially if they co-reside. We did not find that the presence of the maternal grandmother could substitute for a non-resident father.

Father's co-residence with the mother was significantly and positively associated with the infant's birth weight. However, our results suggest that studies that focus only on fathers or on marital status can miss important distinctions in relationships and the support these relationships provide for child health. A strength of the method we adopted was the ability to identify the type of relationship that existed between the mother and her partner in more detail than in previous studies. We were able to establish patterns of co-residence in the same homestead and membership in the same household. Birth weight was highest among infants born to married women and lowest among those born to women with no regular partner, even after adjusting for maternal and household characteristics. Nonetheless, marriage is not the only type of partnership associated with birth weight. A mother appeared to benefit from being a member of the same household as her non-marital partner and especially from residing in the same homestead. Co-residence was independently associated with higher birth weight, suggesting that co-habitation may provide additional benefits beyond financial support. This emphasizes the value of family contact for migrant workers, for example, by the expansion of family housing in places where employment opportunities attract labour migrants.

The norms and circumstances experienced by families living in KwaZulu-Natal are changing. However, patrilocal traditions remain influential, as evidenced by the finding that a mother's co-residence with the child's father, especially if she is married to him, is associated with better health for her baby while co-residence with her parents is not. By custom, the foetus is thought to belong to the father's lineage and the mother is only a channel through which the child enters the world (Ngubane 1976). From this perspective, it would be expected that the father's kin would have a vested interest in ensuring that the mother lived in a healthy and protected environment. At the same time, because pregnancy is traditionally a time when a woman is expected to limit social exposure (Ngubane 1976), she may have less contact with her native kin, who, in any case would not have as much invested in the pregnancy. In addition, the mother may feel the stress of her marginalization more keenly in the homestead of her own parents, and perhaps welcome the comfort of the new bond with her partner and his family if co-residing with them. Previous studies have found great concern among young women in sub-Saharan Africa about becoming pregnant when not certain of the identity of the father (Nshindano and Maharaj 2008). It may be that it is only when the relationship has been formalized through marriage or co-residence that a woman can feel confident that the legitimacy of her unborn child is confirmed.

Socio-economic features of the homestead environment, specifically assets and financial shocks, were significantly associated with birth weight. The fact that birth weight is more strongly associated with economic shocks than with health shocks may indicate that the effects of shocks are experienced more strongly through reductions in resources than through emotional stress.

Though the results reported above are robust to alternative specifications and to the inclusion of additional variables, we cannot conclude that the relationships between access to family members and birth weight are causal, since residual confounding can arise from characteristics that have not been

captured and from measurement error in the variables that were included. For example, the HIV status of the mother may be associated with access to family support and to weight at birth, but we could not take it into account because HIV testing in the ACDIS had not begun when many of the children were born.

An important concern is the possibility of a bias in the sample because birth weight data were not available for almost half the births. If the effects of grandmothers and partners were the same for those with missing as for those with known birth weight, no bias would have been introduced. However, if family support was more important for health at birth among children whose birth weights were unknown, then our estimates of the relationship between family support and birth weight would have been biased downwards. For example, given that the presence of fathers and grandmothers is known to correlate with probability of survival, and that data were more likely to be missing for children who subsequently died, cases with surviving children were more likely to be represented in our study. Again, our findings would under-estimate the importance of fathers and grandparents because the full effect of not having access to them would not have been observed. A related concern is that family support may have been more important among the poorest households. While we did not find significant interactions between socio-economic status and access to grandparental and partner support, it is possible that these patterns were different among those who were not included in our sample owing to missing data on birth weight. If family was more important among the poorest, with in-kind support substituting for other resources, and the poorest were more likely to be excluded from our sample owing to missing information, again our results would be under-estimates of the importance of grandparental and partner support. To correct for selection caused by missing information on birth weight, we re-estimated all models as Heckman selection correction models. Most results were not significantly different from the OLS results.

Another concern is that previous research has shown that there may be errors in the reporting of birth-weight data in surveys (Boerma et al. 1996; Robles and Goldman 1999). We estimated alternative models with birth weight divided into three categories: low, average, and high. The results (not shown) were consistent with those reported above.

Because respondents were not asked about the support they received from or gave to others, we were unable to take into account the extent and type of contact with and assistance from partners and the child's grandparents.

The results of our analyses illustrate the importance of adequately characterizing partnership arrangements, especially in settings where marriage is not universal and non-marital childbearing is common. They also highlight the fact that relationships may be supportive in some circumstances but not in others. For example, while co-residence with a partner appears to be beneficial, co-residence with a grandparent does not. Conversely, a grandmother residing elsewhere seems to be beneficial, while a father residing elsewhere does not. An improved understanding of the ways in which family members provide support can inform policies to promote and enhance positive family support to mothers and children.

There is mounting evidence that social support is of benefit to health, but what it is about social support that is beneficial remains unclear. It may be that support networks actually provide care, information, and goods that are instrumental in health promotion. There may also be psychosomatic benefits to receiving and giving support that can improve health. Whether in KwaZulu-Natal or elsewhere, the family is the primary source of social support. We have shown that the benefits of the family environment may extend not only to the individual, but to the well-being of the next generation from the very beginning. Family arrangements and the ways in which different types of support are provided within families are not static in South Africa and elsewhere. Our findings suggest that demographers' and policy-makers' definitions of the family also need be flexible in order to identify and strengthen the sources of support on which mothers rely.

Notes

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2 This study was partially supported by the National Institute of Child Health Department (NICHD) training grant T 32 HD 007242 awarded to the University of Pennsylvania. The Welcome Trust in the UK provided funding support through grants to the Africa Centre

Demographic and HIV Surveillance (#GRO82384/Z/07/Z) and Victoria Hosegood (#WT082599MA). We thank the ACDIS field and data centre staff and the Africa Centre for Health & Population Studies. This paper benefited from the comments of Christopher Cunningham, Marie-Louise Newell, Jere Behrman, Susan Watkins, and Etienne Van De Walle.

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Appendix

Table A1 Regression of child's birth weight in grams on maternal grandmother's survival and residence, and on mother's partnership arrangement: comparison of estimates from models using Heckman selection correction and OLS regression models KwaZulu-Natal, South Africa, 2000–2003

	OLS model		Heckman selection model	
Maternal grandmother's survival and residence (not co-residing with mother)				
Co-residing with mother	11.78	(21.35)	−15.28	(23.04)
Deceased	−38.00	(24.37)	−51.40	(25.17)*
Mother's partnerships (no partner)[2]				
Married	179.60	(36.35)**	122.62	(37.98)**
Partner co-resident and is a household member	121.88	(37.91)**	99.96	(39.01)*
Partner not co-resident but is a household member	107.21	(36.86)**	89.60	(39.46)*
Partner not co-resident and not a household member	83.98	(24.28)**	86.17	(25.67)**

[1]In the Heckman selection correction models, the non-selection hazard is estimated in the first stage on all covariates presented in the paper plus two exclusion variables, which are: distance to the nearest clinic or hospital and whether the child subsequently died. These variables were selected because they were expected to affect whether birth weight data are obtained or retained by the family while not affecting birth weight itself. Distance to clinic predicts missing birth weight ($p = 0.032$), as does whether the child subsequently died ($p = 0.000$).

[2]The models also include: child's sex, mother's age at child's birth, parity, mother's education, household wealth and health shocks, *isigodi* (traditional administrative unit) and year-of-birth dummy variables, and dummy-variable adjustments for missing values.

Notes: Statistical significance: $+p < 0.10$; $*p < 0.05$; $**p < 0.01$.

Source: As for Table 1.

Table A2 Regression of child's birth weight in grams on access to family in specific circumstances, coefficients estimated from ordinary least squares (OLS) regression with interaction terms, KwaZulu-Natal, South Africa, 2000–2003

	Marriage and poverty[1]	Pension and co-residence[2]	First birth and co-residence[2]	Travel and co-residence[2]	Economic shocks and co-residence[2]
Maternal grandmother's survival and residence (not co-residing with mother)					
Co-residing with mother	10.90	−12.47	28.83	−7.28	
	(21.32)	(21.78)	(27.93)	(21.32)	
Deceased	−37.60	−43.32	−53.74	−41.19	
	(24.39)	(24.96)+	(29.78)+	(25.21)	
Maternal grandmother pension-eligible		10.64			
		(31.96)			
Bio-demographic characteristics					
First-born child	−74.62	−100.00	−74.43	−99.74	−104.24
	(22.77)**	(22.11)**	(30.09)*	(22.12)**	(23.46)**
Social and economic characteristics					
Mother married	194.14				
	(47.15)**				
Mother spends time away regularly	−24.03	−34.78	−37.18	−18.67	−31.95
	(26.88)	(26.80)	(26.77)	(46.60)	(28.81)
Household poorer than mean	−69.84				
	(38.17)+				
Experienced economic shock	−41.34	−45.74	−47.15	−45.56	−43.55
	(24.07)+	(24.17)+	(24.15)+	(24.14)+	(34.74)
Interactions					
Married × Household poorer than mean	−26.91				
	(54.91)				
Maternal grandmother co-residing with mother × Pension-eligible		12.78			
		(44.86)			
Maternal grandmother co-residing with mother × First-born child			−67.88		
			(37.64)+		
Maternal grandmother co-residing with mother × Mother spends time away regularly				−17.19	
				(58.21)	
Maternal grandmother co-residing with mother × Household experienced economic shock					−37.82
					(49.67)
Constant	3,155.16	3,148.50	3,136.95	3,146.28	3,170.22
	(54.90)**	(49.23)**	(49.76)**	(49.38)**	(53.94)**
Observations	3,993	3,993	3,993	3,993	3,993
R^2	0.06	0.05	0.05	0.05	0.06

[1]The model also includes: child's sex, mother's age at child's birth, parity, mother's education, health shocks, *isigodi* (traditional administrative unit) and year-of-birth dummy variables, and dummy-variable adjustments for missing values.
[2]The models also include: child's sex, mother's age at child's birth, parity, mother's education, household wealth and health shocks, father's survival and residence, *isigodi* (traditional administrative unit) and year-of-birth dummy variables, and dummy-variable adjustments for missing values.
Notes: Robust standard errors in parentheses. Statistical significance: $+p < 0.10$; $*p < 0.05$; $**p < 0.01$.
Source: As for Table 1.