Health outcomes for children born to teen mothers in Cape Town, South Africa

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Prepared for the PAA Conference
Dallas, Texas
15-17 April 2010
Session 353: Prenatal Care, Early-Life Health and Child Development: Evidence from Developing Countries

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Abstract:

This paper analyzes the effect of being born to a teen mother on child health outcomes in South Africa using propensity score reweighting. Exploiting the longitudinal nature of the Cape Area Panel Study, we estimate the probability of being a teen mother conditional on pre-childbirth characteristics. We use this score to construct a weighted counterfactual group of children born to mothers over nineteen whose pre-childbirth characteristics are very similar to the teen mother sample except for their age at the birth of their first child. Our reweighted regressions indicate that being born to a teen mother has some significant adverse effects on child health, especially among coloured children. In particular, children born to teens are more likely to be underweight at birth and to be stunted with the negative effect being double the size for coloureds than Africans. No negative impact of teenage childbearing is found on head circumference at birth or the incidence of incomplete first year immunizations.

1. Introduction

Research into the consequences of teenage childbearing for the mother and her child is abundant in the international literature. Early childbearing is commonly associated with reduced education, worse labour market outcomes and poverty. However, since teenagers tend to come from disadvantaged backgrounds, the size of the causal effect of teenage childbearing is less definite. In this paper we attempt to assess the casual impact of being born to a teen mother on child health outcomes. We assess whether teenage childbearing has a real impact on child outcomes or whether teen mothers are already on a disadvantaged trajectory and hence the perceived adverse outcomes for the child is actually a result of selection of women from poorer socio economic status into early childbearing. If the latter is true, policy directed at reducing teenage childbearing will not reduce the disadvantage these children face; they would experience adverse outcomes even if their mother's delayed childbearing beyond their teens.

This paper uses the Cape Area Panel Study (CAPS) data, a uniquely rich longitudinal dataset of youths and their children in Cape Town. We estimate the effect of being born to a teen mother on a range of child health outcomes. Our main econometric challenge is to account for characteristics which effect both the mother's odds of becoming a teen mother and the child's outcomes; in other words to find a plausible counterfactual which allows us to isolate the effect of being born to a teen mother. The richness of the data and the length of the panel allow us to go quite some way towards controlling for selection into teenage childbearing and hence for the socioeconomic status into which the child is born.

We use a propensity score reweighting approach. This method relies on the assumption that, conditional on observable characteristics sample selection into being born to a teen mother is random. Given the richness of the CAPS data, this assumption is more believable than it might otherwise be. More specifically, the data contain information on maternal characteristics prior to the birth of the child, in addition to age at sexual debut, contraception use at first sexual encounter and other factors which might influence the probability of falling pregnant during adolescence.

We find some evidence that the health outcomes of children born to teen mothers are adversely affected. Children born to teen mothers are significantly more likely to be born underweight, are shorter and are more likely to be stunted. We however, find no evidence of a negative effect on head circumference at birth or on the incidence of incomplete first year child immunizations.

The rest of the paper is organised as follows. Section 2 introduces the econometric challenge in estimating the effect of early childbearing on child outcomes in addition to the different approaches used in the literature to control for it. Secti (Victora, et al., 2008)on 3 discusses the data, sample and outcome variables. Section 4 sets out the methodology used in the analysis, discusses the underlying assumptions of the method and tests for their validity. The results are presented in section 5 followed by the sensitivity analysis in Section 6. Section 7 presents a discussion and concludes.

2. Related literature

Childhood health is important both for survival and life outcomes. The Millennium Development Goals place the reduction of childhood mortality on the international agenda by identifying it as the fourth of eight goals that the world must respond to effectively by 2015 (United Nations, 2000). Childhood health has been found to be an important determinant of socioeconomic conditions in childhood, young adulthood and middle age (Thomas & Strauss, 1997, Alderman et al, 2003; Case et al, 2005; Yamauchi, 2006, Victoria et al, 2008) and forms a foundation which potentially affects all subsequent outcomes. Using data from Great Britain, Case et al (2005) find that childhood health has both direct effects, for instance on middle age health, and indirect effects as a result of reduced educational attainment during young adulthood. In addition, Thomas & Strauss (1997) find that taller people in Brazil earn more on average than their shorter counterparts.

Research on the long term effects of childhood health in South Africa is limited by the data available. However, Victoria et al (2008) find positive associations between child (birth weight) and young adult health (current height and weight for age) and schooling, adult health, income and wealth outcomes using a pooled data containing data from South Africa. Yamauchi (2006) find short run effects of childhood health in South Africa. Comparing siblings, an increase in the height-for-age z-scores at ages 1 to 3 is associated with earlier enrolment, higher grade completion rate and lower grade repetition (Yamauchi, 2006).

The debate around whether teenage childbearing has adverse outcomes for child health is centred on the idea that teens are biologically and psychosocially less mature and therefore less prepared to face pregnancy, childbirth and subsequent childcare (Zabin & Kiragu, 1992, 1998, LeGrand & Mbacke, 1993, Lawlor & Shaw, 2002). Thus teenage childbearing is argued to increase the risk of poor child health for both physiological and behavioural reasons. For instance, LeGrand and Mbacke (1993) find that teen mothers in urban Sahel are more likely to postpone prenatal care and had higher child mortality rates. In addition, they find that babies of teen mothers are more likely to be born underweight, are less likely to receive the recommended vaccinations and are weaned at an earlier age (ibid). Geronimus and Korenman (1993) however, note that studies which find large negative health effects due to young maternal age generally confound the effect of maternal age with background characteristics by inappropriately controlling for pre-childbirth characteristics. Since teen mothers are more likely to come from, on average, more disadvantaged backgrounds, their children would likely have experienced worse outcomes even if their mothers delayed their birth beyond her teens (ibid).

Econometric endogeneity is therefore our main challenge in calculating the effect on child health of being born to a teen mother. In this context, endogeneity arises because factors which affect the likelihood of a respondent becoming pregnant during her teens are also likely to affect her child's health outcomes. For example, the mother's education level is likely to affect both her odds of becoming a teen mother and the health of her child.

One approach used in the teenage childbearing literature to control for endogeneity is to find an instrument which is highly correlated with the likelihood of being a teen mother but is orthogonal to the outcome of interest (Angrist & Evan 1996, Ribar 1994 & 1999, Klepinger et al 1999 and 1995). Instruments used in the literature include the mothers' age at menarche, regional availability of doctors/nurses, abortion rates (Klepinger et al 1999 and 1995, Ribar, 1994) and abortion policy reforms (Angrist & Evan 1996). However, the regional availability of doctors/nurses is likely to be correlated with child health as they signal access to resources and age at menarche and abortion rates has been shown to be correlated with SES (Knaul, 2000).

Another approach used in this literature is to exploit miscarriage as a natural experiment (Hotz et al 1997 & 2005, Levine et al 2001, Ashcraft & Lang 2006, Fletcher & Wolfe 2008). Assuming that miscarriage is random (which is controversial (Fletcher & Wolfe 2008)), children born to teens are compared to children born to mothers whose first pregnancy was during adolescence but resulted in miscarriage. While this method appears appealing in principle, it is plagued by excessive data requirements due to the rarity as well as the underreporting of miscarriages.

Finally, some researchers use siblings and/or cousin fixed effects estimation in an attempt to control for unobservable characteristics statistically (Geronimus & Korenman 1992 & 1993, Geronimus et al 1994, Levine et al 2004 & 2007, Turley 2003, Holmlund 2004, Ribar 1999 and Francesconi 2008). Family fixed effects methods rest on the assumption that the comparison of two sisters, or two cousins born to sisters, one who gave birth to a child in their teens and one that did not, controls for unobservable heterogeneity between families.

The literature which looks at health outcomes for children born to teen mothers controlling for endogeneity is scarce. Geronimus and Korenman's 1993 paper is the only paper we found which assesses the effect of teenage childbearing on child health outcomes while attempting to control for selection directly. Other papers which control for pre-birth characteristics tend to focus on maternal outcomes and child educational and behavioural outcomes. Geronimus and Korenman (1993) use a siblings fixed effects framework to assess whether there is a teen-mother-child-health-disadvantage using the US National longitudinal study of youth. Once pre-childbirth characteristics which are homogeneous between sisters are controlled for they find very limited evidence of an association between poor child health and maternal age on a wide range of outcomes. No significant increase in the prevalence of smoking or drinking during pregnancy, no differential inadequacy of well-child visits or increased frequency of low birth weight babies is found (ibid). They find some weak evidence however, that black teen mothers are more likely to delay prenatal care and that white teens are marginally less likely to breastfeed when compared to their sibling. They conclude that there is little evidence of a relationship between teen motherhood and child health above that related to worse family background characteristics (ibid).

Each approach mentioned to control for pre-childbirth characteristics is imperfect. Moreover, the use of miscarriage as a natural experiment and the siblings/cousins fixed effects methods are infeasible given our data; we have very few reported miscarriages or siblings/cousins who have both given birth.

We therefore turn to methods based on the propensity score to address selection. Propensity score matching matches women who gave birth in their teens to women who gave birth at an older age on a score representing the probability of being in the teen mother group. This probability is determined on pre-childbirth observed characteristics. This method has been used to look at the consequences of early childbearing for maternal outcomes in the United States (Levine & Painter 2003, Sanders et al unpublished, Lee 2009), in Britain (Chevalier & Viitanen 2003) and in Cape Town (Ranchhod et al, unpublished).

3. Data, sample and outcome variables

3.1 The Cape Area Panel study

The analysis makes use of the Cape Area Panel Study (CAPS) a longitudinal survey of youth in Cape Town. The first wave of the CAPS, collected in 2002, included 4,752 young adults (YAs) aged 14-22. Three additional waves of YA data were collected in 2003/2004, 2005 and 2006. The primary questionnaire in each wave is a YA questionnaire. In waves 1, 3 and 4 this was supplemented with a household questionnaire. In 2006, in addition to the primary questionnaires, a child questionnaire collected information on all children born to female YAs who were successfully interviewed. This child sample is the basis of our analysis. Details about the CAPS are available in Lam et al (2008).[1]

The YA questionnaire was administered to up to three residents aged 14-22 in each sampled household and covers a wide range of issues including schooling, sexual practices, fertility and childhood home environment. The questionnaire included a life history calendar that recorded

[1] Additional detail and technical documentation are available on the CAPS web site, www.caps.uct.ac.za.

residential movements, marriage and partnerships, pregnancies, schooling outcomes, employment and whether the young adult lived with their mother, father, maternal and paternal grandparents every year since birth. The first wave included a self-administered written literacy and numeracy evaluation. From Wave 2 onwards information on schooling, residential moves and employment were asked in a format that updated information from the month of the young adults' last completed interview. Thus information on these variables is available for each age until the age at which the young adult was last seen. In Waves 1, 3 and 4 young adults completed a detailed birth history, with each additional wave adding subsequent births. The Wave 4 (2006) child questionnaire included current physical measurements, weight-for-age measurements since birth, head circumference at birth and the child's vaccination history.

We thus have detailed information about the mother's individual and household characteristics both before and after the birth of her child in addition to measures of child health. This affords us the unique opportunity to use propensity score reweighting to explore whether maternal age at birth affects child health outcomes for people living in Cape Town.

3.2 Analysis sample

Our analysis sample includes all children born to female YAs who were successfully interviewed in 2006. Table 1 presents information on the sample size and response rates for the data classified as the full sample and the older sample. The full sample includes only African and coloured female YAs. White respondents were excluded from the sample due to the low frequency of births in this group. The older sample is restricted to African and coloured female YAs who were 20 years or older in Wave 4 and is the sample from which the children in the analysis are drawn. We restrict the sample to YAs older than 19 to avoid including YAs who could still potentially become teen mothers. In the third row of Table 1 we see that the response rates to the Wave 4 survey in 2006 were relatively high (76.4%), but the older sample has a slightly lower response rate (71.1%). This is consistent with attrition being higher for older young adults since they are at the age where they move out of home and are therefore more difficult to follow.

By 2006, 654 women in the older sample had given birth. This is just under 50% of the older sample of women. In total these women gave birth to 833 children, resulting in an average of 1.3 children per women. The child questionnaire was successfully completed for 751 (90%) of these children and 44% were born to teen mothers. Our analysis is restricted to first born children. We restrict our sample to first born children to avoid potential birth order biases. For instance, LeGrand & Mbacke (1993) find that first born children are exposed to greater health risks than their younger siblings although they find that first born children are more likely to be vaccinated. The final sample is comprised of 607 children, 50.7% of whom were born to teen mothers.

Table 1: Sample Information – African and Coloured children born to female young adults interviewed in Wave 4

	Full Sample	Older Sample
No. of female YAs in 2002	2300	1838
No. of female YAs in 2006	1758	1318
Response Rate	*76.4%*	*71.7%*
No. of female YAs who had given birth by 2006	737	654
% who gave birth	*41.9%*	*49.6%*
No. of female YAs who had given birth before 2002	230	227
% of births in the panel	*68.8%*	*65.3%*
No. of children born to female YAs by 2006	920	833
No. of child questionnaires	832	**751**
Response Rate in Child Sample	*90.4%*	*90.2%*
% born to teens	*49.5%*	*44.1%*
No. of first born children	686	**607**
% born to teens	*56.4%*	*50.7%*

Our treatment variable is being born to a teen mother, defined as being born to a woman before her 20th birthday. Table 2 presents the maternal age distribution of mothers at the birth of their first child and highlights two points about the sample. First, our treatment indicator, being born to a teen mother, combines a number of potential treatments which could be examined separately – being born to a 13, 15, …,19 year old mother. Due to small samples within each cell, a finer grained analysis assessing the effect of, for instance, younger and older teen mothers, is not feasible with this data. Second, 50% of the potential older sample has not yet begun their childbearing and of those who have, the difference in average age between teen and older mothers is fairly small. Table 2 shows that the majority of teen mothers in our sample are in their late teens, an average age of 17.6 and the majority of older mothers are in their early twenties, average age of 21.6 Our sample is therefore selective of women who begin childbearing early. Thus in our analysis we compare the outcomes of children born to teen mothers to the outcomes of children born to mothers between the age of 20 and 27. Thus the causal effect we estimate is the average effect of being born to a teen mother versus a mother in her early twenties.

Table 2: Mother's age at first child's birth

Age	Teen	Older	%
13	1		0.2
14	4		0.7
15	17		2.8
16	40		6.6
17	63		10.4
18	88		14.5
19	96		15.8
20		88	14.5
21		70	11.5
22		65	10.7
23		45	7.4
24		18	3.0
25		9	1.5
26		3	0.5
Total	309	298	100
Average	17.6	21.6	

3.2 Maternal characteristics

Table 3 presents mean maternal characteristics. The first two columns stratify characteristics by teen versus older mother. In contrast to the majority of findings in the literature, teen mothers do not appear to come from worse socioeconomic backgrounds. In fact, teen mothers fare significantly better on some variables. Teen mothers are significantly older, more likely to be coloured, live in richer neighbourhoods and in households that own stoves. They have attained more education by age 12 and experience menarche at a younger age, a correlate of better nutrition. On the other hand, teen mothers are more likely to have lived with an alcoholic and/or drug addict in their first 14 years of life and attend schools with larger class size. We find no significant differences in maternal grandparents' education levels, wave 1 per capita household income, the odds of the mother classifying her childhood household as poor or very poor, childhood family structures or the prevalence of being unwilling at first sexual encounter.

The similarity in socioeconomic levels between teen and older mothers is in part a result of the higher representation of coloured respondents in the teen group. The apartheid system classified the population into four population groups, namely African, coloured, Asian and white. This classification was used to differentiate the rights and opportunities of each group. While all blacks were discriminated against, Africans had the most severe discrimination, with Asian and coloureds having greater rights and opportunities than Africans but fewer than whites.

The second panel in Table 3 compares the mean characteristics of coloureds and Africans and shows that coloured mothers are more advantaged than African mothers, even though the share of teens mothers is larger. Coloured mothers are significantly less likely to describe their childhood household as poor and live in richer neighbourhoods with household per capita incomes more than double that of African households. While their mothers have similar levels of education to the mothers of African mothers, coloured father have, on average, more education than the African fathers. Coloured and African mothers also spend their childhood in different family structures. Africans spend less time with their mothers and fathers and more time with their maternal grandparent(s).

Individual characteristics also differ. Coloured mothers have attained close to an additional year of schooling by age 12 even though they are marginally more likely to have failed a grade by this age and they attend schools with smaller class size. Finally, coloured mothers reach menarche at a significantly younger age.

The final two panels of Table 3 compare teen and older mother within population group. For coloureds, the teen mother sample is no longer at an advantage but rather teen mothers appear to be worse off than older mothers. Teen mothers report higher levels of childhood household poverty and presence of drug users and live in households with few or no books. Differences between teens and older mothers are small for Africans, and teen mothers fare better with regards to presence of books in the household and age at menarche. African teen mothers do however have significantly lower literacy and numeracy scores.

Thus the characteristics of teen and older mothers in our data are strongly affected by the share of coloureds within each group. The overall teen mother group is, in part, ‘protected’ by the larger share of coloured mothers which, due to racial inequalities, reduce their overall disadvantage.

Table 3: Mean maternal characteristics

	All			All			Coloured			African		
	Teen	Older		Coloured	African		Teen	Older		Teen	Older	
Teen mother				0.57	0.44	***						
Age in wave 4	22.73	23.93	***									
Coloured	0.69	0.58	***									
Describes childhood household as poor or very poor	0.13	0.15		0.06	0.27	***	0.08	0.03	*	0.24	0.31	
Log mean per capita household income of sub place	10.53	10.44	*	10.81	9.93	***	10.79	10.83		9.94	9.91	
Someone in wave 1 household owns 5 or more books	0.75	0.78		0.85	0.61	***	0.78	0.94	***	0.66	0.56	*
Wave 1 household per capita income	567.02	581.71		703.12	346.03	***	670.00	747.62		332.72	356.69	
Wave 1 household owns a stove	0.84	0.77	**	0.96	0.54	***	0.96	0.95		0.57	0.52	
Mother's education	7.50	7.61		7.65	7.36		7.54	7.80		7.39	7.34	
Father's education	7.65	7.79		8.29	6.67	***	8.11	8.51		6.53	6.77	
Proportion of life lived with mother	0.85	0.83		0.87	0.77	***	0.87	0.87		0.78	0.77	
Proportion of life lived with father	0.55	0.55		0.58	0.49	**	0.58	0.59		0.48	0.50	
Proportion of life lived with maternal grandparent(s)	0.18	0.20		0.17	0.23	*	0.17	0.18		0.22	0.23	
Drug addict in childhood household	0.14	0.08	*	0.15	0.04	***	0.19	0.10	*	0.03	0.05	
Alcoholic in childhood household	0.25	0.18	*	0.23	0.21		0.26	0.18		0.23	0.19	
Highest grade at age 12	5.37	5.19	*	5.63	4.68	***	5.62	5.63		4.79	4.60	
Failed a grade by age 12	0.29	0.25		0.30	0.23	*	0.30	0.29		0.26	0.21	
Standardised numeracy and literacy score	-0.03	0.04		0.01	-0.02		0.02	0.00		-0.14	0.09	**
Number of students in class	40.94	38.91	**	37.44	44.35	***	39.02	35.40	***	45.18	43.69	
Age at menarche	13.34	13.62	*	13.00	14.31	***	13.06	12.92		13.99	14.58	***
Willing at first sex	0.87	0.84		0.90	0.79	***	0.91	0.88		0.78	0.80	
Sample size	309	298		288	319		169	119		140	179	

Notes to table 3: Sample includes all CAPS young adults who had a child by wave 4 and were successfully interviewed in wave 4. Weighted means presented. Stars signify significant differences between prior two columns. P-values <0.01***, <0.05**, <0.1*

3.3 Outcome variables

Five child health outcomes are used in the analysis[2]. These measures include head circumference and weight at birth, current height for age (HAZ) for children over six months and for children one year and older a measure of whether the child's first year immunisations have been completed. In addition, we have indicators of malnutrition or extreme adverse outcomes. We look at whether the child was underweight or had a very small head at birth and whose current height for age would classify them as stunted. The childhood anthropometric measures are universally recognized as efficient measures of childhood nutrition and are not easily influenced by data errors systematically related to teen mother status. Table 4 presents a summary of the outcome variables. The underweight at birth, small head at birth and stunted indicators are defined as Weight at birth (WA_0Z), Head-circumference (HC_0Z) at birth and Height-for-Age (HAZ) Z-scores more than two standard deviations below the median score for the WHO reference population (WHO, 2006).

Following WHO recommendations, values for HAZ more than 6 standard deviations below or above the median were deemed biologically implausible and set to missing (28 cases). Similarly, values of WA_0Z 6 standard deviations below or 5 standard deviations above the median and HC_0Z values above or below 5 standard deviations from the median were set to missing (2 and16 cases respectively). 32 heights, 141 birth weights and 229 birth head circumferences are missing due to 'don't know' responses and refusals. Thus the final samples for the regressions on stunted, underweight at birth and small head at birth are 520, 464 and 362 cases respectively.

Table 4 shows that while the difference between the mean WAZ score for children born to teen versus older mothers is not significant, there is a significant difference in the percentage classified as underweight at birth. 11.6% have WAZ scores at birth below 2 standard deviations from the reference median and 13.3% have birth weights below 2.5kg, a common measure for underweight newborns. A significantly larger percentage of children born to teens are born under 2.5 kilograms (16.5% compared to 10.1%). The opposite is true for head circumference at birth. While children born to teen mothers have head circumference z-scores significantly below those

[2] Current weight and weight for height were also investigated, but the prevalence of underweight children or wasting (low weight for height) children was low. Only 13 children were defined as wasting

born to older mothers, the percentage with small heads is not significantly different between children born to teen versus older mothers.

Table 4: Child outcomes by teen versus older mothers (first born children only)

	All		Born to Teen Mothers		Born to Older Mothers		Difference (Teen-Older)		
	N	Mean	N	Mean	N	Mean	Mean	S. E.	T-stat
WAZ at birth	464	-0.70	219	-0.80	245	-0.60	-0.20	0.13	-1.54
% underweight		11.6%		14.6%		8.8%	0.06	0.03	1.89
% with birthweight<2.5kg		13.3%		16.5%		10.1%	0.06	0.03	2.02
HCZ at birth	362	-0.7	164	-0.88	198	-0.53	-0.34	0.18	-1.92
% with small heads		16.8%		19.4%		14.5%	0.05	0.04	1.17
HAZ	520	-1.18	280	-1.32	240	-1.01	-0.31	0.19	-1.63
% stunted		33.6%		34.7%		32.3%	0.02	0.05	0.51
Immunisations:									
First year immunisations completed	312	75.8%	161	74.5%	151	77.3%	-0.03	0.06	-0.49
Not up-to-date	576	5.8%	288	6.9%	288	4.7%	0.02	0.02	1.11

Notes to table 4: Weighted means presented.

Overall one third of our sample is classified as stunted, with the average HAZ score more than a standard deviation below (-1.18) the reference median. Children born to teen mothers have lower HAZ scores than children born to older mothers but there is little difference in the proportion classified as stunted.

The immunization information comes from two sources. First, for children one year and older whose mother/guardian had their health-chart available at the time of the survey we constructed an indicator of whether the child's first year of routine immunisations has been completed (http://www.capegateway.gov.za/eng/directories/services/11502/6539). This is a measure used by the department of health to assess the progress of child health care in South Africa[3] (Department of health, 2004). For details on the immunisation schedule see Appendix A. Table 4 shows that this measure is only available for 312 children. The immunisation data was recorded

[3] One of the instruments used by the fourth MDG to assess progress is the proportion of 1 year old children immunised against measles. We find similar results to those shown above when this measure of immunization is used

from the child's road to health card[4]. At the interview, only 386 respondents[5] had these clinic cards available. Of these, respondents that were under one year (74 cases) were excluded from the sample.

The second immunisation measure comes from the response to the question *Are the child's immunizations up to date?* and was taken at face value. Response categories were yes, no or don't know. The immunization indicator takes on a value of 1 if immunizations are *not* up to date and zero if they are up to date[6].

Differences are seen between children born to teen mothers versus older mothers but are not significant. At the mean, 74.5% of children born to teen mothers have received all 15 of their first year immunisations while 77.3% of children born to older mothers have completed their first year immunisations. A smaller proportion of mothers indicate directly that their child's immunisations are not up to date[7]. 5.8 % of the total sample indicate that their child's immunizations are not up to date, with teen mothers being marginally more likely to report that their child's immunizations are not up to date (6.9% compared to 4.7%).

4. Methodologies

4.1 Overview

The main challenge in estimating the causal impact of teenage childbearing on young child outcomes is to identify an appropriate counterfactual. For the question at hand, this entails creating a comparison group of non teen mothers who have similar characteristics to teen mothers with the exception that they gave birth at an age older than nineteen. We follow the notation used in the program evaluation literature.

[4] The card records immunisations and growth rate and is given to mothers when their infant is born and is used to monitor the development of the child until it is five years old (http://www.capegateway.gov.za/eng/pubs/public_info/R/3321)

[5] 55.66% of children born to teens and 71.81% born to older mothers had clinic cards available.

[6] Including don't knows as ones had no effect

[7] The correspondence between the two measures is not all that strong. 24% of children whose first year immunizations are not completed have mothers who report that their child's immunizations are up to date. An even larger share of mothers, 38.5%, indicate that their child's immunizations are not up to date although their child successfully completed their first year immunizations. In the second case, the mother is possibly referring to the child missing immunizations given after age one.

Our 'treatment' in the program evaluation literature sense, is being born to a teen mother and is denoted by the binary variable T_i. Let $Y_i(1)$ denote the outcome child i would obtain under treatment and $Y_i(0)$ the outcome obtained under control (being born to a mother who was older than nineteen). We observe $Y_i = T_i Y_i(1) + (1 - T_i) Y_i(0)$, but never the pair $\left(Y_i(1), Y_i(0)\right)$; a child is either born to a teen mother or an older mother. Let the propensity score, the conditional probability of being born to a teen mother, be denoted by $p(x) \equiv P(T_i = 1 | X_i = x)$, where X_i is a list of the mother's pre-childbirth characteristics. Let $\alpha(x) = E[Y_i(1) - Y_i(0) | \, X_i = x]$ denote the covariate-specific average treatment effect. We are interested in estimating the average treatment effect on the treated denoted by $ATT(x) = E[\alpha(x) | \, T_i = 1]$.

We consider three estimators of the ATT: two reweighting estimators and one double robust estimator. Each of these estimators is a two-step estimator and relies on first estimating the propensity score and then using this score to construct a weighted counterfactual from the older mother sample.

When $\sum_{j=1}^{n} \left(1 - T_j\right) \bar{w}_{ij} = 1$, the general notation for the reweighting estimators of ATT is

$$\hat{\theta} = \frac{\sum_{i=1}^{n} T_i Y_i}{\sum_{i=1}^{n} T_i} - \frac{\sum_{j=1}^{n} (1 - T_j) \widehat{V}_j Y_j}{\sum_{j=1}^{n} (1 - T_j) \widehat{V}_j} \qquad (1)$$

where $\widehat{V}_j = \frac{\sum_{i=1}^{n} T_i \bar{w}_{ij}}{\sum_{i=1}^{n} T_i}$ is the average weight observation j in the control group (older mothers) receives across all treatment observations i (Busso et al, 2009).

This means we are interested in calculating β_1 in the following weighted regressions

$$probit Y_i = \alpha_0 + \beta_1 T_i + Z_i' \beta + \varepsilon_i \qquad (2)$$

$$Y_i = \alpha_0 + \beta_1 T_i + Z_i' \beta + \varepsilon_i \qquad (3)$$

where $\beta_1$is an estimate of the casual effect of being born to a teen mother, Z_i' is a vector of child demographic characteristics and ε_i is the error term. Equation 2 is used for binary outcomes and equation 3 for continuous outcome measures.

Our two reweighting estimators have weights of the following form (Sanders et al, unpublished):

$$\overline{w}_{ipw}(j) = \frac{\frac{\hat{p}(x_j)}{1-\hat{p}(x_j)} \cdot SW_j}{\sum_{j\in\{T=0\}} \frac{\hat{p}(x_j)}{1-\hat{p}(x_j)} \cdot SW_j}$$

$$\overline{w}_{kern}(j) = \frac{K\left[\frac{\hat{p}(x_i)-\hat{p}(x_j)}{a_n}\right] \cdot SW_j}{\sum_{j\in\{T=0\}} K\left[\frac{\hat{p}(x_i)-\hat{p}(x_j)}{a_n}\right] \cdot SW_j}$$

$\overline{w}_{ipw}(j)$ presents Hirano et al's (2003) inverse probability weight (IPW) normalised to one. In words, all children born to older mothers are assigned a weight proportional to the conditional probability that their mother gave birth in her teens, the propensity score. $\overline{w}_{kern}(j)$ (KERN) is calculated using a kernel function of the propensity score with $K(\cdot)$ representing the kernel function and a_n the bandwidth[8]. The bandwidth selects the sub-sample of children born to older mothers to form the counterfactual comparison group and the kernel function assigns the importance of each individual included for each child born to a teen mother. Each weight takes into account the CAPS sample design with SW_j denoting the sampling weight for observation j. The weights sum to one by design.

For the double robust estimation, we run a weighted regression of the outcome on a constant, the teen mother indicator and a cubic function of the propensity score. The IPW weight is used. In this way, inclusion of the covariates via the function of the propensity score controls for

[8] We use an epanechnikov kernel with a bandwidth of 0.06

misspecification in the propensity score and hence results in a more consistent estimate of ATT if the outcome equation is correctly specified (Busso et al, 2009).

4.2 Assumptions underlying the model

Two assumptions underlie the consistent estimation of the average effect of being born to a teen mother on children born to teen mothers (Dehejia & Wahba, 2002). The first assumption, commonly called the selection on observables assumption, requires that given X_i, a set of observed covariates, treatment is random (Rosenbaum and Rubin, 1983). The second assumption, often referred to as the overlap or common support assumption, requires that no value of the observed covariates predict treatment assignment exactly. Formally, the common support assumption required to estimate the ATT is $p(x) < 1$ (Sanders et al, 2009).

The plausibility of the selection on observables assumption rests on whether the data are informative enough to account for selection into teenage childbearing. Given the longitudinal nature of the CAPS data in addition to the retrospective calendar of information collected in wave 1, we have many variables measuring individual and household characteristics of mothers prior to the birth of her first child. In addition to the usual demographic variables, the CAPS data collected detailed information about educational progress, sexual history (including age at menarche, sexual debut and protection used during first sexual experience), childhood living arrangements and household characteristics.

Appendix B lists all the variables used to estimate the propensity score. This is a parsimonious specification and explains about a third of the variation in the probability of being a teen mother. We assessed the sensitivity of our estimates to a ‘kitchen sink’ approach where all possible pre-childbirth characteristics were included, and found them to be fairly robust. The choice of variables in our final specification is informed by the literature on the determinants of teenage childbearing and can be broadly categorised into individual, childhood household, household in 2002 and first sexual experience characteristics. Teenage childbearing is often perceived as a result of deviant individual behaviour and lack of contraceptive use (Panday et al, 2009). However, a recent review of the literature on the determinants of teenage childbearing finds that teenage fertility is a “result of a complex set of varied and inter-related factors, largely related to the social conditions under which children grow up" (Panday et al, 2009:15). Students that do poorly at school are more likely to drop out and have less motivation to prevent pregnancy (ibid). On the other hand, Lam et al (2009) find that students that progress through school without failure and are exposed to older peers are at risk of earlier sexual debut. This is consistent the finding that teenage pregnancy rates are higher in schools which combine primary and secondary grades (Panday et al, 2009). Exposure to the risk of teenage pregnancy also makes a difference. Girls who reach menarche and sexual debut at a younger age have a longer exposure period and are therefore at higher risk of falling pregnant during their teens. Teenage childbearing is also associated with poverty (Panday et al, 2009). Children who grow up in poor households, without their parents, especially the absence of their mother, are found to have a higher risk of teenage childbearing (ibid). Finally, social environments where communication about sex is limited or where power relationships between men and women are imbalanced are associated with higher teen fertility (ibid).

We examine the validity of the selection on observables assumption by testing whether the observed characteristics in the treatment and control group are balanced given the propensity score specification. First, we check whether X is orthogonal to our treatment variable given $p(x)$ using the regression based balancing test presented by Smith and Todd (2005). For every covariate x_k we test the joint null hypothesis that all the coefficients on the terms involving T equal zero using an F-test[9]

$$x_k = \delta_0 + \delta_1\hat{p}(x) + \delta_2\hat{p}(x)^2 + \delta_3\hat{p}(x)^3 + \alpha_0 T + \alpha_1 T\hat{p}(x) + \alpha_2 T\hat{p}(x)^2 + \alpha_3 T\hat{p}(x)^3 + \varepsilon_k$$

The test relies on the condition that T should provide no information about the observed characteristics conditional on the estimated propensity score (Smith and Todd, 2005). If any of these F-statistics exceed the 5% significance level, higher order and interaction terms of the

[9] One of the limitations of this test is that the order of the polynomial needs to be chosen. We follow Sanders et al (2009) in the choice of a cubic specification in p(x)

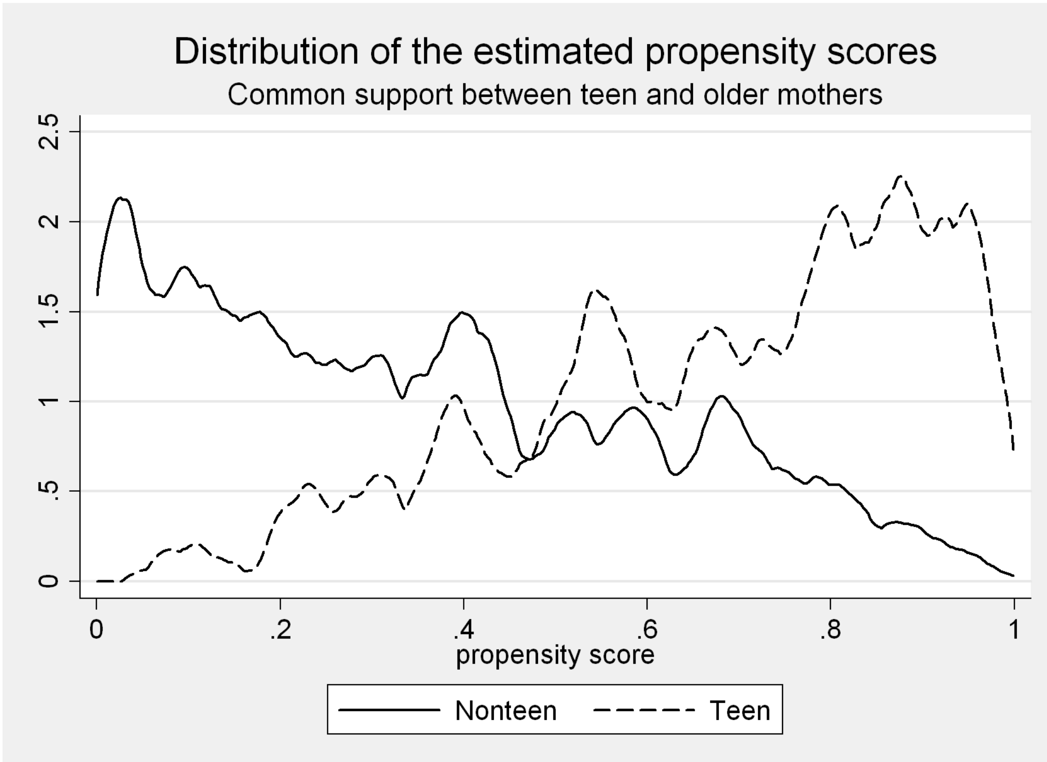
unbalanced variables were included in the propensity score specification and the regressions rerun[10].

Second, we see whether the specification used to predict the propensity score succeeds in balancing variables used in the estimation (internal balancing tests) and variables not used in the estimation (external balancing tests). Appendix D presents the results from these tests. It is clear that the assumption of selection on observables is met; significant differences between the teen and older mother groups are eliminated when the inverse propensity score weight or kernel weight are used.

Figure 3 illustrates that the common support assumption, the second assumption underlying our method, is met. The figure shows that the distribution of the estimated propensity score for children born to teen mothers overlaps the distribution of the estimated propensity score for children born to older mothers.

[10]In total we include 4 additional variables to balance the observables. These are the square of the numeracy and literacy test score, and interactions between poor and the test score, poor and the test score squared, highest grade at age 12 and the test score and poor and the community household income measure

Figure 3[11]



5. Results

Table 5, columns 3-5, presents estimates of the causal effect of being born to a teen mother (β_1) on our range of child health outcome measures. Each cell presents the teen mother coefficient from a different regression. For the dichotomous outcomes, this coefficient is the marginal effect on the teen mother indicator from a probit specification ($\beta_1$in equation 2) and for the continuous outcomes, it is the coefficient on the teen mother indicator from a weighted least squares specification ($\beta_1$in equation 3).

The Naive model and straight models are included for comparison purposes. The Naive model includes only child controls (indicators of the child's population group and sex and a quadratic in age in days for current outcome measures) and the Controls model includes all observables used

[11] A similar figure, in Appendix E, illustrates that the common support condition is met when the propensity score is estimates for Africans and coloureds separately.

to predict the probability of being a teen mother in addition to the child controls. The IPW and Kernel models mimic the naive model in structure but are weighted by the inverse probability and kernel weight respectively. DR is the double robust model which includes both the child controls and a cubic function of the propensity score and is weighted by the inverse probability weight. Robust standard errors are presented in parenthesis and are bootstrapped for the IPW, Kernel and DR regressions.

Table 5: Effect of being born to a teen mother on child health outcomes

	OLS		Matching			
	Naïve	Controls	IPW	Kernel	DR	Sample
WAZ at birth	-0.109	-0.141	-0.268*	-0.233	-0.255*	422
	(0.13)	(0.15)	(0.15)	(0.16)	(0.15)	
underweight at birth	0.072**	0.071**	0.098***	0.097**	0.098***	412
	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	
low birth weight	0.076**	0.087**	0.117***	0.116***	0.117***	412
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	
current HAZ	-0.272	-0.561*	-1.078**	-1.19*	-1.093**	481
	(0.26)	(0.32)	(0.5)	(0.64)	(0.55)	
stunted	0.01	0.022	0.136**	0.14**	0.157**	481
	(0.06)	(0.08)	(0.07)	(0.07)	(0.07)	
HCZ at birth	-0.298	-0.214	-0.42	-0.228	-0.363	320
	(0.19)	(0.22)	(0.49)	(0.6)	(0.49)	
small head at birth	0.036	0.019	0.063	0.046	0.058	313
	(0.05)	(0.04)	(0.05)	(0.07)	(0.05)	
First year immunisations complete	-0.021	-0.042	-0.057	-0.052	-0.063	288
	(0.06)	(0.09)	(0.06)	(0.08)	(0.07)	
Not up to date	0.015	0.01	-0.027	-0.051	-0.022	518
	(0.02)	(0.01)	(0.07)	(0.07)	(0.08)	

Notes to Table 5: Marginal effect of being born to a teen mother from weighted probit regression for dichotomous outcomes. Weighted OLS regression used for continuous outcomes. Standard errors presented in parenthesis, bootstrapped for IPW, Kernel and DR. Naive is weighted by sample weights, Controls includes all controls used in matching procedure and is weighted by sample weights, IPW is weighted by inverse probability weight, kernel by the kernel weight and DR represents the double robust specification. The same sample is used for each regression on a common outcome. All regressions include African and male indicators. Current outcome measures (HAZ and stunted) also include a quadratic in age in days.

The naïve and straight estimates show a small and insignificant effect of being born to a teen mother on the child's weight at birth z-score. Children born to teen mothers have WAZ at birth values 0.1 standard deviations lower than children born to older mothers. Shifting to columns 3-5, our estimates of the causal effect, the size of the coefficient increases and becomes marginally significant. Children born to teen mothers have WAZ at birth scores a quarter of a standard deviation below the average score for children born to older mothers.

The adverse effect of being born to a teen mother is even more apparent when considering whether the child was born underweight as defined by two standard deviations below the WHO references population (underweight at birth) or below 2.5kg (low birth weight). For the underweight at birth outcome, the naïve and straight estimators show that children born to teen mothers are seven percent more likely to be underweight at birth. These estimates cannot however be interpreted as causal. If we shift to the matching estimates in columns 3-5, the adverse effect of being born to a teen mother increases. Children born to teen mothers are around 10 percentage points more likely to be born underweight than children born to older mothers. These effects are highly significant. Similar, but larger, effects are seen when the low birth weight measure is used.

Height for age also appears to be linked to maternal age. While the naïve and straight estimates show a small and insignificant effect of being born to a teen mother on the child's HAZ and likelihood of being stunted, when we shift to the matching estimates in columns 3-5, we find large effects. Child born to teens are 1.1 standard deviations shorter than children born to older mothers and this effect is significant. In addition, children born to teen mothers are between 13 and 16 percent more likely to be stunted.

The size and significance of the teen mother effect on the child's probability of being born underweight or stunted is consistently measured across the IPW, KERN and DR regression.

We find less evidence of a negative effect of being born to a teen mother for the other outcomes. The direction of the coefficient on head circumference at birth and completed first year immunisations signal a negative effect of being born to a teen but the indicator of the mother reporting that her child's immunisations were not up to date signals that teen mothers are more likely to report that their child's immunisations are up to date. Since children born to teen mothers are on average older at the time of the survey, this could be a signal that teen mothers have had more time to complete the required immunisations. None of these effects are however precisely measured.

Table 6: Underweight at birth – differences in the effect of being born to a teen mother on the likelihood of being underweight between Africans and coloured

	OLS		Matching			
	Naïve	Controls	IPW	Kernel	DR	Sample
African only:						
underweight at birth	0.055	0.055	0.059	0.081	0.06	236
	(0.05)	(0.04)	(0.07)	(0.06)	(0.06)	
low birth weight	0.052	0.054	0.067	0.085	0.068	236
	(0.05)	(0.05)	(0.07)	(0.06)	(0.06)	
Coloured only:						
underweight at birth	0.130***	0.036	0.132	0.139	0.136	170
	(0.04)	(0.03)	(0.09)	(0.09)	(0.09)	
low birth weight	0.134***	0.099***	0.16*	0.166*	0.158*	170
	(0.05)	(0.03)	(0.1)	(0.1)	(0.09)	

	OLS		Matching			
	Naïve	Controls	IPW	Kernel	DR	Sample
African only:						
current HAZ	-0.261	-0.185	-0.242	-0.289	-0.245	242
	(0.18)	(0.2)	(0.4)	(0.44)	(0.43)	
stunted	-0.01	-0.054	0.064	0.058	0.082	246
	(0.07)	(0.1)	(0.1)	(0.11)	(0.11)	
Coloured only:						
current HAZ	-0.548	-0.567	-1.395	-2.213**	-1.347	206
	(0.41)	(0.49)	(1.09)	(1.03)	(1.15)	
stunted	0.047	-0.071	0.078	0.16	0.06	206
	(0.08)	(0.14)	(0.14)	(0.15)	(0.16)	

Notes to Table 6: Marginal effect of being born to a teen mother from weighted probit regression for dichotomous outcomes and weighted OLS regression for continuous outcomes. Standard errors presented in parenthesis, bootstrapped for IPW, Kernel and DR. Naive is weighted by sample weights, Controls includes all controls used in matching procedure and is weighted by sample weights, IPW is weighted by inverse propensity score weight, kernel by the kernel weight and DR represents the double robust specification. All regressions include a male indicator and current measures include a quadratic in age in days. Full African only restricts the sample to Africans resulting in matching within the African population group. Similarly, coloured only matches individuals within the Coloured population group only.

Table 6 presents the birth weight and height outcomes when matching is done within population group. For instance, in the top half of the top panel (African only) the sample is restricted to Africans and the IPW and kernel weights calculated. Thus the teen counterfactual is constructed based on a propensity score calculated within the African population group. Samples are small once the full sample is separated into African and coloured and the common support condition enforced, thus we have limited power to find significant results. We therefore discuss the relative size of the coefficients between Africans and coloureds even if significance is not found.

The adverse effect of being born to a teen on birth weight is much larger for coloureds than Africans. Coloured children born to teen mothers are around 16 percent more likely to be born with low birth weight than children born to older mothers. These effects are significant and consistently measured across all matching algorithms. The effect is about half as bad for Africans. African children born to teen mothers are, on average, between 7 and 8.5 percent more likely to be born underweight. However, the size of the effect is not consistently measured across all matching algorithms and is not significant.

Similar, albeit larger, differences are seen between population groups for the height-for-age measures, although these estimates are not robustly measured. Children born to teens in the African sample have z-scores 0.25 standard deviations below children born to older mothers. A much larger disadvantage is seen in the coloured only group. Children born to coloured teens are between 1.3 and 2.2 standard deviations shorter than children born to older mothers. The difference between population groups in the probability of being stunted is however small.

6. Sensitivity analysis

Our estimate of a negative effect of being born to a teen mother on birth weight is at odds with findings from Geronimus and Korenman (1993). Using a siblings fixed effects model they find no causal effect of maternal age on, among other things, birth weight when children born to women in their teens are compared to their cousins born to their aunt at an older age (ibid). Our estimates are unbiased conditional on observable characteristics while the siblings fixed effects models control for both observable and unobservable characteristics common between siblings. Hence part of the difference in our findings could be a result of bias due to unobservable characteristics. We follow Ichino, Mealli and Nannicini (2007) and perform a sensitivity analysis in an attempt to assess whether we can construct a confounder that has the potential to wipe out this negative effect of being born to a teen mother.

Our estimates rely on the selection on observable assumption (CIA), which means that treatment is random conditional on characteristics observed in the data. This assumption does not however condition on unobservable characteristic(s). If these unobserved factors influence both the likelihood of teenage childbearing and the child outcome, our estimates of the effect of early childbearing will be biased. For instance, the data might not contain variables on decision making within the household. Thus, if the structure of household decision making affects both the likelihood of teenage childbearing and the child's outcomes our estimates will be biased. We follow Ichino et al's (2007) sensitivity analysis to test for violations of the conditional independence assumption. More specifically we assess whether a potential unobserved confounder, U, if observed could drive the ATT to zero.

We introduce U which summarises the unobservables in a simplified binary variable and assume that the CIA assumption only holds when we condition on U in addition to the previous X controls. Since U is not observed, the outcomes from the older mothers cannot be used to construct a counterfactual outcome for the teen mother. We therefore simulate the distribution of U in order to assess the effect of this potential confounder on the ATT estimate. U is assumed to be binary and to be independently and identically distributed across the cell of the Cartesian product of the treatment and outcome values i.e. it is fully characterized by the following four parameters:

$$p_{ij} \equiv Pr(U = 1|T = i, Y = j) = Pr(U = 1|T = i, Y = j, X) \quad (4)$$

$$p_{ij} \equiv Pr(U = 1|T = i, I(Y > y^{*}) = j) \quad (5)$$

where equations (4) and (5) are applied for discrete and continuous outcomes respectively and $i, j \in \{0,1\}$, I is an indicator function and y^{*} is a chosen tipping point in the distribution of Y (Nannicini, 2007). In words, p_{ij} presents the probability that $U = 1$ in each group defined by the treatment (i) and outcome (j).

The p_{ij} parameters are set arbitrarily and a value of U assigned to each respondent. This simulated U can therefore be treated as another observed covariate and included in the estimation of the propensity score and hence the estimated ATT over multiple simulations. In this way, an estimate of ATT can be calculated that is robust to the failure of the CIA implied by the choice of the p_{ij} parameters, in other words to a confounder which is of the particular configuration specified.

Potentially problematic confounders result in

$$Pr(Y(0) = 1|T, X, U) \neq Pr(Y(0) = 1|T, X) \quad (6)$$

$$Pr(T = 1| X, U) \neq Pr(T = 1| X) \quad (7)$$

Where in (6) U is a confounding factor that have a positive effect on the untreated outcome $Y(0)$, and in (7), U has a positive effect on the assignment of treatment, both after conditioning on X. Ichino et al (2007) show that assuming $p_{01} > p_{00}$ in equation (6) and $p_{1.} > p_{0.}$ in equation (7) in the simulation results in confounders of the required form. Thus we can calculate the effect that U, the simulated confounder, has on $Y(0)$ and T after conditioning on X.

At every iteration the average odds ratio of U, Γ[12] is calculated from a logit model $Pr(Y = 1|T = 0, U, X)$[13], which Ichino et al (2007) call the "outcome effect". We assess how large this effect needs to be to drive the ATT to zero. Similarly, $Pr(T = 1|U, X)$ is estimated at each iteration and Λ[14], the "selection effect" reported (Nannicini, 2007).

Table 7 presents the results from the sensitivity analysis. The estimated effect of teenage childbearing on the likelihood of low birth weight (ATT), the between iteration standard error (SE) and the outcome and selection effects are presented for different levels of $d = p_{01} - p_{00}$ and $s = p_{1.} - p_{0.}$.

Table 7 shows that our estimate of an increased risk of being born underweight if born to a teen mother is fairly robust; even for a simulated unobservable that plays a large role in both the propensity score and outcome equation the effect remains negative and significant. For instance, if we look at the first panel of results, even for U associated with a very large selection and

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[12] $\Gamma \equiv \frac{\frac{Pr(Y=1|T=0,U=1,X)}{Pr(Y=0|T=0,U=1,X)}}{\frac{Pr(Y=1|T=0,U=0,X)}{Pr(Y=0|T=0,U=0,X)}}$

[13] For continuous outcomes the odds ratio is calculated from the probit model $Pr(Y > y^{*}|T = 0, U, X)$

[14] $\Lambda \equiv \frac{\frac{Pr(T=1|U=1,X)}{Pr(T=0|U=1,X)}}{\frac{Pr(T=1|U=0,X)}{Pr(T=0|U=0,X)}}$

outcome effect (e.g. Λ =7.7[15] and Γ= 2.1[16]), the simulated effect of being born to a teen mother on birth weight remain very close to the baseline estimate (d=s=0). Observing the rest of the table, only for very extreme (and likely implausible) levels of selection and outcome effects does the effect of young maternal age on the probability of being born underweight diminish and become indistinguishable.

Another way to think about this, is that in order to drive our baseline casual estimate to zero, we require a confounder that increases the likelihood of being born to a teen mother 18.7 fold and increases the likelihood of being born underweight among children born to older mothers, 70.3 times.

[15] In other words, the odds of being born to a teen mother conditional on this confounder and the other X observables would increase 7.7 fold

[16] The odds of being born underweight among the non teen mothers would increase 2.1 times

Table 7: Sensitivity Analysis – simulating a confounder that would wipe out the disadvantage on birth weight of being born to a teen mother

d	0.1				0.2				0.3				0.4				0.5			
s	ATT	SE	Γ	Λ	ATT	SE	Γ	Λ	ATT	SE	Γ	Λ	ATT	SE	Γ	Λ	ATT	SE	Γ	Λ
0.1	0.09	0.01	2.9	1.6	0.09	0.00	6.6	1.6	0.08	0.01	42.0	1.7	0.08	0.01	105970.8	1.7	0.08	0.01	7.28E+03	1.8
0.2	0.08	0.01	7.3	2.5	0.08	0.01	7.1	2.5	0.07	0.01	26.1	2.7	0.07	0.01	548.1	3.0	0.07	0.01	1.22E+05	2.6
0.3	0.09	0.03	2.5	5.0	0.07	0.02	9.5	4.5	0.07	0.02	24.2	5.2	0.07	0.02	22.4	4.6	0.07	0.02	3.81E+01	3.7
0.4	0.08	0.02	2.1	7.7	0.06	0.03	6.1	7.6	0.06	0.03	24.5	7.6	0.01	0.05	32.4	8.4	0.05	0.02	2.47E+02	6.3
0.5	0.07	0.05	3.7	13.8	0.05	0.06	8.3	17.7	0.04	0.04	18.9	20.5	0.00	0.06	70.3	18.7	0.00	0.04	8.26E+03	13.2
0.6	0.07	0.06	5.2	35.7	-0.01	0.06	12.7	31.0	-0.05	0.10	82.3	28.5	-0.03	0.08	36.7	28.1	-0.13	0.08	1.18E+36	44.5
0.7	0.06	0.05	5.3	74.8	0.02	0.09	23.0	131.6	-0.20	0.15	1438.6	119.7	-0.23	0.15	14448.1	111.1	-0.38	0.20	2.31E+04	137.4

Notes to Table 7: Sensitivity analysis output with ten iterations. Kernel matching algorithm used to calculate the ATT, with bootstrapped standard errors. $Pr(U = 1)$ set to 0.4 and $p_{11} - p_{10}$ set to 0.2 since these quantities are not meant to pose a threat to the baseline estimate from table 5. Outcome and selection effects calculated as per footnote 11 and 13 respectively. $d = p_{01} - p_{00}$ and $s = p_{1.} - p_{0.}$

7. Discussion and conclusions

Studies of teenage childbearing and its socioeconomic consequences have been concerned with the bias introduced into the estimation of the 'true' effect of teenage childbearing as a result of omitted variables and selection bias. This paper attempts to contribute to this debate by using propensity score reweighting to find a statistically appropriate comparison group for children born to teen mothers and by extending the research to the South African context, in particular to Cape Town.

We find results which are in some ways inconsistent with previous research (Geronimus and Korenman, 1993, Lee, 2006, Levine et al, 2007 and others). Unlike previous studies, our propensity score results do not suggest that teen mothers are inherently socioeconomically disadvantaged. In fact, once teen mothers are matched to older mothers of similar characteristics the effects of being born to a teen on all our child outcome measures increases rather than decreases as would be expected if much of the effect of having a teenage mother was driven by her pre-childbirth disadvantage. Our estimates suggest that in our sample, teen mothers are not selective of women from intrinsically worse backgrounds.

Comparing mean characteristics between teen mothers and older mothers in our sample give some information about why our teen group does not appear to be selective of women from worse SES. While we find significant differences on age, population group, age at sexual debut and the likelihood of having a drug user in the mother's childhood house (our teen mothers are older, more likely to be coloured, to have had their sexual debut at a younger age and to be exposed to a drug users in their childhood home), they do not appear to live in households of poorer socioeconomic status and are not significantly further behind at school.

The first reason our sample of children born to teen mothers does not appear to come from inherently more disadvantaged backgrounds is a result of the larger share of coloureds in the teen group. Due to political discrimination under apartheid, coloureds are on average more socioeconomically advantaged than Africans. Thus population group remains a proxy for unobserved socio economic differences between groups. The naive estimates of the effect of being born to a teen mother are thus masked by the greater representation of coloureds in the teen mother group.

Second, our teen mothers do not appear to be poor students prior to the birth of their child. Teen mothers have similar test score and rates of failure by age 12 and have completed significantly more grades by age 12 than non teen mothers[17]. These results are consistent with evidence from a sister study on the CAPS data. Lam et al (2009) find that high grade repetition and school enrolment in South African schools creates an environment in which students that progress through school without failure, i.e. 'good' students, experience sexual debut earlier likely a result of exposure to older peers' behaviour.

Thus when we compared children born to teen mothers to their matched counterparts whose mothers are similar on the observed pre existing characteristics (including population group) except that they gave birth at an age older than 19, we find some evidence that children born to teens have worse health outcomes. Children born to teen mothers are more likely to be underweight at birth, are shorter for their age and are more likely to be stunted.

We find differences between Africans and coloured, with a much larger adverse effect of early childbearing among coloureds. Coloured children born to teen mothers have around twice the disadvantage when compared to children born to older mothers than is apparent in the African sample. We find similar difference between African and coloureds in another study on the consequences of being born to a teen mother using CAPS. In that study we find that while coloured children born to teens are found to be at risk of worse educational and home environment outcomes, with negative home environment outcomes apparent even after controlling for unobserved factors common between siblings, there is not even evidence of a strong correlation between being born to a teen mother and young adult outcomes among Africans (Branson et al, unpublished).

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[17] Marteleto et al (2006) find that young adults in the CAPS data who gave birth to children during their teens were significantly further behind young adults that did not give birth, even before the birth. We however compare teen mothers to other older, although still relatively, young mothers.

Geronimus and Korenman (1993) included low birth weight as one of their child outcomes when assessing the effect of young maternal age on health disadvantage. They find no significant difference in the odds of bearing an underweight child for teen mothers when they are compared to their sisters who gave birth at an older age. The difference in result could be a function of many things. First, the sample population is different. Geronimus (1996) notes, that the effect of young maternal age on child wellbeing is heterogeneous across different groups partly a result of social inequalities. For example, she finds that the incidence of low birth weight babies increases for African American mothers between the late teens and twenties, while it decreases for white women over the same period. She attributes this to deteriorating maternal health with age resulting in higher risks at childbirth in poorer communities (Geronimus, 1996).

Second, comparing sisters with differences in the timing of their births might result in downward biased estimates. Sisters are more likely to give birth to children of similar size for genetic reasons. This would result in smaller differences between sisters and therefore between children born to teen versus older mothers. Finally, the sample is selective of women who have siblings who have also given birth and therefore, as noted by Geronimus and Korenman (1993) themselves, is not a representative group.

Several limitations of this paper and areas for further research should be mentioned. First, the propensity score method is a statistical attempt to estimate the causal impact of being born to a teen mother. It does not present a solution to resolve all the selection bias issues. In particular it does not deal with selection on unobservable and hence omitted variables. The results from the sensitivity analysis however, show that the baseline negative effect on birth weight is robust to potential unobserved confounders, even ones with fairly large selection and outcome effects. Second, the results reported here, as is common in this literature, refer to the average effect of being born to a teen mother, i.e. the reduced form effect. We have not attempted to unpack the underlying mechanisms by which being born to a teen mother affects the child's health outcomes. Third, it is likely that structural factors influence the association between teenage childbearing and subsequent outcomes and therefore our findings are conditional on the context in Cape Town. Societal norms and barriers to premarital sex in addition to housing density, schooling duration and grade repetition rates vary significantly across South Africa and thus the estimated effect of teenage childbearing on child health in Cape Town is unlikely to be representative of South Africa in general.

Despite these limitations, this paper clearly indicates that teenage childbearing has an intergenerational effect on child health. In addition, to the extent that childhood health outcomes affect the future life course of the child, via their impact on educational attainment or adult health, our results have policy relevance. They suggest that family planning information, education and communication programmes aimed at postponing teenage pregnancies to beyond age 19 could have a positive impact on child health and future outcomes.

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APPENDIX A

Table A.1: Routine childhood immunisation schedule

Age	Vaccine	How?
At birth	BCG (vaccine against TB) Polio vaccine	Vaccination upper right arm Drops by mouth
6 weeks old	Polio vaccine DTP* vacc + Hib# vacc Hepatitis B vaccine	Drops by mouth Injection in left thigh Injection in right thigh
10 weeks old	Polio vaccine DTP* vacc + Hib# vacc Hepatitis B vaccine	Drops by mouth Injection in left thigh Injection in right thigh
14 weeks old	Polio vaccine DTP* vacc + Hib# vacc Hepatitis B vaccine	Drops by mouth Injection in left thigh Injection in right thigh
9 months old	Measles vaccine	Injection in right thigh
18 months old	Polio vaccine DTP* vaccine Measles vaccine	Drops by mouth Injection in left arm Injection in right arm
6 years old	Td** vaccine	Injection in left arm

DTP* = vaccine against diphteria, pertussis (whooping cough) and tetanus

DT** = vaccine against diphteria and tetanus (lock jaw) only

Hib# = vaccine against Haemophilus influenza type b

Source: http://www.capegateway.gov.za/eng/directories/services/11502/6539

APPENDIX B

Table B.1: Descriptive characteristics for child outcome variables

	All			Coloured			African			All			Coloured			African		
	Stunted	Not stunted		Stunted	Not stunted		Stunted	Not stunted		Under-weight at birth	Not under-weight		Under-weight at birth	Not under-weight		Under-weight at birth	Not under-weight	
Born to a teen mother	0.57	0.52		0.64	0.57		0.41	0.45		0.62	0.47	*	0.69	0.52	*	0.50	0.40	
Coloured	0.69	0.57	**							0.62	0.61							
Mother's characteristics:																		
Describes childhood HH as poor or very poor	0.12	0.16		0.06	0.07		0.25	0.28		0.17	0.14		0.15	0.04		0.21	0.28	
Log mean per capita HH income of sub place	10.54	10.43		10.84	10.79		9.88	9.95		10.47	10.46		10.80	10.82		9.93	9.92	
Wave 1 household per capita income	513.3	568.9		611.2	721.0		299.1	364.5	*	509.9	570.7		641.2	717.2		299.2	346.2	
Someone in w1 HH owns 5 or more books	0.68	0.78	***	0.74	0.89	***	0.56	0.64		0.70	0.76		0.76	0.86		0.61	0.60	
Wave 1 household owns a stove	0.85	0.78	**	0.97	0.96		0.59	0.54		0.82	0.78		0.97	0.95		0.57	0.53	
Mothers's education	6.89	7.68	**	6.74	7.85	**	7.26	7.46		6.90	7.55		7.06	7.64		6.64	7.41	
Fathers's education	7.40	7.69		7.64	8.44		6.82	6.67		7.21	7.77		8.31	8.16		5.73	7.09	
Prop. of life lived with mother	0.81	0.84		0.86	0.88		0.71	0.80	*	0.83	0.84		0.81	0.88		0.86	0.77	
Prop. of life lived with father	0.57	0.54		0.62	0.57		0.46	0.50		0.59	0.55		0.57	0.61		0.63	0.46	*
Prop. of life lived with maternal grandparent(s)	0.17	0.20		0.13	0.19		0.25	0.22		0.18	0.20		0.18	0.17		0.18	0.24	
Drug addict in childhood HH	0.10	0.12		0.11	0.18		0.06	0.04		0.10	0.10		0.17	0.15		0.00	0.04	***
Alcoholic in childhood HH	0.25	0.20		0.25	0.19		0.25	0.20		0.30	0.22		0.30	0.24		0.30	0.18	
Number of students inclass	39.45	40.20		37.70	37.12		43.38	44.23		38.63	40.73		35.56	38.20		43.33	44.61	
Age at menarche	13.61	13.44		13.41	12.72	***	14.06	14.42	*	13.34	13.41		12.75	12.82		14.30	14.30	
(Average) sample size	168	364		87	149		81	215		51	400		22	178		29	222	

Notes to table B.1: Weighted means presented. Stars portray significant differences between prior two columns. <0.01***, <0.05**, <0.1*

APPENDIX C

Table C.1: Variables used in Propensity score estimate

Born to a teenage mother indicator	
Teen	Child's mother gave birth to them before the age of 20
Mother's characteristics:	
Age	Mother's age at wave 4 interview (2006) -quadratic included
Coloured	Indicator that the mother is coloured
Numeracy score	Age standardised numeracy score
Literacy score	Age standardised literacy score
Education	Highest grade completed by age 12
Failed	Mother failed at least one grade by age 12
Married*	Mother was married before she gave birth to child
Menarche	Age at menarche -quadratic included
Mother's first sexual experience:	
Sexual debut	Age of sexual debut -quadratic included
Willing*	Mother was a willing participant at first sex
Contraception*	Used contraception at first sex
Condom	Used condom at first sex
Disease only*	Used contraception to prevent disease only at first sex
Mother's childhood household:	
Poor	Mother defines her childhood household as poor or very poor
Drugs	When growing up (up to age 14) lived with someone who used street drugs
Alcoholic	When growing up (up to age 14) lived with someone who was an alcoholic
Live with mother	Proportion of first 13 years (age 0 to 12) that mother lived with her mother
Lived with father	Proportion of first 13 years (age 0 to 12) that mother lived with her father
Lived with maternal grandparent(s)	Proportion of first 13 years (age 0 to 12) that mother lived with her maternal grandparent(s)
Mother's education	Mother's mother's highest level of education
Father's education	Mother's father's highest level of education
Mother's household in Wave 1:	
Household income	The logarithm of mean household income in Wave 1 sub place
Owned 5 books	Someone in Wave 1 household owned 5 or more books
No religion*	No main religion in Wave 1 household

*Variables not included in final specification

APPENDIX D

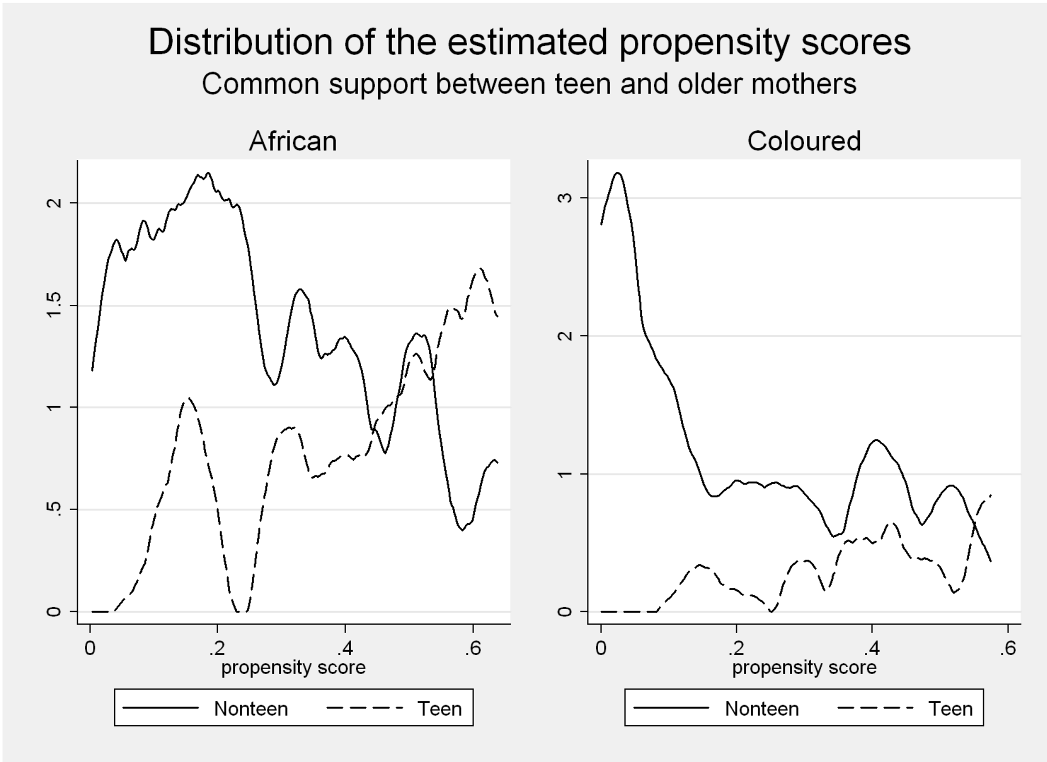
TableD.1: Internal balancing tests

	Average		Sample weight only				Inverse propensity score weight			Kernel weight		
	Teen	Older	Difference (Teen - Older)	Std. Error	Sign. Diff.		Difference (Teen - Older)	Std. Error	Sign. Diff.	Difference (Teen - Older)	Std. Error	Sign. Diff.
Mother's age	22.73	23.93	-1.21	0.16	0.00	***	0.16	0.39	0.68	0.05	0.35	0.89
Coloured	0.69	0.58	0.12	0.04	0.00	**	0.01	0.06	0.86	-0.02	0.06	0.69
Failed grade by age 12	0.29	0.25	0.03	0.04	0.46		0.00	0.07	0.99	-0.02	0.07	0.81
LNE score	-0.03	0.04	-0.07	0.08	0.40		-0.21	0.16	0.18	-0.20	0.15	0.18
Age of menarche	13.34	13.62	-0.30	0.15	0.06		-0.32	0.18	0.08	-0.23	0.29	0.44
Age of sexual debut	16.46	18.01	-1.57	0.17	0.00	***	-0.02	0.21	0.92	-0.23	0.24	0.33
Use condom at first sex	0.37	0.40	-0.03	0.04	0.44		0.09	0.06	0.12	0.09	0.07	0.17
Grandmother's highest level of education	7.50	7.61	-0.13	0.28	0.65		-0.14	0.32	0.66	-0.50	0.43	0.24
Grandfather's highest level of education	7.65	7.79	-0.08	0.39	0.84		-0.29	0.48	0.54	-0.58	0.56	0.30
Drugs in mother's childhood household	0.14	0.08	0.06	0.03	0.04	*	0.07	0.04	0.07	0.07	0.04	0.09
Alcoholic in mother's childhood household	0.25	0.18	0.06	0.04	0.10		0.07	0.05	0.17	0.05	0.07	0.51
Mother defines childhood household as poor	0.13	0.15	-0.02	0.03	0.54		0.00	0.05	0.94	0.01	0.05	0.86
Log of mean household income in Wave 1 subplace	10.53	10.44	0.09	0.05	0.12		-0.02	0.07	0.78	-0.05	0.08	0.52
Own 5 books	0.75	0.78	-0.03	0.04	0.46		0.01	0.07	0.92	-0.04	0.06	0.54
Proportion childhood mother lived with mother	0.85	0.83	0.01	0.03	0.61		-0.01	0.04	0.73	-0.03	0.04	0.40
Proportion childhood mother lived with father	0.55	0.55	0.00	0.04	0.94		-0.06	0.07	0.45	-0.01	0.08	0.89
Proportion childhood mother lived with grandparent(s)	0.18	0.20	-0.01	0.03	0.62		0.03	0.04	0.49	0.00	0.05	0.93
No main religion in Wave 1 household	0.04	0.06	-0.02	0.02	0.15		-0.01	0.02	0.68	-0.01	0.03	0.64

Table D.2: External balancing tests

	Average		Sample weight only				Inverse propensity score weight				Kernel weight			
	Teen	Older	Difference (Teen - Older)	Std. Error	Sign. Diff.		Difference (Teen - Older)	Std. Error	Sign. Diff.		Difference (Teen - Older)	Std. Error	Sign. Diff.	
Per capita Wave 1 household income	567.02	581.71	-5.79	57.78	0.92		22.82	81.29	0.78		-14.32	130.47	0.91	
Wave 1 household owns a stove	0.84	0.77	0.08	0.03	0.01	*	0.10	0.06	0.10		0.10	0.06	0.13	
Highest grade at age 15	8.02	7.89	0.11	0.12	0.33		0.05	0.19	0.79		-0.01	0.16	0.95	
Highest grade at age 16	8.70	8.69	0.00	0.13	0.97		-0.04	0.23	0.86		-0.12	0.20	0.53	
Highest grade at age 17	9.13	9.38	-0.25	0.16	0.12		0.05	0.20	0.79		0.04	0.21	0.85	
Highest grade at age 18	9.34	10.00	-0.66	0.20	0.00	***	-0.14	0.27	0.60		-0.12	0.28	0.68	
Highest grade at age 19	9.49	10.30	-0.81	0.22	0.00	***	-0.38	0.35	0.29		-0.27	0.36	0.45	
Failed at age 15	0.10	0.12	-0.02	0.02	0.42		0.01	0.04	0.82		0.02	0.03	0.56	
Failed at age 16	0.08	0.13	-0.05	0.03	0.07		-0.21	0.10	0.03	*	-0.16	0.08	0.04	*
Failed at age 17	0.07	0.12	-0.05	0.02	0.04	*	-0.10	0.06	0.10		-0.10	0.06	0.10	
Failed at age 18	0.07	0.12	-0.04	0.03	0.24		-0.02	0.05	0.65		0.00	0.05	0.95	
Number of students in mothers class	40.94	38.91	2.15	0.95	0.03	*	0.51	1.62	0.75		0.61	1.60	0.71	
Willing at first sex	0.87	0.84	0.03	0.03	0.31		0.06	0.05	0.24		0.04	0.06	0.44	
Used contraception at first sex	0.47	0.59	-0.13	0.05	0.01	**	-0.06	0.07	0.42		-0.09	0.08	0.26	

APPENDIX E


Distribution of the estimated propensity scores
Common support between teen and older mothers
African
Coloured
0
.5
1
1.5
2
3
0
.2
.4
.6
propensity score
Nonteen
Teen