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

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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. These results remain robust even when we simulate influential unobservable effects in both the reweighting equation and the outcome equation.

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1. Introduction

Research into the consequences of teenage childbearing for the mother and her child is abundant in the international literature (see Hoffman et al., 1993 for a review). 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 delayed childbearing beyond her 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 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. Section 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 (see Currie (2009) for a recent review) and forms a foundation which potentially affects all subsequent outcomes. For example, 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. 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. 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 set containing data from South Africa. Yamauchi

(2006) find short run effects of childhood health using data from the Kwazulu-Natal province in South Africa. Comparing siblings, an increase in the height-for-age z-scores at ages 1 to 3 is associated with earlier enrolment, a higher grade completion rate and lower grade repetition (Yamauchi, 2006).

The debate around whether teenage childbearing has adverse outcomes for child health is centered on the idea that teens are biologically and psychosocially less mature and therefore less prepared to face pregnancy, childbirth and subsequent childcare (Zabin & Kiragu, 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) note, however, 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 experience worse outcomes even if their mothers delayed child birth to beyond her teens (ibid).

The problem is how to disentangle whether the poorer outcome is a result of the early timing of the birth or a consequence of other existing social and economic disadvantages. In essence, the question which the literature attempts to answer is whether the child, if born to the same mother at a later age would fare better on the measured outcomes. Econometric endogeneity is therefore the main challenge in calculating the effect of being born to a teen mother on child outcomes. Four primary methodologies are used in the teen childbearing literature to construct, under specific assumptions, plausible counterfactuals. These methodologies can broadly be classified as controlling for unobserved heterogeneity using instrumental variables, 'natural' experiments, family fixed effects and 'selection-on-observables'.

Instruments used in the literature include mothers' age at menarche, regional availability of doctors/nurses, abortion rates (Klepinger et al., 1999 & 1995; Ribar, 1994) and abortion policy reforms (Angrist & Evan, 1996). Regional availability of doctors/nurses is however very likely to be correlated with child health as they signal access to resources. Similarly, age at menarche and abortion rates has been shown to be correlated with socioeconomic status (Knaul, 2000). Thus these instruments will not be valid for the investigation of the impact of teenage childbearing on child health.

Miscarriage has been exploited as a natural experiment to investigate teenage mother outcomes (Hotz et al., 1997 & 2004, Ashcraft & Lang, 2006, Fletcher & Wolfe, 2008). Assuming that miscarriage is random[2], children born to teens are compared to children born to mothers whose first pregnancy was during adolescence but ended in miscarriage. While this method appears appealing in principle, it is plagued by small sample sizes since miscarriages are both rare and underreported.

Controlling for unobserved heterogeneity using family fixed effects is the predominant approach used in the intergenerational teenage childbearing literature. The most common family fixed effects approach is cousin fixed-effects estimation (Geronimus & Korenman, 1993; Geronimus et al., 1994; Rosenzweig & Wolpin, 1995; Turley, 2003; Levine et al., 2007). Children of sisters with differential childbirth timing are compared. Family fixed effects methods rest on the assumption that the comparison of two sisters, one who gave birth to a child in her teens and one that did not, control for time invariant unobservable heterogeneity between families. In a different variation, Rosenzweig & Wolpin (1995) and Francesconi (2008) use fixed effects but look for differences between children of the same mother (siblings fixed effects). Finally, Levine et al. (2007) use a combined sibling/cousin fixed effects model.

Finally, the 'selection-on-observables' methodology can be divided into two approaches in the teenage childbearing literature; explicit controls models (OLS, probits or logistic

[2] This assumption is controversial. Fletcher and Wolfe (2008) find that including community-level fixed effects has a significant impact on their results. They include timing of miscarriages and birth control options in their analysis to improve the relevancy of the teen mother control group.

regression) and propensity score matching. These models assume that conditional on observable characteristics, fertility timing is exogenous to the outcome being measured, i.e. selection into teenage childbearing is explained by the observables. Explicit control models attempts to control for selection by including observed pre-childbirth background and individual characteristic in the regression analysis. Propensity score matching matches women who gave birth during their teens and women who did not on the basis of a score representing the probability of being in the teen mother group determined on pre-childbirth observed characteristics.

The literature which looks at health outcomes for children born to teen mothers controlling for endogeneity is scarce. Geronimus and Korenman (1993) and Rosenzweig and Wolpin (1995) are the only papers 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 or 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).

Rosenzweig and Wolpin (1995) use the same data as Geronimus and Korenman (1993) to compare results on the effect of teenage childbearing on gestational age and child birth weight between a cousin fixed effects specification and a sibling fixed effects specification. In line with the findings of Geronimus and Korenman (1993) they find no evidence that children born to teen mothers are at risk of lower birth weight in either specification, and find only marginal differences in gestational age when siblings are compared.

Each methodological approach mentioned to control for pre-childbirth characteristics has both advantages and disadvantages. However, given our data, a method based on the propensity score to address selection is optimal for this study[3]. 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., 2008; Lee 2009), in Britain (Chevalier & Viitanen, 2003) and in South Africa (Ranchhod et al*.,* 2009).

3. Data, sample and outcome variables

3.1 The Cape Area Panel study

The analysis makes use of the Cape Area Panel Study (CAPS). The CAPS is a longitudinal study of youth in Cape Town. The first wave of the CAPS was collected in 2002 (Wave 1) and included 4,752 young people aged 14-22. Youth respondents were re-interviewed in 2003 or 2004 (Wave 2), in 2005 (Wave 3), in 2006 (Wave 4) and in 2009 (Wave 5). Data from waves 1 through 4 are publicly available and were used in this paper. Details about the CAPS are available in Lam et al (2008).[4]

The main instrument was a young adult questionnaire which was administered to up to three resident youths aged 14-22 in each sampled household. In addition to this primary questionnaire the CAPS Waves 1, 3 and 4 included a household questionnaire which collected basic information on all household members (the household roster) as well as household level information on resources and shocks. A household roster was also included in the young adult questionnaire for Wave 2.

The young adult questionnaire covered a wide range of issues including schooling, sexual practices, fertility and childhood home environment. Wave 1 included a retrospective calendar containing information on schooling, living arrangements and marital status for

[3] We have very few reported miscarriages or siblings/cousins who have both given birth. On the other hand, CAPS contains a rich array of information about the mother prior to her first birth.

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

each age from birth. In Waves 1, 3 and 4 young adults completed a detailed birth history, with each additional wave adding subsequent births. In Wave 4, in addition to the primary young adult and household questionnaires, a child questionnaire collected information on all children born to female young adults who were successfully interviewed. This child sample is the basis of the analysis in this paper. The child questionnaire included current physical measurements, weight-for-age measurements since birth, head circumference at birth and each child's vaccination history. These measures are the child health outcomes assessed.

Thus the CAPS data contains detailed information about the mother's individual and household characteristics both before and after the birth of her child in addition to measures of her children's health. This affords us the opportunity to use propensity score reweighting to explore whether maternal age at birth affects the health outcomes of children living in Cape Town.

3.2 Analysis sample

The analysis sample consists of first born African[5] and Coloured children. As such the analysis sample contains a subsample of children born to young adults by 2006. Only children born to African and Coloured female young adults were included in the sample. Due to the low frequency of births in the White population group, the children of White respondents were excluded from the sample. Indians are not represented in the CAPS data as the percentage of the population that is Indian in the Western Cape is very small. In addition, the sample is restricted to first born children to avoid potential birth order biases[6].

Table 1 presents information on the sample. 1758 African and Coloured female respondents were interviewed in 2006, resulting in a 76.5% response rate between the 2002 and 2006 waves. Of these women, 737 (41.9%) had given birth by 2006. In total these women gave

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[5] The apartheid system classified the population into four groups, namely African, Coloured, Indian/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 Indian/Asian and Coloureds having greater rights and opportunities than Africans but fewer than Whites.

[6] 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.

birth to 920 children, resulting in an average of 1.3 children per women. The child questionnaire was successfully completed for 832 (90.4%) children. 686 children were first born children. The final sample therefore comprises 686 children, 56.6% of whom were born to teen mothers.

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

	Number	%
African and Coloured female respondents in 2002	2300	
African and Coloured female respondents in 2006	1758	
African and Coloured female response rate 2002-2006		76.4
African and Coloured female respondents who had given birth by 2006	737	41.9
Children born to African and Coloured respondents by 2006	920	
Child sample	832	
Response Rate in Child Sample		90.4
First born children - the analysis sample	**686**	
% born to teen mothers		56.6

Notes to Table 1: The analysis sample includes all first born children African and Coloured female respondents successfully interviewed in 2006. The child sample response rate gives the percentage of children born by 2006 who had a child questionnaire completed for them.

The variable of interest 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, the variable of interest, being born to a teen mother, combines a number of potential variables of interest which could be examined separately – being born to a 13, 14, …,19 year old mother. Due to small samples within each cell, a finer grained analysis that assesses the effect of, for instance, younger and older teen motherhood, is not feasible with these data. Second, 58% of the CAPS female respondents had not yet begun their childbearing by 2006. Of those who had, the difference in average age between teen and older mothers is fairly small. Table 2 shows that the majority of teen mothers in the sample were in their late teens at the birth of their first child while the majority of older mothers were in their early twenties. The average age of teen mothers at first birth is 17.6 and the average age of older mothers is 21.6.

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

Age	Teen	Older	%
13	1		0.2
14	5		0.7
15	22		3.2
16	53		7.7
17	85		12.4
18	115		16.8
19	107		15.6
20		88	12.8
21		70	10.2
22		65	9.5
23		45	6.6
24		18	2.6
25		9	1.3
26		3	0.4
Total	388	298	100
Average	17.5	21.6	

Notes to Table 2: The table presents the number and distribution of children by their mother's age at first birth. In addition, the average age of teen and older mothers is presented.

The sample is therefore selective of children born to women who begin childbearing early. In the analysis we therefore 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 effect estimated is the average effect of being born to a teen mother versus a mother in her early twenties. The policy implication is that estimates of the effect of teenage childbearing shown in this paper signal the effect that policy would have of delaying teenage childbearing by on average four years.

3.3 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 in the CAPS sample do not appear to come from worse socioeconomic backgrounds. In fact, teen mothers fare significantly better on some variables. The similarity in socioeconomic levels between teen and older mothers is a result of the higher representation of Coloured respondents in the teen group. As noted in footnote 2, the apartheid system classified the population into four groups, namely African, Coloured, Indian/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 Indian/Asian and Coloureds having greater rights and opportunities than Africans but fewer than Whites.

The consequences of these discriminatory policies are evident in the comparison between columns 3 and 4 of Table 3 where the mean characteristics of Coloureds and Africans are compared. Coloured mothers are more advantaged than African mothers, even though the share of teen mothers is larger.

Columns 5 and 6 and 7 and 8 of Table 3 compare teen and older mother within population group. The results are consistent with those presented at the national level. For Coloureds, teen mothers are worse off than older mothers. Coloured teen mothers report significantly higher levels of childhood household poverty, have a higher prevalence of drug users and alcoholics in their childhood households and in 2002 lived in households with few or no books. Differences between teen and older mothers for Africans are small and often not significant. African teen mothers have significantly lower literacy and numeracy scores. On two outcomes African teen mothers are found to fare better. Teen mothers are more likely to live in a household in 2002 where someone owns five or more books and reach menarche at a younger average age. Note however, that while younger age at menarche is correlated with better nutrition, it is also a risk factor for teenage birth.

Table 3: Mean maternal characteristics

	(1)	(2)		(3)	(4)		(5)	(6)		(7)	(8)	
	All			All			Coloured			African		
	Teen	Older		Coloured	African		Teen	Older		Teen	Older	
Teen mother				0.63	0.50	***						
Age in wave 4	21.86	23.93	***									
Coloured	0.70	0.58	***									
Describes childhood household as poor or very poor	0.14	0.15		0.06	0.29	***	0.08	0.03		0.27	0.31	
Log mean per capita household income of sub place	10.54	10.44	*	10.80	9.94	***	10.79	10.83		9.97	9.91	
Someone in wave 1 household owns 5 or more books	0.76	0.78		0.85	0.62	***	0.80	0.94	***	0.68	0.57	**
Wave 1 household per capita income	603.48	581.71		730.95	343.14	***	721.24	747.62		329.60	356.69	
Wave 1 household owns a stove	0.85	0.77	***	0.96	0.54	***	0.97	0.95		0.56	0.52	
Mother's education	7.70	7.61		7.78	7.45		7.77	7.80		7.55	7.34	
Father's education	7.58	7.79		8.21	6.62	***	8.03	8.51		6.46	6.77	
Proportion of life lived with mother	0.85	0.83		0.88	0.77	***	0.89	0.87		0.76	0.77	
Proportion of life lived with father	0.56	0.55		0.60	0.48	***	0.61	0.59		0.46	0.50	
Proportion of life lived with maternal grandparent(s)	0.20	0.20		0.18	0.24	*	0.18	0.18		0.24	0.23	
Drug addict in childhood household	0.14	0.08	*	0.15	0.04	***	0.18	0.10	*	0.03	0.05	
Alcoholic in childhood household	0.27	0.18	**	0.25	0.21		0.29	0.18	**	0.24	0.19	
Highest grade at age 12	5.44	5.19	**	5.67	4.72	***	5.69	5.63		4.84	4.60	
Failed a grade by age 12	0.27	0.25		0.29	0.23	*	0.29	0.29		0.25	0.21	
Standardised numeracy and literacy score	-0.18	-0.10		0.04	-0.49	***	0.01	0.11		-0.60	-0.38	***
Number of students in class	41.71	38.91	***	38.26	44.64	***	39.99	35.40	***	45.59	43.69	
Age at menarche	13.22	13.62	***	12.93	14.23	***	12.94	12.92		13.88	14.58	***
Willing at first sex	0.86	0.84		0.89	0.79	***	0.89	0.88		0.78	0.80	
Sample size	388	298		334	352		215	119		173	179	

Notes to Table 3: Means adjusted for sample design and non-response presented. Sample includes all African and Coloured female respondents whose first born child forms part of the analysis sample. Weighted means presented. Asterisks signify significant differences between prior two columns. Differences marked with three asterisks (***) are significant at the 1% level, those marked with two (**) are significant at the 5% level, and those marked with one (*) are significant at the 10% level.

3.4 Outcome variables

Five child health outcomes are used in the analysis[7]. 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, indicators of malnutrition or extreme adverse outcomes are constructed. These measures indicate whether the child was underweight or had a very small head at birth and whether their current height for age would be classified as stunted. The underweight at birth, small head at birth and stunted indicators are defined as Weight at birth (WA_0Z), Head-circumference at birth (HC_0Z) and Height-for-Age (HAZ) Z-scores more than two standard deviations below the median score for the World Health Organisation (WHO) reference population (WHO, 2006).

[7] 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.

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). 73 heights, 153 birth weights and 246 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 613, 533 and 420 cases respectively. Table 4 presents a summary of the outcome variables.

Table 4 shows that while the difference between the mean WA_0Z 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. 12% have WA_0Z scores at birth below 2 standard deviations from the reference median and 14% 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 (17% compared to 10%). The opposite is true for head circumference at birth. While children born to teen mothers have head circumference z-scores significantly below those 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	533	-0.72	288	-0.81	245	-0.60	-0.20	0.11	-1.82
Underweight		0.12		0.14		0.09	0.05	0.03	1.83
Birthweight <2.5 kg		0.14		0.17		0.10	0.07	0.03	2.29
HCZ at birth	420	-0.69	222	-0.82	198	-0.53	-0.29	0.16	-1.78
Small head		0.16		0.18		0.15	0.03	0.04	0.89
HAZ	613	-1.21	347	-1.40	266	-0.93	-0.48	0.19	-2.56
Stunted		0.36		0.39		0.31	0.08	0.04	1.68
Immunisations:									
First year immunisations completed	346	0.75	195	0.74	151	0.77	-0.04	0.05	-0.71
Not up-to-date	652	0.06	364	0.07	288	0.05	0.02	0.02	1.26

Notes to table 4: Means adjusted for sample design and non-response and sample sizes (N) presented.

Overall one third of the sample is classified as stunted, with the average HAZ score more than a standard deviation below (-1.21) 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 road to health card[8] available at the survey, an indicator of whether the child's first year of routine immunisations were complete, was constructed (http://www.capegateway.gov.za). This measure is used by the Department of Health to assess the progress of child health care in South Africa[9] (Department of Health, 2005). For details on the immunisation schedule see Appendix Table A.1. Table 4 shows that this measure was only available for 346 children. At the interview, only 447 respondents[10] had these clinic cards available. Of these, respondents that were under one year (101 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[11].

Differences are seen between children born to teen mothers versus older mothers but are not significant. At the mean, 74% of children born to teen mothers have received all 15 first year immunisations while 77% of children born to older mothers have completed their first year immunisations. A small proportion of mothers indicate directly that their child's immunisations are not up to date[12]. Of the total sample, 6% indicate that their child's

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

[9] 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.

[10] 60.05% of children born to teens and 71.81% born to older mothers had clinic cards available.

[11] Including 'don't knows' as ones had no effect on the analysis.

[12]The correspondence between the two measures is not all that strong. While only 5% of children whose first year immunizations are complete have mothers who report that their child's immunizations are not up to date,

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 (7% compared to 5%).

The table of means shows some differences in outcomes between children born to teen versus older mothers. However, the differences presented are confounded by pre-childbirth factors and therefore cannot be interpreted as a result of being born to a teen mother. In particular, we showed that the socioeconomic status of teen sample is comparatively high given the higher proportion of Coloured versus African children born to teen mothers in the sample. We now proceed to isolate the effect of being born to a teen mother on child health outcomes using propensity score matching.

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 older 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.

The '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). $Y_i = T_i Y_i(1) + (1 - T_i) Y_i(0)$ is observed, 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 $ATT(x) = E[\alpha(x) | T_i = 1]$ (Rosenbaum & Rubin, 1983).

81% of children whose immunizations are not up to date have mothers who report that they are. This is consistent with survey misreporting; mothers/guardians do not wish to appear negligent.

Two assumptions underlie the consistent estimation of the average effect of being born to a teen mother. The first assumption, commonly referred to as the selection-on-observables assumption, requires that given X_i, the set of observed covariates, treatment is random (Rosenbaum & Rubin, 1983). This assumption allows the construction of a hypothetical counterfactual for teen mothers from women who did not give birth in their teens but are similar on all variables that affect both the potential outcomes and the probability of being a teen mother.

The second assumption, 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 $p(x) < 1$ (Angrist & Pischke, 2009). This assumption ensures that the estimates are calculated off a sample in which both the treated and control observations have values for the observed covariates. This avoids the calculation of estimates on parts of the sample where the covariate distributions of the treatment and controls do not overlap (Angrist & Pischke, 2009), i.e. avoids out of sample extrapolation.

Three estimators of the ATT are considered: two reweighting estimators (Hirano et al., 2003 and Sanders et al., 2008) and one double robust estimator (Robins et al., 1995). 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.

Busso et al., (2009) show that all these estimators share the common trait that they are weighted least squares estimators. More specifically, when $\sum_{j=1}^{n}\left(1-T_j\right)\bar{w}_{ij} = 1$, the reweighting estimators of the ATT is a difference in the average outcomes between the treated observations and a group of controls weighted by their covariate similarity to the treated observations. The general notation for the reweighting estimators of ATT is therefore,

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

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 regression

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

where β_1 is an estimate of the effect of being born to a teen mother, $Z_i^{'}$ is a vector of child demographic characteristics and ε_i is the error term. Ordinary least squares regressions are used for continuous outcomes and probit regressions are used for binary outcomes.

The two reweighting estimators have weights of the following form:

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

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

$\bar{w}_{ipw}(j)$ presents Hirano et al.'s (2003) inverse probability weight (IPW) normalised to one. This assigns a weight to children born to older mothers that is proportional to the conditional probability that their mother gave birth in her teens. $\bar{w}_{kern}(j)$ (KERN) presents Sanders et al.'s (2008) adaptation of the kernel weight. It is calculated using a kernel function of the propensity score with $K(\cdot)$ representing the kernel function and a_n the bandwidth[13]. The bandwidth selects the sub-sample of children born to older mothers who form the counterfactual comparison group and the kernel function assigns the importance of each individual included for each child born to a teen mother. Both weights take into

[13] An epanechnikov kernel with a bandwidth of 0.06 was used.

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, weighted regression of the outcome on a constant, the teen mother indicator and a cubic function of the propensity score are run. The IPW weight is used. In this way, inclusion of the covariates via the function of the propensity score controls for mis-specification in the propensity score and hence results in a more consistent, relative to the IPW, estimate of ATT if the outcome equation is correctly specified (Robins et al., 1995).

4.2 Checking the assumptions underlying the model

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, many variables measuring individual and household characteristics of mothers prior to the birth of her first child are available. 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. I argue that the data contain sufficient observable characteristics to create a decent counterfactual.

Appendix Table A.2 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. The sensitivity of these estimates to a ‘kitchen sink’, approach where all possible pre-childbirth characteristics are included, was assessed and found to be robust. The choice of variables in the 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, p. 15). Students that do poorly at school are more likely to drop out and have less motivation to prevent pregnancy (Panday et al., 2009). On the other hand, Lam et al. (2009) find that students in Cape Town who progress through school without failure and are exposed to older peers are at risk of earlier sexual debut. This is consistent with 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 (Panday et al., 2009). 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 (Panday et al., 2009).

We examined the validity of the first assumption, the selection on observables assumption, by testing whether the observed characteristics in the treatment and control group were balanced given the propensity score specification. Two approaches are used. First, we checked whether X is orthogonal to the treatment variable given $p(x)$ using the regression based balancing test presented by Smith and Todd (2005). For every covariate x_k the joint null hypothesis that all the coefficients on the terms involving T in equation 3 below equal zero was tested using an F-test[14]

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

[14] One of the limitations of this test is that the order of the polynomial needs to be chosen. I follow Sanders et al. (2008) in the choice of a cubic specification in p(x).

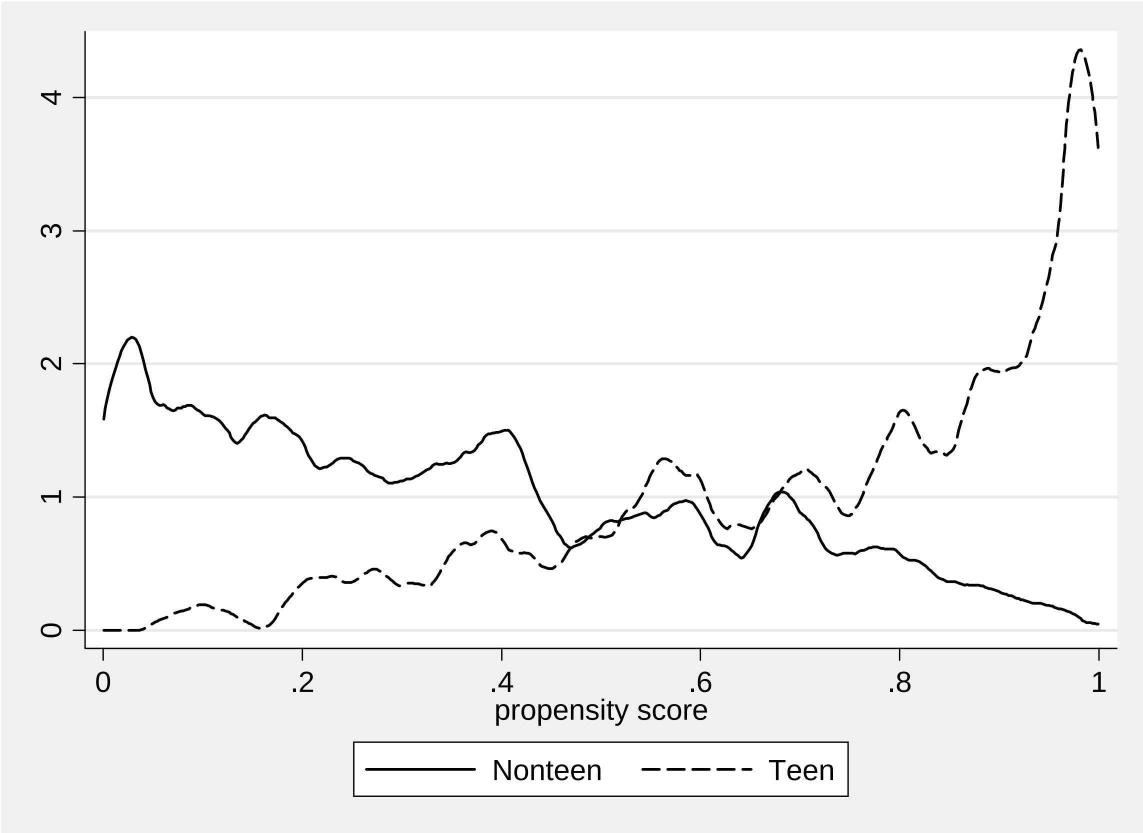
The test relies on the condition that T should provide no information about the observed characteristics conditional on the estimated propensity score (Smith & Todd, 2005). When any of these F-statistics exceeded the 5% significance level, higher order and interaction terms of the unbalanced variables were included in the propensity score specification and the regressions rerun[15]. Second, we checked whether the specification used to predict the propensity score succeeded in balancing variables used in the estimation (internal balancing tests) and variables not used in the estimation (external balancing tests). Appendix Tables A.3 and A.4 present the results from these tests. The assumption of selection on observables appears met; significant differences between the teen and older mother groups are eliminated when the inverse propensity score weight or kernel weight are used.

The second assumption was checked graphically. Figure 1 illustrates that the common support assumption, the second assumption underlying the method, appears 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[16].

[15] In total five additional variables were included 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.

[16] A similar figure, Figure B5.1 in Appendix B, illustrates that the common support condition is met when the propensity score is estimated for Africans and Coloureds separately.

Figure 1: Distribution of the estimated Propensity Scores – common support between teen and older mothers



Notes to Figure 5.1: The propensity score is the conditional probability that the child's mother gave birth to them in her teens. The propensity score is calculated using a logit specification. Conditional variables included in the logit specification are listed in Appendix Table A.2.

5. Results

Table 5, columns 3-5, presents estimates of the effect of being born to a teen mother (β_1) on the 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 (β_1) from a probit specification and for the continuous outcomes, it is the coefficient on the teen mother indicator (β_1) from a weighted least squares specification.

The Naive and Control models are included in columns 1 and 2 for comparison purposes. The Naive model includes only child controls (indicators that the child is African and male and a quadratic in age in days for current outcome measures). The Controls model includes all observables used 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 (Wooldridge, 2002, p. 378) for the IPW, Kernel and DR regressions.

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

	(1)	(2)	(3)	(4)	(5)	
	Explicit Control		Matching			
	Naïve	Controls	IPW	Kernel	DR	Sample
WAZ at birth	-0.132	-0.139	-0.3*	-0.292*	-0.314**	487
	(0.12)	(0.15)	(0.16)	(0.17)	(0.16)	
underweight at birth	0.068**	0.072**	0.096***	0.099***	0.099***	481
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	
low birth weight	0.085***	0.087**	0.127***	0.129***	0.129***	481
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	
current HAZ	-0.309	-0.428	-1.15**	-1.269*	-1.075*	531
	(0.24)	(0.31)	(0.5)	(0.68)	(0.6)	
stunted	0.039	0.024	0.188***	0.202***	0.201**	531
	(0.05)	(0.08)	(0.07)	(0.07)	(0.08)	
HCZ at birth	-0.167	-0.228	-0.393	-0.244	-0.428	366
	(0.18)	(0.22)	(0.49)	(0.6)	(0.49)	
small head at birth	0.015	0.02	0.059	0.079	0.073	363
	(0.04)	(0.04)	(0.05)	(0.07)	(0.05)	
First year immunisations comp	-0.023	-0.035	-0.059	-0.062	-0.067	319
	(0.05)	(0.09)	(0.08)	(0.14)	(0.1)	
Not up to date	0.023	0.006	-0.015	-0.027	-0.02	593
	(0.02)	(0.01)	(0.04)	(0.08)	(0.05)	

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. Estimates marked with three asterisks (***) are significant at the 1% level, those marked with two (**) are significant at the 5% level, and those marked with one (*) are significant at the 10% level. 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 control model estimates show a small and insignificant association between 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 0.13 standard deviations lower than children born to older mothers. Shifting to columns 3-5, the estimates of the effect of being born to a teen mother, the size of the coefficient increases and becomes significant. Children born to teen mothers have WAZ at birth scores close to a third 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 control model estimates show that children born to teen mothers are seven percentage points more likely to be underweight at birth. These estimates cannot however be interpreted as causal. Shifting 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 at childbirth. While the naïve and control model estimate a small and insignificant association between being born to a teen mother and child HAZ or likelihood of being stunted, the matching estimates in columns 3-5 find large effects. Children 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 19 and 20 percentage points 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.

Less evidence of a negative teen mother effect is found 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 that the mother reported 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 and Stunting – differences between Africans and Coloured

	(1)	(2)	(3)	(4)	(5)	
	Explicit Control		Matching			Sample
	Naïve	Controls	IPW	Kernel	DR	
African only:						
underweight at birth	0.046	0.046	0.05	0.075	0.049	221
	(0.04)	(0.04)	(0.07)	(0.06)	(0.07)	
low birth weight	0.051	0.044	0.06	0.08	0.06	221
	(0.05)	(0.04)	(0.07)	(0.07)	(0.07)	
current HAZ	-0.171	-0.269	-0.348	-0.269	-0.27	246
	(0.25)	(0.44)	(0.38)	(0.45)	(0.45)	
stunted	-0.029	-0.049	0.041	0.047	0.065	246
	(0.07)	(0.1)	(0.1)	(0.12)	(0.12)	
	Naïve	Controls	IPW	Kernel	DR	Sample
Coloured only:						
underweight at birth	0.121***	0.069***	0.123	0.125	0.123	206
	(0.03)	(0.02)	(0.09)	(0.09)	(0.08)	
low birth weight	0.162***	0.111***	0.158	0.161	0.158	206
	(0.04)	(0.03)	(0.11)	(0.11)	(0.1)	
current HAZ	-0.768**	-0.554	-1.598	-2.44**	-1.538	234
	(0.38)	(0.48)	(1.09)	(1.07)	(1.22)	
stunted	0.101	-0.041	0.171	0.235	0.153	234
	(0.08)	(0.13)	(0.14)	(0.14)	(0.17)	

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. . Estimates marked with three asterisks (***) are significant at the 1% level, those marked with two (**) are significant at the 5% level, and those marked with one (*) are significant at the 10% level. All regressions include a male indicator and current measures include a quadratic in age in days. 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 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 stratified into African and Coloured and the common support condition enforced, thus there is limited power to find significant results and 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 percentage points more likely to be born with low birth weight than children born to older mothers. These effects are 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 6 and 8 percentage points more likely to be born with low birth weight. However, the size of the effect is not consistently measured across all matching algorithms and standard errors are large.

Similar, albeit larger, differences are seen between population groups for the height-for-age measures. Children born to teens in the African sample have z-scores 0.3 standard deviations below children born to older mothers. A much larger disadvantage is seen for Coloured children. Children born to Coloured teens are between 1.5 and 2.4 standard deviations shorter than children born to older mothers.

It is clear therefore that the 'pooled' estimates present the average effect of being born to a teen mother for all South Africans. The negative effects found are therefore overestimates for Africans and underestimates for Coloureds.

6. Sensitivity analysis

The 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) and Rosenzweig and Wolpin (1995). Using fixed effects models they find no causal effect of maternal age on birth weight. The estimates in this paper control for observable characteristics while the fixed effects models control for both observable and unobservable time invariant characteristics common between cousins or siblings depending on the specification. Hence part of the difference in the findings could be a result of bias due to unobservable characteristics. We follow Ichino et al. (2008) and perform a sensitivity analysis in an attempt to assess whether a confounder can be constructed that has the potential to remove the negative effect of being born to a teen mother.

The estimates presented in the previous section 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, the 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 the estimates will be biased. We follow Ichino et al.'s (2008)[17] 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.

Introduce U which summarises the unobservables in a simplified binary variable and assume that the CIA assumption only holds when the analysis conditions 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. In addition to assuming U to be binary, U is assumed to be independently and identically distributed across the cells of the Cartesian product of the treatment and outcome values i.e. it is fully characterized by the following four parameters:

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

where $i, j \in \{0,1\}$ and I is an indicator function (Nannicini, 2007). In words, p_{ij} presents the probability that $U = 1$ in each group defined by the treatment (i) and outcome (j).

[17] Nannicini (2007) presents the Stata program (sensatt) that implements the sensitivity analysis for matching estimators proposed by Ichino et al. (2008).

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, robust to a confounder which is of the particular configuration specified.

There are two instances where unobserved confounders can result in biased estimates of the effect of being born to a teen mother. If the probability of an outcome for children born to older mothers is different once U is included or the probability of a respondent being born to a teen mother is different once U is included. Specifically, potentially problematic confounders result in

$$Pr(Y(0) = 1|T, X, U) \neq Pr(Y(0) = 1|T, X) \qquad (5)$$

$$Pr(T = 1|\, X, U) \neq Pr(T = 1|\, X) \qquad (6)$$

where, after conditioning on X, in (5), U is a confounding factor that has a positive effect on the untreated outcome $Y(0)$, and in (6), U has a positive effect on the assignment of treatment. Ichino et al. (2008) show that assuming $p_{01} > p_{00}$ and $p_{1.} > p_{0.}$ in the simulation, results in confounders of the required form i.e. those specified in equations (5) and (6) respectively. Thus the effect that U, the simulated confounder, has on $Y(0)$ and T after conditioning on X can be calculated.

We are interested in the effect of $d = p_{01} - p_{00}$ and $s = p_{1.} - p_{0.}$ after conditioning on X. This is addressed in the following way. At every iteration the average odds ratio of U, Γ[18], is calculated from a logit model $Pr(Y = 1|T = 0, U, X)$[19]. Ichino et al. (2008) call this the “outcome effect” (Nannicini, 2007). We assess how large this effect needs to be to drive the

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

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

ATT to zero. Similarly, $Pr(T = 1|U, X)$ is estimated at each iteration and Λ[20], 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 the 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, observing the first panel of results, even for U associated with a very large selection and outcome effect (e.g. Λ =7.7[21] and Γ= 2.1[22]), the simulated effect of being born to a teen mother on birth weight remain very close to the baseline estimate (i.e. where d=s=0). Observing the rest of the table, only for very extreme (and very 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 insignificant.

Another way to think about this is that in order to drive the baseline casual estimate to zero, a currently unobserved 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, needs to be found.

---

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

[21] 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.

[22] 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. Outcome and selection effects calculated as per footnote 17 and 19 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 contributes 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.

When children born to teen mothers are compared to their matched counterparts whose mothers are similar on observed pre childbirth characteristics except that they gave birth at an age older than 19, some evidence that children born to teens have worse health outcomes is found. 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.

Differences are found 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.

Geronimus and Korenman (1993) and Rosenzweig and Wolpin (1995) 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 when the comparison is made between cousins or siblings one born to a teen mother and one born to an older mother (Geronimus & Korenman 1993; Rosenzweig & Wolpin, 1995). The difference in their results and the findings of this paper could be a function of many things. First, the sample population is different. Both Geronimus and Korenman (1993) and Rosenzweig and Wolpin (1995) use data from the United States National Longitudinal Survey of Youth. Geronimus (1996) notes, that the effect of young maternal age on child wellbeing is heterogeneous across different groups partly as 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 which increases the 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. This argument holds even more strongly within the siblings fixed effects framework. The birth weights of children born to the same mother, differentiated only by birth timing, are likely to be highly correlated.

Third, the samples are selective of women who have siblings who have also given birth or of women who have more than one child and therefore, as noted by Geronimus and Korenman (1993) themselves, are not a representative group.

Finally, 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 selection bias issues. In particular, whether the estimates are causal strongly depends on the selection on observables assumption. It does not deal with selection on unobservable and hence omitted variables. Cousin\sibling fixed effects estimation controls for both observable and time invariant unobservable characteristics common between cousins\siblings. 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.

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. In addition, it is likely that structural factors influence the association between teenage childbearing and subsequent outcomes and therefore these 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.

This paper shows 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, these 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.

Appendix

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

Notes to Table A.1: The table presents the details of the routine immunisations given to children in South Africa. DTP* is the vaccine against diphteria, pertussis (whooping cough) and tetanus. Hib# is the vaccine against haemophilus influenza type b. Td** is the vaccine given to children over six and adults as a boosters for immunity to diphtheria and tetanus. Sourced from http://www.capegateway.gov.za.

Table A.2: 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
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 grndprnt(s)	Proportion of first 13 years (age 0 to 12) 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 subplace
Owned 5 books	Someone in Wave 1 household owned 5 or more books
No religion*	No main religion in Wave 1 household

Notes to Table A.2: The table details pre-childbearing observable characteristics in the Cape Area Panel Study data. Those with an asterisks (*) were not included in the final specification of the propensity score.

Table A.3: 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	21.85	23.93	-2.05	0.16	0.00 ***	-0.53	0.45	0.25	-0.16	0.58	0.79
Coloured	0.70	0.58	0.13	0.04	0.00 ***	0.01	0.07	0.92	-0.10	0.06	0.11
Failed grade by age 12	0.27	0.25	0.02	0.04	0.64	0.00	0.07	0.99	0.07	0.08	0.40
LNE score	-0.01	0.04	-0.06	0.08	0.45	-0.22	0.18	0.24	-0.27	0.22	0.23
Age of menarche	13.22	13.62	-0.41	0.15	0.01 **	-0.44	0.18	0.02 *	-0.49	0.37	0.19
Age of sexual debut	16.31	18.01	-1.70	0.17	0.00 ***	-0.15	0.20	0.44	-0.32	0.30	0.29
Use condom at first sex	0.40	0.40	0.00	0.04	0.96	0.15	0.06	0.02 *	0.14	0.09	0.13
Grandmother's highest level of education	7.70	7.61	0.09	0.28	0.74	0.05	0.33	0.87	-0.26	0.44	0.55
Grandfather's highest level of education	7.58	7.79	-0.16	0.36	0.66	-0.39	0.44	0.38	-1.00	0.59	0.09
Drugs in mother's childhood household	0.14	0.08	0.06	0.03	0.05 *	0.06	0.04	0.17	0.06	0.04	0.14
Alcoholic in mother's childhood household	0.27	0.18	0.08	0.04	0.02 *	0.10	0.05	0.05	0.08	0.09	0.35
Mother defines childhood household as poor	0.14	0.15	-0.01	0.03	0.74	0.01	0.05	0.77	0.03	0.06	0.61
Log of mean household income in W1 subplace	10.54	10.44	0.09	0.06	0.10	-0.02	0.07	0.80	-0.07	0.09	0.45
Own 5 books	0.76	0.78	-0.01	0.04	0.85	0.02	0.07	0.81	-0.11	0.05	0.03 *
Proportion childhood mother lived with mother	0.85	0.83	0.02	0.03	0.50	-0.02	0.04	0.58	-0.08	0.03	0.02 *
Proportion childhood mother lived with father	0.56	0.55	0.01	0.04	0.69	-0.05	0.08	0.50	-0.08	0.11	0.44
Prop. childhd mother lived with grandparent(s)	0.20	0.20	0.00	0.03	0.91	0.05	0.04	0.24	0.08	0.04	0.07
No main religion in Wave 1 household	0.04	0.06	-0.03	0.02	0.11	-0.03	0.03	0.34	-0.01	0.03	0.73

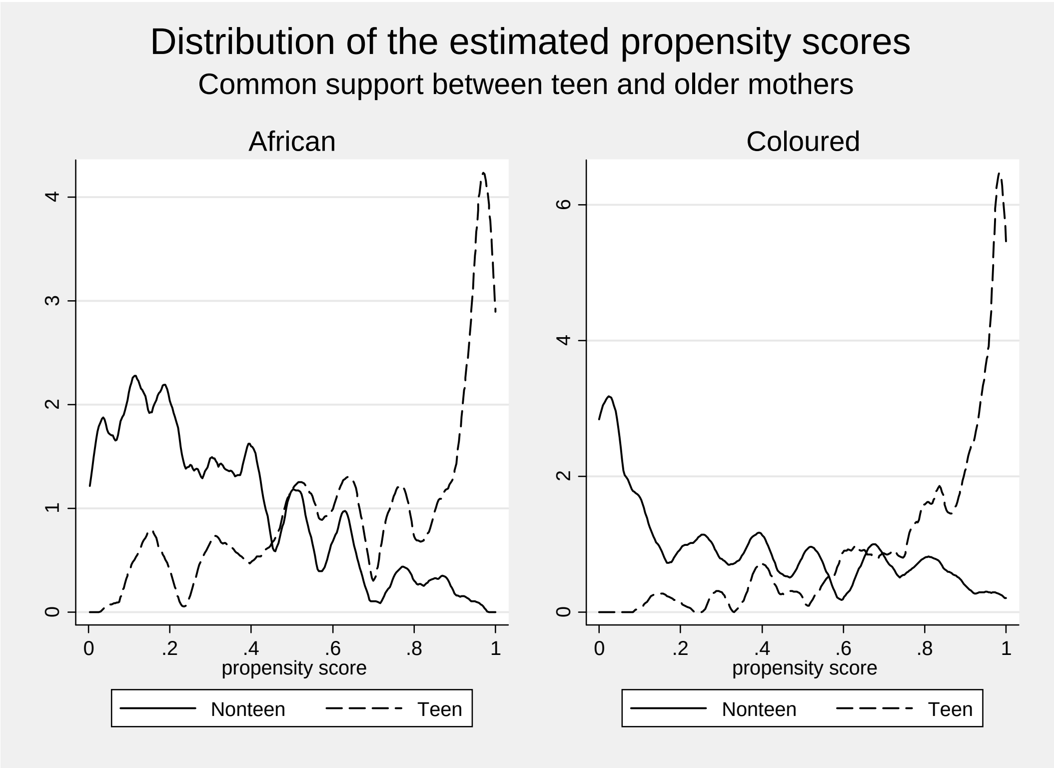
Notes to Table A.3: The table presents variable means and the difference in means between teen and older mothers, the standard error of this difference and whether it is significant weighted using the sample weight, the inverse propensity score weight and the kernel weight. Variables included are those used in the propensity score. Differences marked with three asterisks (***) are significant at the 1% level, those marked with two (**) are significant at the 5% level, and those marked with one (*) are significant at the 10% level. The table shows that once the data are weight by the inverse propensity score weight or kernel weight differences between teen and older mother characteristics are minimal or 'balanced'.

Table A.4: 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 HH income	603.48	581.71	32.28	60.42	0.59		80.21	76.56	0.30		-12.90	135.79	0.92	
Wave 1 household owns a stove	0.85	0.77	0.08	0.03	0.00	**	0.10	0.06	0.13		0.05	0.08	0.53	
Highest grade at age 15	8.03	7.89	0.12	0.11	0.28		0.00	0.20	0.99		-0.21	0.22	0.32	
Highest grade at age 16	8.70	8.69	0.01	0.13	0.96		-0.11	0.25	0.67		-0.38	0.26	0.15	
Highest grade at age 17	9.13	9.38	-0.25	0.16	0.11		0.07	0.20	0.71		-0.02	0.24	0.95	
Highest grade at age 18	9.34	10.00	-0.66	0.20	0.00	***	-0.08	0.27	0.77		-0.13	0.31	0.68	
Highest grade at age 19	9.49	10.30	-0.81	0.22	0.00	***	-0.28	0.36	0.45		-0.19	0.37	0.61	
Failed at age 15	0.13	0.12	0.01	0.03	0.77		0.04	0.04	0.35		0.07	0.03	0.01	*
Failed at age 16	0.08	0.13	-0.04	0.03	0.10		-0.25	0.11	0.03	*	-0.23	0.16	0.15	
Failed at age 17	0.07	0.12	-0.06	0.02	0.01	*	-0.09	0.06	0.12		-0.07	0.08	0.36	
Failed at age 18	0.07	0.12	-0.05	0.03	0.10		-0.03	0.06	0.55		0.04	0.02	0.07	
No. of students in mother's class	41.71	38.91	2.95	0.92	0.00	**	1.68	1.60	0.29		1.46	2.17	0.50	
Willing at first sex	0.86	0.84	0.01	0.03	0.63		0.04	0.05	0.39		0.07	0.09	0.47	
Used contraception at first sex	0.53	0.59	-0.06	0.04	0.18		0.03	0.07	0.70		-0.08	0.09	0.39	

Notes to Table A.4: The table presents variable means, the difference in means between teen and older mothers, the standard error of this difference and whether it is significant using the sample weight, the inverse propensity score weight and the kernel weight. Variables included are those not included in the propensity score estimation. Differences marked with three asterisks (***) are significant at the 1% level, those marked with two (**) are significant at the 5% level, and those marked with one (*) are significant at the 10% level. The table shows that once the data are weight by the inverse propensity score weight or kernel weight differences between teen and older mother characteristics are minimal or ‘balanced’.

Figure A.1: Distribution of the estimated propensity scores by population group



Notes to Figure A.1: The figure presents the distribution of the propensity score for teen and older mothers for Africans and Coloureds separately. The propensity score is the conditional probability that the child's mother gave birth to them in her teens. The propensity score is calculated using a logit specification. Conditional variables included in the logit specification are listed in Table A.2.

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southern africa labour and development research unit

The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy. In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.

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