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Analysing the links between child health and education outcomes: Evidence from NIDS Waves 1-4

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1. Introduction

The focus of this discussion paper is on the relationship between child health and education outcomes in the National Income Dynamics Study (NIDS) panel data. NIDS collects detailed information on the health status of children, including anthropometric data, and on their progression through the schooling system, providing the unique opportunity to analyse the implications of child health for human capital accumulation over the life-cycle at the national level. The 1993 Project for Statistics on Living Standards and Development (PSLSD) also collected data on both anthropometric and education outcomes for a nationally representative sample, but only at the cross-section, while other longitudinal studies for South Africa with this information are region-specific, have smaller sample sizes, and are from a much earlier period.

Research drawing on these earlier datasets suggests negative causal pathways from poor nutrition to other human capital outcomes. Casale, Desmond and Richter (2014) find that children who suffered from early malnutrition, indexed by stunting, did worse on cognitive tests than other children of preschool age, using the Birth to Twenty data from 1990 to 1995, an urban birth cohort study conducted in Johannesburg. Yamauchi (2008) provides evidence of better schooling outcomes among children who were well-nourished in the pre-primary years, using the KwaZulu-Natal Income Dynamics Study (KIDS) from 1993, 1998, and 2004. This paper investigates the possibilities for updating this research at the national level using the recent release of NIDS data from 2008 to 2014/2015.[1]

In particular, the focus of the empirical work in this paper is on the relationship between poor nutrition, captured by stunting and obesity in early childhood, and schooling outcomes for children aged 14 years and younger. Poor nutrition in early childhood, which manifests in low height-for-age or stunting, is predicted to affect educational attainment for a number of reasons. From a

[1] Earlier discussion papers using the first waves of NIDS showed the high prevalence of poor nutrition amongst South African children (Ardington and Case, 2009; Ardington and Gasealahwe, 2012), and the slow progression through the schooling system (Branson and Lam, 2009; Branson, Lam and Zuze, 2012), with inequalities in outcomes by race and socio-economic status. However, the links between the two sets of data have not been explored.

physiological perspective, a lack of nutrients may cause structural damage to the brain, especially in the first few years of a child's life when the rate of formation of neural connections is highest (Morgan and Gibson, 1991). In addition, children who are poorly nourished may lack energy, affecting the way they engage with their environment and ultimately how they learn. Parents and teachers may also treat children who look smaller differently from other children their age, challenging them less (Behrman, 1996). Poor nutrition resulting in obesity has been hypothesised to influence children's educational attainment through cognitive function because of a potential deficiency in micronutrients. Further, being overweight or obese can affect children's self-esteem, mental health, and social interactions, which in turn can influence their performance at school (Caird *et al.*, 2011).

If a poorly nourished child starts school later, or is more likely to repeat grades, then the child will complete fewer years of schooling, or will enter the labour market later (or both). Even if the child completes the same number of years of schooling as their peers, entering the labour market later will result in a significant reduction in lifetime earnings (Alderman *et al.*, 2009). Therefore understanding the implications of child health for educational attainment is important, particularly in the South African context of large and persistent inequalities in human capital accumulation, labour market success, and, consequently, household income. If children who suffer from poor nutrition in early childhood perform worse at school than otherwise comparable children, more attention should be paid to investing in child health in the early years, given that these children are unlikely to receive remedial support in an already overburdened education system.

The remainder of this paper is structured as follows. Section 2 gives a brief description of the data used in the empirical work. Section 3 describes the child health outcomes from Wave 1, and specifically the anthropometric data used to proxy for poor nutrition. Section 4 provides both a descriptive and regression analysis of the relationship between child nutritional status in Wave 1 and educational outcomes in Wave 4. Section 5 summarises the findings and includes a discussion of various ways in which the NIDS data can be used to extend this work.

2. A brief note on the data

In this paper, the data that were collected through the child questionnaires are analysed. In the first wave of NIDS in 2008, information was collected in the child questionnaire for all children who were resident in the sampled households and who were aged 0 to 14 years (9605 children). In subsequent waves, information was collected in the child questionnaires also on children born to or adopted by female continuing sample members (CSMs)[2], and children co-resident with CSMs at the time of the interview (or temporary sample members). However, because we link the anthropometric data collected in the Wave 1 child questionnaire to the educational outcomes collected in the Wave 4 child questionnaire, by definition, our sample of interest becomes restricted to children who were original CSMs aged 0 to 8 years in 2008 and aged 7 to 14 years in 2014/2015 (5049 children).[3] Due to attrition in the survey, only 89% of this group were successfully re-interviewed, resulting in an effective sample of 4482 children. (There are some additional more minor restrictions to the sample that will be described later.)

The child questionnaire is administered either to the mother or the caregiver of the child or to another household member knowledgeable about the child. For about 68% of children in our sample in Wave

[2] These are resident members of the original Wave 1 households (including children) and any children born to or adopted by female CSMs in the subsequent waves.

[3] The Wave 4 interviews were conducted over two years which, as will be discussed in Section 4, affects some of the current education variables. The majority of the interviews were conducted in 2015, with about 28% conducted in 2014.

1, the respondent was a parent, for another 18% it was a grandparent, and in 8% of the cases it was either the uncle or the aunt responding. In Wave 4 the comparable figures are 60%, 18% and 14%. For the remainder of the children it was generally either a sibling, cousin or other relative who responded. Information was collected predominantly on the child's health, education history, their parents and care arrangements, and grant income.

3. Health outcomes in Wave 1

In Wave 1 (and the subsequent waves) the child questionnaire includes a relatively extensive module on health where questions are asked on, for example, the overall state of the child's health, whether the child had any serious disabilities or illnesses, whether the child had been sick in the previous 30 days, and various related questions around medical aid, the road to health card, and visits to a hospital/doctor/clinic. There is little variation on the self-assessed health variables for this age group though. For instance only 1.4% of children were reported as being in poor health and another 4.7% in fair health (the other categories were good, very good and excellent). Only 5.9% were reported as having any serious disability or illness (these were mainly respiratory or to do with sight, speech, and hearing). Just under 10% were reported as being sick for at least 3 days in the previous 30 (although the severity of the illness is not specified and frequent bouts of illness are relatively common in small children whose immune systems are still under-developed).[4]

Instead, as is commonplace, we use the anthropometric data to proxy for child health. Data is collected in each NIDS wave on the child's height and weight if they were six months or older and the child's waist measurement for children two years and older.[5] Height-for-age, weight-for-age, weight-for height and body mass index (BMI) z-scores are derived from these measurements and released with the NIDS individual dataset. As described in the NIDS manual (de Villiers et al., 2013: 30), for children up to the age of five years, the z-scores were calculated using the WHO international child growth standards (WHO, 2006). For children older than five years, the WHO growth standards for school-aged children and adolescents (de Onis et al, 2007) were used as the reference. The data are pre-cleaned, with biologically implausible values set to missing, following WHO guidelines (further detail can be found in de Villiers et al., 2013: 30-32).

Ardington and Case (2009) analyse these data for Wave 1 in some detail in an earlier discussion paper, so here the focus is to present specifically the data that will be linked to the education outcomes in Wave 4. In this work we choose to examine two forms of poor nutrition in childhood, manifested in stunting (low height-for-age)[6] and obesity (high BMI). While the emphasis is on these two measures, we also present the estimates of severe stunting and overweight in the descriptive tables below to show how children are distributed over a wider spectrum of nutritional status (and keeping in mind that the cut-off points are ultimately arbitrary).

We use the standard WHO cut-offs to classify children as stunted, i.e. height-for-age z-score (HAZ) <-2 (in other words, the child's height-for-age is two standard deviations below the mean of a healthy reference population), where severe stunting is HAZ <-3. There are different ways of classifying

[4] These variables also have little or no explanatory power when tested in regressions on Wave 4 educational outcomes (discussed later).

[5] Children aged six years and older were asked for their permission to be measured, and 85 percent (for whom there is a response on this question) agreed.

[6] In studies of nutrition low height-for-age is preferred as a measure of undernutrition as it captures longer-term growth retardation, compared to measures based on weight-for-age or weight-for-height which are more variable.

children as overweight and obese[7] and we follow de Onis and Lobstein (2010) here, who suggest using different cut-offs for children up to the age of 5 years and for children aged 5 to 14 years. Overweight is defined as a BMI z-score >2 for children under 5 years and > 1 for children aged 5-14 years, and obese is defined as a BMI z-score >3 for children under 5 years and > 2 for children aged 5-14 years.[8] In Wave 1, 77% of children aged 6 months to 14 years have a valid HAZ value and 74% have a valid BMI z-score.[9]

The estimates for stunting, severe stunting, overweight and obesity in 2008 are displayed in Table 1 for the full sample and disaggregated by age group, gender, population group, urban/rural residence, and per capita household income quintiles.[10] Overall, the prevalence of stunting among children aged 6 months[11] to 14 years is just over 17%, while 6.5% of children are severely stunted. Close to 19% of children are overweight and 7.5% are classified as obese. The youngest children (in the age cohort 6 months – 4 years) suffer from the highest prevalence of stunting and severe stunting (24.9% and 9.5% respectively), while the prevalence of overweight and obesity rises with age (rates of overweight and obesity among the group of 10-14 year olds are 21.2% and 9.6% respectively). Girls are marginally less likely than boys to be stunted or severely stunted, while they are more likely than boys to be overweight or obese.

The differences by race are pronounced. African and coloured children are much more likely to be stunted or severely stunted than Indian and white children. For example, the prevalence of stunting among African children is 18%, among coloured children it is 20%, while for Indian and white children it is 11% and 7% respectively (although these latter figures are based on very small samples sizes). The estimates of obesity are also highest among African (7.2%) and coloured children (13.9%), compared to Indian (1.5%) and white children (5.9%), but the data suggest similarly high rates of overweight (of between 19-21%) for African, coloured and white children, with Indian children being the least likely to be overweight (11.5%).

Stunting and severe stunting are higher in rural areas, while rates of overweight and obesity are lower in rural areas, compared to urban areas. This is likely to reflect in part socio-economic status, and indeed the data show that stunting and severe stunting are strongly positively correlated with the per capita household income quintiles, while overweight and obesity are strongly negatively correlated with the income quintiles. For example, the prevalence of stunting is 20% among children in quintile

[7] For instance, instead of using standard cut-off points, some studies use the 85% or 95% percentile cut-off of the national BMI distribution, but with rising rates of child obesity, this is not preferred (de Onis and Lobstein, 2010).

[8] The WHO suggests a more cautious approach in classifying young children as overweight and obese as children in this group are still growing, and there is risk attached to placing young children on restricted diets (de Onis and Lobstein, 2010)

[9] The response rates on these variables vary quite substantially over the waves, with big improvements in response rates for Waves 3 and 4 in particular: for Wave 2 the response rate was 56.3% on HAZ and 54.0% on BMI; for Wave 3, 83.4% on HAZ and 82.6% on BMI and in Wave 4, 90.8% on HAZ and 90.5% on BMI.

[10] The estimates of the prevalence of stunting are similar to those presented by Ardington and Case (2009) (they do not provide estimates of severe stunting), as are the estimates for overweight and obesity among the 5 to 14 year old age group, for which we use comparable definitions.

[11] To estimate prevalence for the age group 6 months and older we needed to create a variable for age in months from the birth and interview date information in the NIDS release. There may be some misclassification of children in our age variable around the 6 month cut-off as we only have month and year of birth and not the exact date with which to estimate decimal age. At most this will affect around 25 observations as overall there are 48 and 54 children who are classified as being 5 and 6 months of age respectively

1 compared to around 12% for children in quintile 5, whereas the prevalence of obesity is 6% among children in quintile 1 and 13% among children in quintile 5.

Table 1. Selected anthropometric data for children aged 6 months – 14 years

	Stunting	Severe Stunting	N	Overweight	Obese	N
All (6m -14y)	17.48	6.46	7155	18.96	7.55	6834
Age range						
6m-4y	24.9	9.54	2067	16.13	4.8	1907
5-9y	12.21	4.29	2485	18.82	7.53	2361
10-14y	16.8	6.15	2603	21.23	9.62	2566
Gender						
Boys	18.59	6.30	3618	18.16	6.67	3453
Girls	16.36	6.62	3536	19.77	8.43	3380
Population group						
African	17.93	6.54	6108	18.74	7.22	5851
Coloured	20.05	6.86	847	21.63	13.86	787
Indian	10.59	7.83	62	11.5	1.54	63
White	7.40	3.93	138	21.38	5.92	133
Area type						
Urban	14.92	5.26	2693	21.71	9.42	2534
Rural	19.93	7.60	4462	16.38	5.78	4300
Per capita household income						
Quintile 1	20.17	6.89	2265	17.27	6.14	2154
Quintile 2	19.32	8.15	2180	17.21	6.41	2098
Quintile 3	16.96	5.15	1441	17.52	7.22	806
Quintile 4	12.98	3.88	842	21.1	8.81	806
Quintile 5	12.35	6.8	427	27.86	13.19	402

Notes: Data are weighted using post-stratification weights for 2008.

To get a sense of the reliability of the anthropometric data in NIDS, Table 2 compares the prevalence of stunting and severe stunting in the Wave 1 sample with prevalence rates from two other national surveys conducted within the same ten year period as NIDS 2008 - the National Food Consumption Survey (NFCS) of 2005 and the South African National Health and Nutrition Examination Survey (SANHANES) of 2012. The figures are shown for the age groups for which there are comparable data, namely 1-3 years, 4-6 years and 7-9 years (as provided in Shisana et al., 2013). It is reassuring that the three surveys provide prevalence rates within an acceptable range of each other. Assuming the data are comparable, it appears that while stunting and severe stunting are on the decline for the age groups 4-6 years and 7-9 years, the prevalence rates for both stunting and severe stunting have increased since 2005 for the group most vulnerable to malnutrition, children aged 1-3 years.

Table 2. 2008 stunting and severe stunting

	Stunting (HAZ<-2)			Severe stunting (HAZ <-3)		
	NFCS 2005	NIDS 2008	SANHANES 2012	NFCS 2005	NIDS 2008	SANHANES 2012
1-3 years	23.4	28.18	26.5	6.4	10.84	9.5
4-6 years	16.4	15.19	11.9	5.1	4.73	2.2
7-9 years	12.0	11.66	9.4	3.4	4.21	1.7

Source: Own calculations from NIDS 2008; Shisana et al., 2013

While the SANHANES release (Shisana et al., 2013: 211-212) used different definitions of obesity (a cut-off of BMI >=30 for all ages), again the estimates fall within a fair range. For instance, the obesity prevalence is 7.1% among girls and 4.7% among boys for the age group 2-14 years based on the SANHANES 2012 data. For that same age group, the NIDS 2008 data produce a prevalence of 8.5% for girls and 6.8% for boys. Although the point estimates are not easily compared given the different definitions used, the patterns with respect to gender, race and area of residence found in NIDS 2008 are also similar to those found in SANHANES 2012.

4. Linking Wave 1 health data to education outcomes in Wave 4

4.1 Description of the data

In this section the educational outcomes of children who were re-interviewed in Wave 4 are examined, dependent on their childhood nutritional status from Wave 1. NIDS collects a large amount of data on schooling in the child (and adult) questionnaire, and as with the anthropometric data, these have been described in detail in previous discussion papers (see Branson and Lam, 2009 and Branson *et al.*, 2012). The purpose of this paper is to link the earlier health data to the Wave 4 education outcomes, and so a detailed description of all the child education variables over the waves is not provided here. Rather, three measures of educational outcomes commonly used in the research on human capital accumulation in childhood (Glewwe *et al.*, 2001; Yamauchi, 2008; Alderman *et al.*, 2009; Timaeus *et al.*, 2013) are chosen for further analysis, each capturing a slightly different aspect of the schooling process.

Before describing these three measures, it is worth pointing out that we do not use enrolment rates when we examine educational outcomes by nutritional status, even though this is frequently used as an outcome in the human capital literature. This is because for our group of children who are aged 7 to 14 years in Wave 4, and for whom schooling is compulsory in South Africa, enrolment is around 98-99%. In South Africa, enrolment rates tend to start declining only after the age of 14 (see Branson and Lam (2009) who use the NIDS Wave 1 data, and Hall (2015) for more recent estimates based on the GHS 2013).

The first measure used here is the age the child started Grade 1. This is calculated by subtracting the child's birth year from the year the child was reported to have first enrolled in Grade 1 (plus one year). The non-response rate on this latter question in Wave 4 is just under 13% (of the 6664 children aged 7 to 14 who were attending or had ever attended school). This is an improvement on the Wave 1 result, for instance, where around 24% did not provide a response to the same question (Branson and Lam, 2009). As in Branson and Lam (2009), we exclude children whose starting age was younger than 4 and older than 11 years - we lose 178 observations as a result.[12]

The second measure of educational attainment from Wave 4 is the number of grades completed, based on the derived variable in the NIDS individual data file. There is a similar non-response rate on this variable; for around 12% of the 7419 children aged between 7 and 14 years, the number of completed grades is unknown/missing in Wave 4. Of course this variable is truncated because children in our sample are aged 7 to 14 years in Wave 4 and so have not completed their schooling.

[12] It is possible that in using this variable we are excluding children who would have started school but haven't yet. This problem is likely to be minor though as the children in our sample in Wave 4 are aged 7 to 14 years, and as the data on enrolment and age at first entry indicate, almost all children aged 7 to 14 are enrolled, and the vast majority had started school by age 7 (in Wave 4, 95% of children for whom we had plausible values).

Nonetheless, as others have pointed out, one benefit of focussing on this age range is that schooling is still compulsory for this age group and enrolment rates are very high, reducing concerns around selection among children who drop out (Yamauchi 2008).

The third measure uses the series of questions asked in NIDS on whether the child had passed, failed or withdrawn before completing the grade, conditional on attendance. The questions are asked for each year going back to 2008, but only the data for the preceding three years, namely 2012, 2013, and 2014, are used here. This is because the further back in time one goes, the smaller the sample, as the number of children who become age-ineligible increases. A variable equal to one is created if the child failed or withdrew at least once in those preceding three years. For convenience this is referred to as 'failing the grade' as less than half a percent withdrew in any of the years (0.15% or 8 observations in 2014; 0.15% or 10 observations in 2013; and 0.21% or 12 observations in 2012). The response rates on these questions are high: conditional on attendance, only 2.5% of children are missing a value on the result for 2014, and in 2013 and 2012 less than half a percent are missing values. One complication is that because Wave 4 was conducted over 2014 and 2015, the 27% of children who were interviewed in 2014 obviously were not asked about the 2014 result, so part of the sample is lost because of the way the variable is defined. In addition therefore, a variable based on the 2012 and 2013 outcomes only is used, as these are the most recent years for which a result would have been known for all the children in the Wave 4 sample (who attended school).

Table 3 presents data on the educational outcomes from Wave 4 by child nutritional status from Wave 1, and from here on we present only the results for the stunting and obesity indicators. The sample sizes in the table drop substantially for three reasons, mainly to do with the panel nature of the data, as discussed in Section 2. First, because we link anthropometric data from Wave 1 to Wave 4 our sample becomes restricted to those Wave 1 CSMs who were aged 6 months to 8 years in 2008 and therefore aged 7 to 14 in 2014/15 (4655 children). Second, due to attrition, only about 89% of these children were successfully re-interviewed in Wave 4 (4224 children). Third, we lose additional observations because of the high rates of missing data on the derived height-for-age and body mass index variables (24% and 29% respectively for this group of children). In the tables that follow, we further restrict the sample to African and coloured children, given the very small samples of Indian and white children among this group (around 58 observations in total).

The results in Table 3 show significant differences in educational outcomes by stunting status. Children who were not stunted in Wave 1 started school on average between a quarter and a third of a year earlier than children who were stunted (5.65 vs 5.92). They also complete almost a full year of schooling more than the children who suffered poor early nutrition (4.58 vs 3.47). Moreover, children who were not stunted perform better at school, helping to explain why the gap between completed schooling is wider than the gap between age at first enrolment. A smaller percentage of children who were not stunted in Wave 1 failed the grade they were enrolled for in either 2012 or 2013 (13.9% vs 20.4%), or, using the smaller sample of interviewees from 2015, failed at least once in 2012, 2013 or 2014 (19.89 vs 30.44%).

Table 3. Education outcomes in W4 by nutrition status in W1

	Not stunted (W1)	Stunted (W1)	Not obese (W1)	Obese (W1)
Mean age of entry into Gr 1 (W4)	5.65***	5.92	5.69	5.76
	(0.40)	(0.066)	(0.035)	(0.276)
	2018	570	2290	123
Mean grades completed (W4)	4.58***	3.47	4.38	4.58
	(0.065)	(0.121)	(0.060)	(0.305)
	2424	662	2738	146
Percentage failed at least once in 2012/13[a] (W4)	13.85***	20.43	15.23	13.08
	(1.049)	(2.316)	(1.025)	(3.848)
	2306	626	2606	139
Percentage failed at least once in previous three years (2012-14)[a; b] (W4)	19.89***	30.44	21.58	16.12
	(1.444)	(3.200)	(1.397)	(5.276)
	1653	455	1886	91

Notes: Data are weighted using the panel weights. Standard errors in parentheses.
Differences in means significant: *** p<0.01 ** p<0.05 * p<0.10
The sample consists of African or coloured children who were 6 months and older in W1 and who were re-interviewed in W4 (i.e. aged 7-14 in 2014/15).
[a] Conditional on enrolment in those years.
[b] Sample is restricted to children interviewed in 2015 in Wave 4.

However, children who were classified as obese in Wave 1 do not have significantly different educational outcomes from children who were not classified as obese. If anything, their educational outcomes in Wave 4 are marginally better than for the children who did not suffer from obesity. This is probably because we are not controlling for socio-economic status, and the descriptive results above showed that the prevalence of obesity rises with the household income quintiles. The next section presents the regression results, which include controls for various individual and household level characteristics, including socio-economic status.

4.2 Regression analysis

In this section, the relationships between the Wave 1 nutritional status indicators and the Wave 4 education outcomes are re-estimated, controlling for a number of individual and household level characteristics. An important variable to control for is the child's age, given that the sample includes children between 7 and 14 years of age in Wave 4 and therefore at different stages of development (and schooling). The child's Wave 4 age in months is included in the regressions. However, when dummy variables for each age are included (on their own, or in addition to age in months) the results on nutritional status do not change significantly. Other child characteristics included in the regressions are sex (an indicator for female), race (an indicator for coloured only, as we continue to exclude the 58 white and Indian children remaining in the sample), and mother's schooling in years. The household level characteristics included are urban residence, per capita household income quintiles (using the derived variable in the NIDS household dataset), household size, and province of residence. These variables are based on Wave 1 information.[13]

[13] Indicators for whether the mother was still alive and whether she was resident in the household in Wave 1 were also included in the regressions but these variables did not have significant effects on any of the education outcomes, and so a parsimonious specification was adopted. Nonetheless, in future work it would be interesting to examine more closely the influence of the child's living and care arrangements and how these change over time.

Tables 4 – 6 present the regression results for the three education measures from Wave 4, where the key variable of interest is Wave 1 stunting status. Regression I in Table 4 on age at first enrolment shows that even after controlling for individual and household level controls, the negative effect of poor nutrition in the earlier period remains strong; the coefficient of 0.198 signals that children who were stunted in Wave 1 enrol later than children who were not stunted. Not many of the other variables have significant effects. Coloured children appear to enrol earlier than African children and mother's education is correlated with an earlier age at first enrolment.

Table 4. Effect of stunting in Wave 1 on age started school

	I (OLS)	II (FE)
Stunted (W1)	0.198***	0.159*
	(0.059)	(0.092)
Age in months (W4)	0.000	0.002
	(0.001)	(0.001)
Female	-0.064	-0.069
	(0.048)	(0.072)
Coloured	-0.280**	-0.116
	(0.120)	(0.549)
Mother's schooling (W1)	-0.024***	-0.007
	(0.007)	(0.019)
Urban residence (W1)	-0.047	
	(0.064)	
Quintile 2 (W1)	0.002	
	(0.060)	
Quintile 3 (W1)	0.040	
	(0.070)	
Quintile 4 (W1)	0.012	
	(0.088)	
Quintile 5 (W1)	0.085	
	(0.144)	
Household size (W1)	-0.002	
	(0.008)	
Constant	5.821***	5.601***
	(0.191)	(0.257)
Household fixed effects		Yes
N	2411	2411

Notes: Standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10
Controls for Wave 1 province of residence included

An important limitation of using OLS when trying to make causal claims about the effects of health on education is that unobservable factors, particularly at the household level, may be driving the result. This problem has been well documented in the human capital literature on schooling investments and a common way to try and minimise bias is to use household fixed effects (sometimes referred to as sibling effects[14]) (Glewwe *et al.*, 2001; Alderman *et al.*, 2006; Yamauchi, 2008). Another benefit of

[14] This term is not entirely accurate here as we exploit the differences among children within households, and children living together in a household are not necessarily siblings. We use the Wave 1 household identifier in the fixed effects model rather than the Wave 4 identifier – these identifiers can differ between NIDS waves

using household fixed effects is that young children in the same household are more likely to attend the same (or similar) schools, reducing concerns around school quality confounders (Glewwe *et al*., 2001).[15] The results on Regression II in Table 4, show that after controlling for time-invariant household characteristics, the effect of stunting on age at first enrolment is attenuated slightly (the coefficient falls from 0.198 to 0.159), but a significant effect remains.[16]

Table 5 presents the regression results for number of grades completed. Children who were stunted in Wave 1 complete significantly fewer grades of schooling by Wave 4 compared to those who were not stunted. Again, although the coefficient falls somewhat after controlling for household fixed effects (from -0.294 in Regression I to -0.252 in Regression II), it remains large and significant. Age has the expected positive effect and girls complete more years of schooling than boys. Again mother's schooling has a strong positive influence. Household income per capita does not have a significant effect but this is because mother's schooling appears to be picking up the influence of socio-economic status. When mother's schooling is omitted from the regressions (not shown here), the coefficients on quintiles 4 and 5 become large and strongly significant.

Part of the reason why children who were stunted in Wave 1 complete fewer years of education by Wave 4 is that they start school later. Therefore Regressions III and IV also control for age at first enrolment (as is done in Alderman *et al.*, 2009). As expected, the coefficients from the OLS and FE regressions fall to -0.213 and -0.157 when this additional variable is included, but the remaining effect is still large and significant. This signals that children who suffer from early malnutrition complete fewer years of schooling not only because they start at a later age, but because they progress at a slower rate through the schooling system.

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because individuals can change households over waves (and the households themselves can change characteristics).

[15] An additional form of endogeneity that is much harder to account for is that related to unobserved child-specific differences. For instance, parents could allocate nutritional investments to children based on their perceived academic ability or motivation (although this is less of a concern the younger the child is, as parents are unlikely to know the child's ability at a very young age). To try and account for this potential bias, one needs to find an instrument that is correlated with child nutritional status but that still varies across siblings within a household. Data on drought, civil war, and variation in food prices and rainfall have been used as instruments in the literature, exploiting the age differences between siblings (Glewwe and King, 2001; Alderman *et al.*, 2001; Alderman *et al.*, 2006; Alderman *et al.*, 2009). However, the ability to find suitable instruments such as these is limited, and using this approach itself has limitations (see Glewwe and King, 2001 for further discussion).

[16] The coefficients on coloured and mother's schooling are estimated in the household fixed effects model because there can be variation within the household on these variables (children need not have the same mother), but they are imprecisely estimated because of small sample sizes.

Table 5. Effect of stunting in Wave 1 on grades completed by Wave 4

	I (OLS)	II (FE)	III (OLS)	IV (FE)
Stunted (W1)	-0.294***	-0.252***	-0.213***	-0.157**
	(0.042)	(0.069)	(0.042)	(0.069)
Age in months (W4)	0.073***	0.073***	0.075***	0.074***
	(0.001)	(0.001)	(0.001)	(0.001)
Female	0.387***	0.387***	0.341***	0.346***
	(0.034)	(0.053)	(0.034)	(0.053)
Coloured	-0.009	0.302	-0.034	0.186
	(0.088)	(0.426)	(0.085)	(0.397)
Mother's schooling (W1)	0.047***	0.014	0.043***	0.004
	(0.005)	(0.013)	(0.005)	(0.014)
Urban residence (W1)	-0.044		-0.055	
	(0.046)		(0.045)	
Quintile 2 (W1)	-0.029		-0.061	
	(0.043)		(0.042)	
Quintile 3 (W1)	-0.033		-0.034	
	(0.050)		(0.049)	
Quintile 4 (W1)	0.095		0.102*	
	(0.064)		(0.062)	
Quintile 5 (W1)	0.079		0.027	
	(0.101)		(0.100)	
Household size (W1)	0.002		-0.001	
	(0.006)		(0.006)	
Age first enrolled in Gr1			-0.195***	-0.238***
			(0.014)	(0.028)
Constant	-6.242***	-5.987***	-5.281***	-4.666***
	(0.140)	(0.190)	(0.160)	(0.249)
Household fixed effects		Yes		Yes
N	2855	2855	2348	2348

Notes: Standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10
Controls for Wave 1 province of residence included

This finding is confirmed in Table 6, which shows the effect of stunting on the grade outcome, conditional on enrolment. Compared to children who were not stunted in Wave 1, children who were stunted were more likely to have failed at least once in 2012 or 2013 (Regression I), or to have failed at least once in the three-year period preceding the 2015 interview (Regression III). The effects survive the household fixed effects adjustment and even strengthen somewhat (Regressions II and IV).[17]

[17] Some of the younger children in the sample of 7 to 14 years olds would not have been age eligible in 2012 or 2013 (even though some children do enrol in school earlier). Nonetheless, when we exclude all the 7 and 8 year olds from the regression sample, the results hardly change.

Table 6. Effect of stunting in Wave 1 on grades failed in 2012 to 2014[a]

	I (OLS) Failed 2012/13	II (FE) Failed 2012/13	III (OLS)[b] Failed 2012/13/14	IV (FE)[b] Failed 2012/13/14
Stunted (W1)	0.055***	0.089***	0.077***	0.109***
	(0.016)	(0.032)	(0.022)	(0.040)
Age in months (W4)	-0.001***	-0.001**	-0.001***	-0.001*
	(0.000)	(0.000)	(0.000)	(0.001)
Female	-0.089***	-0.106***	-0.104***	-0.108***
	(0.013)	(0.025)	(0.018)	(0.031)
Coloured	0.004	-0.256	-0.002	-0.266
	(0.034)	(0.194)	(0.044)	(0.230)
Mother's schooling (W1)	-0.012***	-0.010	-0.017***	-0.014*
	(0.002)	(0.006)	(0.003)	(0.007)
Urban residence (W1)	-0.042**		-0.031	
	(0.018)		(0.025)	
Quintile 2 (W1)	0.024		0.022	
	(0.017)		(0.022)	
Quintile 3 (W1)	-0.001		-0.023	
	(0.019)		(0.026)	
Quintile 4 (W1)	0.000		-0.020	
	(0.025)		(0.034)	
Quintile 5 (W1)	-0.025		-0.094*	
	(0.039)		(0.056)	
Household size (W1)	0.003		-0.001	
	(0.002)		(0.003)	
Constant	0.451***	0.432***	0.716***	0.554***
	(0.055)	(0.091)	(0.106)	(0.114)
Household fixed effects		Yes		Yes
N	2692	2692	1935	1935

Notes: Standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10
Controls for Wave 1 province of residence included.
[a] Conditional on enrolment in those years.
[b] Sample is restricted to children interviewed in 2015 in Wave 4.

A full set of comparable regressions were estimated to determine the effects of obesity in Wave 1 on the education outcomes in Wave 4, but only the main results on the obesity indicator are shown in Table 7. As in the unconditional results in Table 3, being classified as obese in childhood appears to have no significant effect on the educational outcomes, even after controlling for individual and household characteristics. Using overweight instead of obesity also produces insignificant results (not shown here). Although there has been less research on the effects of obesity or overweight on educational outcomes (compared to the research on stunting for instance), the literature suggests a generally weak and sometimes insignificant association. In a review of 29 studies linking weight with educational attainment, Caird *et al.* (2011) report that differences in educational attainment by obesity status in childhood were marginal, especially after controlling for other factors like socio-economic status. These studies were conducted on data predominantly from the US though, with a few studies from Canada, the UK, and a number of other European countries.

Table 7. Effect of childhood obesity in Wave 1 on educational outcomes in Wave 4

	OLS	Household fixed effects
Age started Grade 1		
Obese (W1)	-0.095	-0.206
	(0.115)	(0.211)
N	2250	2250
Completed grades		
Obese (W1)	-0.025	-0.166
	(0.082)	(0.160)
N	2197	2197
Failed 2012/13[a]		
Obese (W1)	0.006	-0.020
	(0.032)	(0.071)
N	2522	2522
Failed 2012/13/14 [a; b]		
Obese (W1)	-0.026	-0.066
	(0.044)	(0.087)
N	1817	1817

Notes: A full set of controls is included as in Tables 4-6 on stunting. The regression on grades completed also controls for age at first enrolment.

[a] Conditional on enrolment in those years.

[b] Sample is restricted to children interviewed in 2015 in Wave 4.

5. Discussion

The results from the analysis above suggest that poor nutrition in early childhood, and specifically undernutrition, has a negative effect on educational attainment among young children. There are significant differences in the subsequent educational outcomes of children who were stunted compared to children who were not stunted in Wave 1 (i.e. when they were 8 years or younger). More specifically, the group of children who were stunted (now aged 7 to 14 years in 2014/15) were found to have: 1) enrolled later for Grade 1; 2) completed fewer years of schooling, and 3) been more likely to fail the grades they had enrolled for in the preceding years.

A poorly nourished child may be enrolled in school later because the parents (or teacher) do not consider the child ready for school, but the child could then spend longer in school and ultimately obtain the same number of years of schooling as other children. However, even after controlling for age at first enrolment in the multivariate analysis, children who were stunted completed fewer years of schooling by age 14, suggesting that they are also less productive at learning per year of schooling. This is consistent with the descriptive and regression results which indicate that children who were stunted in Wave 1 were more likely to have failed one or more grades in primary school. Nonetheless, as Alderman *et al.* (2009) point out, even if these children simply progress slower through the schooling system and in the end do not complete fewer years of schooling, they will still enter the labour market at a later age, resulting in a reduction of lifetime earnings.

These results should be considered in light of the most recent estimates on the prevalence of stunting for South Africa, based on the SANHANES 2012 data. For children aged 1 to 3 years old, the prevalence of stunting was found to be 26.5% (Shisana *et al.* 2013: 212), which implies that prevalence for this age group has not declined and may even have risen since 2008. South Africa also fares poorly in global comparisons given its GDP per capita, and was recently identified as one of 34 countries responsible for 90% of the global burden of child malnutrition (Bhutta *et al.*, 2013). The descriptive results for South Africa presented earlier further indicate that the prevalence of stunting in childhood is strongly correlated with the household's socio-economic status, suggesting that existing inequalities are likely to be perpetuated.

Potential for further work

The purpose of this paper was to provide an example of how the longitudinal data from the NIDS surveys can be used to produce policy-relevant research not possible with other national datasets currently available in South Africa. In this case, the focus was on exploring one aspect of human capital accumulation - the relationship between early nutrition and later schooling outcomes in young children. However, this specific work could be extended in a number of ways, and there are many other areas that could be explored if one is interested in research on human capital outcomes.

In terms of extending this work, it would be interesting to examine further the dynamics within the household, and how these play out in children's educational outcomes. One aspect that was not explored here, but that could be examined using the NIDS data, is the influence of birth order and child spacing on children's outcomes, and whether there are gender differences in the effects. While there is a substantial amount of work in the human capital literature on this topic, not much research exists for developing countries (Moshoeshoe, 2015). Also not explored here are the implications of school quality for the results. Data on the number of learners in the child's class and whether or not the school is a no fees school are available within the survey, but another possibility would be to link the NIDS data with the administrative data from the Department of Basic Education, as was done for Waves 1 and 2 in Branson *et al.* (2012).

The empirical work in this paper used data from the child questionnaires and so the outcomes were limited to schooling up to the age of 14 years. This work could be extended by linking these data with the education data from the adult questionnaire for the older cohort of children and for adults to look at progression in secondary schools and final educational attainment. And as further waves become available, there is the potential to analyse the young adult labour market outcomes. Research elsewhere for example has found that improved nutrition in early childhood results in higher productivity in adulthood, measured by hourly wages (Hoddinott *et al*. 2008)

The implications of obesity in early childhood could also be investigated further, especially given growing concerns around the rising rates of obesity worldwide. Although the results of the empirical work did not suggest a significant influence of early childhood obesity on educational outcomes among children aged 14 years and younger, early (and persistent) obesity might result in negative education effects among older children. As Caird *et al.* (2011) note, while obesity in childhood is often found to have a weak association with educational attainment, there could be other negative health and social consequences that in turn impact labour market outcomes. Given the wealth of data in the NIDS adult questionnaire on health, emotional well-being, and social cohesion, as well as labour market outcomes, there may be a number of avenues of research to pursue in this area.

A last suggestion for further work is to look at the persistence of health status in children and whether this has implications for educational (or other) outcomes. Transition matrices of stunting and obesity status between Waves 1 and 4 (shown in Tables A.1 and A.2 in the Appendix) suggest a high degree of mobility in children's nutritional status. For example, of those children classified as obese in Wave 1, around 70% were no longer classified as obese in Wave 4. Of the children classified as stunted in Wave 1, 66% were no longer classified as stunted in Wave 4. While some of this might have to do with measurement error, similarly high 'rates of recovery' from stunting for example were documented between Waves 1 and 2 of NIDS by Ardington and Gasealahwe (2012), and in Casale and Desmond (2016) using the Birth to Twenty cohort data.

Casale and Desmond (2016) explore the relationship between changes in stunting status and cognitive outcomes in preschool children and find that children who 'catch up' in early childhood still do worse on average than children who were never stunted, suggesting that the timing of good nutrition is key in the child's development. However, this is a largely under-researched area of analysis for South Africa, and much more work needs to be done on the biological and socio-economic factors that determine malnutrition in the first instance and subsequent recovery. Understanding the consequences for human capital and other outcomes may have important implications for the timing of nutritional interventions.

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Appendix: Persistence of nutritional outcomes between Waves 1 and 4

Table A.1. Transition matrix of stunting status among children in Waves 1 and 4 (number of observations and cell percentages)

	Not stunted W4	Stunted W4	Total
Not stunted W1	2326 76.11	135 3.32	2461 79.43
Stunted W1	447 13.84	227 6.73	674 20.57
Total	2773 89.95	362 10.05	3135 **100**

Notes: Data are weighted using panel weights.
The sample is of children aged 6 months to 8 years in Wave 1 who were 7 to 14 years in Wave 4 and for whom anthropometric data are available in both waves.

Table A.2. Transition matrix of obesity status among children in Waves 1 and 4 (number of observations and cell percentages)

	Not obese W4	Obese W4	Total
Not obese W1	2643 89.04	130 5.17	2773 94.21
Obese W1	108 4.17	39 1.63	147 5.80
Total	2751 93.2	169 6.8	2920 **100**

Notes: Data are weighted using panel weights.
The sample is of children aged 6 months to 8 years in Wave 1 who were 7 to 14 years in Wave 4 and for whom anthropometric data are available in both waves.

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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