Int J Public Health (2013) 58:459–467
DOI 10.1007/s00038-012-0418-1

ORIGINAL ARTICLE

Access to antenatal care and children's cognitive development: a comparative analysis in Ethiopia, Peru, Vietnam and India

Mariachiara Di Cesare · Ricardo Sabates

Received: 20 July 2011 / Revised: 1 October 2012 / Accepted: 2 October 2012 / Published online: 31 October 2012

Abstract
Objectives Early life interventions are considered essential for reducing the burden of health inequalities over the life course. This paper tests this issue empirically focusing on whether access to antenatal care can later reduce children's health and educational inequalities.
Methods Data came from the Young Lives Project for Ethiopia, Peru, Vietnam, and the State of Andhra Pradesh in India. We selected children born in early 2001/2002 and who were followed longitudinally in 2006/2007. We used multilevel mixed effects linear regression models to estimate the parameters of interest.
Results We found a positive and significant relationship between mothers' access to antenatal care and their children's cognitive development in all countries. In addition, we found a positive and significant relationship between antenatal care and children's cognitive development for stunted children but only in Peru and Vietnam.
Conclusions We conclude that (1) antenatal care has the potential to change the negative consequences of early nutritional deficiencies on later cognitive development in Peru and Vietnam; (2) differentials in the quality of antenatal care services could explain the cross-country differentials in the role of early life interventions found here.

M. Di Cesare (✉)
Department of Epidemiology and Biostatistics, School of Public Health, Imperial College London, 524, Norfolk Place, St Mary's Campus, London W2 1PG, UK
e-mail: m.di-cesare@imperial.ac.uk

R. Sabates
Department of Education, University of Sussex, Brighton, UK

Keywords Health inequalities · Cognitive development · Child nutrition · Antenatal care · Multilevel model · Young Lives Longitudinal Study

Introduction

The last decade has witnessed growing interest in the analysis of early life events and their potential effects on adult life chances (Blane et al. 2004; Case et al. 2005; Heckman 2007). In particular, exposure to risk and disadvantage during childhood, which tends to accumulate during adolescence, is likely to manifest itself again in adulthood generating socioeconomic hardship (Holland et al. 2000). This cumulative process is responsible for the persistence of social and health inequalities between and across generations (CSDH 2008; Exworthy et al. 2003; Marmot 2005; Marmot and Wilkinson 1999; Palloni et al. 2009; Wilkinson and Pickett 2006).

In this life course perspective, child nutrition is known to have important consequences during childhood and adulthood (Victora et al. 2008). Child malnutrition is the underlying cause for more than half of global childhood deaths every year (Caulfield et al. 2004). Malnutrition is likely to reduce individuals' human capital (Grantham-McGregor et al. 2007; Victora et al. 2008) due to its adverse effects on child cognitive development and educational outcomes (Alderman et al. 2001; Feinstein et al. 2008; Handa and Peterman 2007; Jukes 2007; Mendez and Adair 1999; Watanabe et al. 2005; Wisniewski 2010).

In order to deal with the consequences of malnutrition and of ill health in general, the Commission on the Social Determinants of Health (CSDH 2008) calls for early action, both progressive and universal.

Although early action is important to confront the consequences of ill health, not all deal with the consequences of health inequalities (Grantham-McGregor et al. 2007). In particular, dealing with malnutrition in infancy can reduce the burden of health deficiencies on later cognitive development without affecting health or educational inequalities. What needs to be done to address health deficiencies and tackle health inequalities simultaneously?

This paper aims to shed light on this question empirically. In particular, the paper (1) analyses the potential effects that an early intervention, such as access to antenatal care, has on child cognitive development; and (2) investigates the role of antenatal care in reducing the burden of health inequalities on educational inequalities. Three main assumptions support our two research aims: (i) access to antenatal care has direct benefits on the mother's and the foetus's health, and consequently on future health outcomes (Alexander and Korenbrot 1995). It is increasingly recognised how in utero environment affects later adult health (Barker 1998; Gluckman and Hanson 2005); (ii) the use of antenatal health services may increase the use of postpartum health services and change maternal health-related parenting behaviours which, in turn, have consequences for cognitive development (Noonan et al. 2010). In other words, antenatal care can moderate or change the direct effects of ill health on cognitive development; (iii) access to antenatal care may impact on the mother–infant relationship, as shown by specific antenatal interventions (Cooper 2009). In particular, antenatal care may change the effects of ill health on cognitive development by enhancing mother's consciousness of child's needs.

Assumptions (ii) and (iii) support the role of antenatal care in reducing the impact of health inequalities on educational outcomes.

Methods

Data and sample

Data used for this study come from the first two waves of the Young Lives Longitudinal Study (YL) (Boyden 2006), a 15-year study of childhood poverty in four developing countries—Ethiopia (ET), Peru (PE), Vietnam (VI), and the state of Andhra Pradesh in India (AP). The first wave of the survey took place in 2002 and focused on two cohorts of children. The youngest cohort was children aged between 6 and 18 months (baseline sample across countries 8,061 children) and the oldest cohort was children aged between 7 and 8 years old (baseline sample across countries 3,722 children). The second round was conducted in 2006/2007 when the two cohorts were 4–5 years old and 11–12 years old, respectively. Our research uses data exclusively from the youngest cohort at both rounds, since it contains information on mothers' access to antenatal care and child nutrition and cognitive development. Sample sizes 2006/2007 were 1,908 children in Ethiopia, 1,975 in Peru, 1,975 in Vietnam, and 1,950 in Andhra Pradesh.

The sample strategy for YL was based on the sentinel site surveillance for which 20 geographical sites with 100 children each were selected (Wilson et al. 2003). Geographical sites were selected based on poverty status, while households within sites were randomly selected (Wilson et al. 2003). The sample as a whole is not nationally representative, but households are representative within geographical sites. Attrition and non-response biases must be considered in any longitudinal study (Wooldridge 2002). Attrition rates for the youngest cohort (including deaths) were relatively low according to international standards (ET, 4.50 %; PE, 3.75 %, VI, 1.25 %; AP, 3.03 %). Non-participant households in the second wave of the survey did not systematically differ from the rest of the households, in relation to child anthropometric (Sanchez 2009).

Item with missing responses was extremely low, estimated to be between 0.9 % and 3.2 % of the total sample. Of this range, the largest variable with missing responses was found for the cognitive development assessment test as its administration was affected by poor weather conditions and lack of trained interviewers (Cueto et al. 2009). Since the cognitive development assessment test is our outcome variable and for the rest of the factors used in the analysis data loss due to missing responses was less than 1 %, we opted not to undertake any imputation. The only exception was for the variable related to the type of cooking fuel in Vietnam (used for the construction of the wealth index), where information missing from 250 households regarding type of cooking fuel in wave 1 was replaced by information provided by the same households in wave 2.

Our final sample sizes for each country were 1,807 children for Ethiopia, 1,922 for Peru, 1,882 for Vietnam and 1,910 for Andhra Pradesh.

Selection of variables

Our main outcome variable is the quantitative sub-scale of the cognitive development assessment (CDA) test which was collected in 2006/2007 when children were around 5 years old. The CDA test was developed by the International Evaluation Association to assess the effects of preschooling on cognitive development. It is composed of three sub-scales: spatial relation, quantitative and time. YL data only contain the quantitative sub-scale due to its reliability. The test requires children to match the quantitative concept expressed by the examiner with a picture

selected from multiple options. For example in response to a question "point at the plate that has few cakes", the child must select the correct answer from four different pictures (Cueto et al. 2009). The quantitative sub-scale contains 15 items, scoring 1 point for each correct answer, and 0 points for each wrong answer, leading to a maximum of 15 points (Cueto et al. 2009). The CDA is to be preferred to the Peabody Picture Vocabulary Test (PPVT), also available in YL data, because the verbal ability tested using the PPVT is slightly more culturally biased (Brooks-Gunn et al. 2003). Hence, using the PPVT may affect the comparability of the results between the four countries.

The first key explanatory variable is antenatal care (ANC). WHO (WHO 2003) recommendations for ANC for a normal pregnancy consist of four visits during pregnancy, with a visit within the first trimester, and a skilled practitioner during birth (doctor, nurse, or midwife). The WHO recommendations for ANC in deprived areas where YL carried out the data collection imply that only a small minority of women would be following these recommendations. For this reason, we operationalised access to ANC if the mother had at least one of the following: a first visit during the first trimester; at least four visits in total during pregnancy; or a health professional at delivery (doctor, nurse or midwife). We considered poor access to ANC if any of these conditions did not hold or if the mothers did not have access to ANC services.

The second key explanatory variable in the analysis is malnutrition. We use height-for-age z-score, constructed according to the WHO's child growth standards as a proxy measure of early nutritional status (Wisniewski 2010). A value below two in the z-score (also known as stunting) provides a measure of very slow growth since birth and it is considered to be a stock measure of malnutrition (Wisniewski 2010). Despite its well-known use in the empirical literature, height-for-age has its limitations which we will discuss in the conclusions.

Using both access to antenatal care and height-for-age z-score (dichotomous variable measuring stunting), we constructed the following variables from their interaction: (1) poor or no access to ANC and stunted; (2) poor or no access to ANC and not stunted; (3) access to ANC and not stunted; (4) access to ANC and stunted. These variables are used for the empirical model to estimate the interaction between antenatal care and stunting.

The following variables, selected based on previous research, are used as covariates: mother's education (Caldwell 1979; Desai and Alva 1998; Schady 2011); mother's age (Fergusson and Lynskey 1993); child's prematurity (Gladstone et al. 2011); child's birth size (Richards et al. 2002); child's birth order (Kristensen and Bjerkedal 2007); household wealth (Aber et al. 1997); child's pre-school attendance (Sammons et al. 2004); and age and gender of the child. The length of breastfeeding is a key variable for cognitive and motor development (Angelsen et al. 2001), but unfortunately it cannot be used for statistical purposes due to a very small proportion of children breastfed for less than 6 months in the sample areas (fewer than 4 %).

Estimation method

The empirical model considers the relationship of antenatal care (ANC) and nutritional status in 2002 (STUN) on child's cognitive development assessment (CDA) at age five (in 2006/2007). The relationship of ANC and nutritional status with CDA is described by Eq. (1):

$$\mathrm{CDA}_{ij} = b_{00} + b_{1j}\mathrm{ANC}_{ij} + b_{2j}\mathrm{STUN}_{ij} + b_{3j}\mathrm{ANC}_{ij}|\mathrm{STUN}_{ij} + b_{4j}X_{1ij} + \varepsilon_{ij} + u_{0j} \quad (1)$$

where b's are parameters to be estimated, "|" refers to the interaction between ANC and STUN, X_1 is the vector of additional covariates included in the model, ε_{ij} is the micro level error term. Unobserved community variability, which captures differences in quality of health and pre-school services and which affects both our outcome and key variables, is accounted for in the model by u_{0j}. Multilevel mixed-effects linear regression is used to estimate the parameters of this model.

The estimation strategy is as follows. We first estimated Eq. (1) with the inclusion of ANC and STUN but no interaction term or covariates. Parameters estimated are the association of each of these variables with CDA conditional on the other. Then, we include covariates to estimate if the associations of ANC and STUN to CDA remain statistically significant. Finally, using all the covariates we introduce the interaction term to estimate the moderating effect of ANC, that is whether the relationship of STUN to CDA is different for children whose mothers had access to ANC [as described by Eq. (1)].

Causal inference is an important issue in the analysis of the relation between antenatal care, nutrition and cognitive development. Selection bias, reverse causation and spurious effects all play a fundamental role in explaining these relationships (Gilleskie and Harrison 1998). In this paper, we focus on cognitive development at age five to avoid selection bias due to school participation and the fact that not enrolled children may systematically differ from those who are enrolled (Glewwe 2005). In addition, relatively low attrition and missing values reduce selection bias built in the YL data. We focus on antenatal care, nutritional status and cognitive development measured at different points in time to avoid reverse causation. Finally, we partially deal with reverse causality since antenatal care and nutritional status are measured before parents can judge their children's intelligence (Glewwe 2005). This means

that there should not be any rational household decision in allocating more or less resources for child's health according to his/her intelligence and more or less resources for his/her education according to his/her health status. We do, however, acknowledge that causal inference is not guaranteed since a series of unobserved confounding factors, such as parental beliefs and attitudes, may alter the relationship between maternal access to antenatal care services, nutritional status of the child and later cognitive development (Fujiwara and Kawachi 2009). Our interpretation of results in this paper remains at the level of associations.

Results

Table 1 shows the descriptive statistics for the variables used in the model. In relation to the three key variables—CDA score, ANC, stunting—the four countries show different patterns. The difference in CDA score between the four countries is 1.58 points (with the highest score observed in Vietnam and the lowest in Ethiopia). Only 40 % of Ethiopian women had some antenatal care against 92 % in Peru and 85 % in Vietnam, and 82 % in Andhra Pradesh. Almost 30 % of Ethiopian children were stunted between 6 and 17 months of age, whereas 19 % of children were stunted in Andhra Pradesh, 17 % in Peru, and only 10 % in Vietnam. Descriptive statistics for all other covariates are also shown in Table 1.

The mean CDA score by nutritional status and access to ANC is shown in Fig. 1. This gives a first indication of the association between cognitive development and the two key variables. As expected, non-stunted children perform better cognitively than stunted children. However, having had access to antenatal care increases the mean CDA score in both groups of children (stunted and non-stunted). In Vietnam, stunted children whose mothers had access to ANC have a 35 % higher CDA score than stunted children whose mothers had poor access or no access to ANC. Non-stunted children whose mothers had access to antenatal care have 22 % higher CDA score than non-stunted children whose mothers had poor or no access to ANC.

Table 2 shows the relationship of ANC care and stunting on CDA. For each country, columns marked with (1) show results of the base model which estimates the relationship of ANC and stunting on CDA without the inclusion of any other covariate. Columns marked with (2) introduce observable covariates and focus on the relationship of ANC on cognitive development. Finally, columns marked with (3) focus on the interaction between ANC and stunting on CDA, conditional on other covariates.

In all countries, we found a positive relationship of ANC on CDA conditional on nutritional status (Table 2, columns 1). In Ethiopia, children whose mothers had access to ANC achieved, on average, 0.55 points higher CDA scores compared with children whose mothers had poor access or no access to antenatal care services. In Andhra Pradesh, Peru and Vietnam, children whose mothers had access to ANC achieved, on average, 0.51, 1.01 and 0.82 points higher CDA scores compared with children whose mothers had poor access or no access to antenatal care services, respectively.

When covariates for child and mother characteristics, and household socioeconomic factors are introduced in the model, the conditional relationship of ANC with CDA remains statistically significant in Ethiopia, Peru and Vietnam (Table 2, columns 2). The inclusion of these covariates reduces the estimated parameter of ANC in Ethiopia from 0.55 to 0.35, in Peru from 1.01 to 0.68 and in Vietnam from 0.82 to 0.40. In Andhra Pradesh, however, the inclusion of covariates reduces the estimated association between ANC and CDA from 0.51 to 0.22 and the conditional association becomes statistically non significant.

The key result of this paper is shown in Table 2, columns 3, where the interaction between ANC and stunting is introduced in the analysis. In all countries, our results show that children who were not stunted and whose mothers had access to antenatal care services achieved, on average, higher test scores (0.56 points in Ethiopia; 0.76 points in Andhra Pradesh; 1.17 points in Peru; 0.79 points in Vietnam) than children who were stunted and whose mothers had poor or no access to ANC. But only in Peru and Vietnam is the relationship of stunting and CDA test score weakened if the mother had access to ANC. Stunted children whose mothers had access to ANC achieved, on average, 1.07 and 0.60 points higher in CDA test in Peru and Vietnam, respectively, than stunted children whose mothers had poor or no access to ANC. In Peru, in addition, children who were not stunted and whose mothers had poor or no access to ANC services achieved, on average, 0.64 higher points than children in the reference group. We found the expected relationship between other covariates, including malnutrition and CDA. Results are shown in Table 2, but not explained in the paper.

Discussion

This paper follows the call for remedial action early in life to close the health gap and reduce the reproduction of inequalities in one generation suggested by the Commission on the social determinants of health (CSDH 2008). In considering the effects of health conditions early in life, such as nutritional status, on subsequent cognitive development, we identified access to antenatal care services as one possible action. Our hypothesis that access to antenatal

Table 1 Variable definitions and descriptive statistics for main variables, mean and (SD)

Variables	Round	Description	Mean (SD)		Mean (SD)	
			Ethiopia	Andhra Pradesh (India)	Peru	Vietnam
Outcome variable						
Cognitive development assessment score (*age 5*)	2006/2007	Cognitive development assessment score, 15 items, range 0–15	8.21 (2.99)	9.39 (2.61)	8.37 (2.16)	9.79 (2.51)
Main explanatory variables						
Access to antenatal care	2002	Access to antenatal care defined if one visit during first trimester, more than four visits or a health professional at delivery	0.40 (0.49)	0.82 (0.33)	0.92 (0.27)	0.85 (0.35)
Stunting (*age 1*)	2002	Child nutritional status, stunted lower than −2 height-for-age z-score	0.30 (0.46)	0.19 (0.40)	0.17 (0.38)	0.10 (0.29)
Main covariates						
Pre-school	2006/2007	Child in pre-school by age 5	0.27 (0.44)	0.94 (0.24)	0.81 (0.39)	0.90 (0.31)
Gender	2006/2007	Gender of the child, proportion of girls.	0.47 (0.50)	0.47 (0.50)	0.50 (0.50)	0.49 (0.50)
Child age	2006/2007	Child's age in months	61.82 (3.86)	64.29 (3.89)	63.44 (4.70)	63.10 (3.71)
Mum education	2002	Mothers who have more than 6 years of education	0.21 (0.41)	0.31 (0.46)	0.70 (0.46)	0.62 (0.49)
Mum age	2002	Mother's age in years	27.49 (6.37)	23.65 (4.33)	26.85 (6.73)	27.13 (5.75)
Birth order	2002	First born	0.21 (0.41)	0.38 (0.48)	0.26 (0.48)	0.44 (0.50)
Prematurity	2002	Child born premature (at least 3 weeks earlier)	0.02 (0.150)	0.03 (0.16)	0.07 (0.26)	0.05 (0.21)
Birth size	2002	Perception of child's size at birth average-larger than others	0.71 (0.46)	0.76 (0.43)	0.72 (0.45)	0.80 (0.40)
Wealth	2002	Wealth index (included in quintiles)	0.17 (0.16)	0.39 (0.21)	0.46 (0.23)	0.45 (0.23)
Wealth change	2006/2007	Worsening of wealth status between R1 and R2	0.32 (0.47)	0.27 (0.45)	0.25 (0.43)	0.26 (0.44)
Community	2002	Number of communities	26	101	82	31
Number of observations			1,807	1,910	1,922	1,882

Ethiopia, Andhra Pradesh (India), Peru, Vietnam. Young Lives Longitudinal Study 2002 and 2006/2007

Variables such as ethnicity and urban/rural place of residence have been omitted due to the high correlation with the community level control introduced by multilevel models

care can moderate or change the effects of poor nutrition on cognitive development was supported through previous research on the impact of antenatal care on postnatal access to health services, and maternal parenting behaviours (Noonan et al. 2010). Previous research also showed that antenatal care can have a direct impact on cognitive development which is channelled mainly via better health for the child (Cooper and 2009).

Our findings suggest that access to some kind of antenatal care is positively associated with child's cognitive development in Ethiopia, Peru, and Vietnam. Children whose mothers had access to antenatal care during pregnancy were likely to achieve higher test scores at age five than children whose mothers had poor access or no access to antenatal care. This result is in line with research concerning the potential long-term benefits of access to antenatal health care services (Alexander and Korenbrot 1995; Gluckman and Hanson 2005). In addition, we found that in all countries, children whose mothers had access to antenatal care services and who were not stunted during the first 2 years of life achieved the highest test scores. This result is not surprising since better off children continue to outperform those who live in poverty and who started in a position of disadvantage (Brooks-Gunn et al. 2003).

The main evidence from this study suggests that the effect of nutritional deficiencies in the first months of life

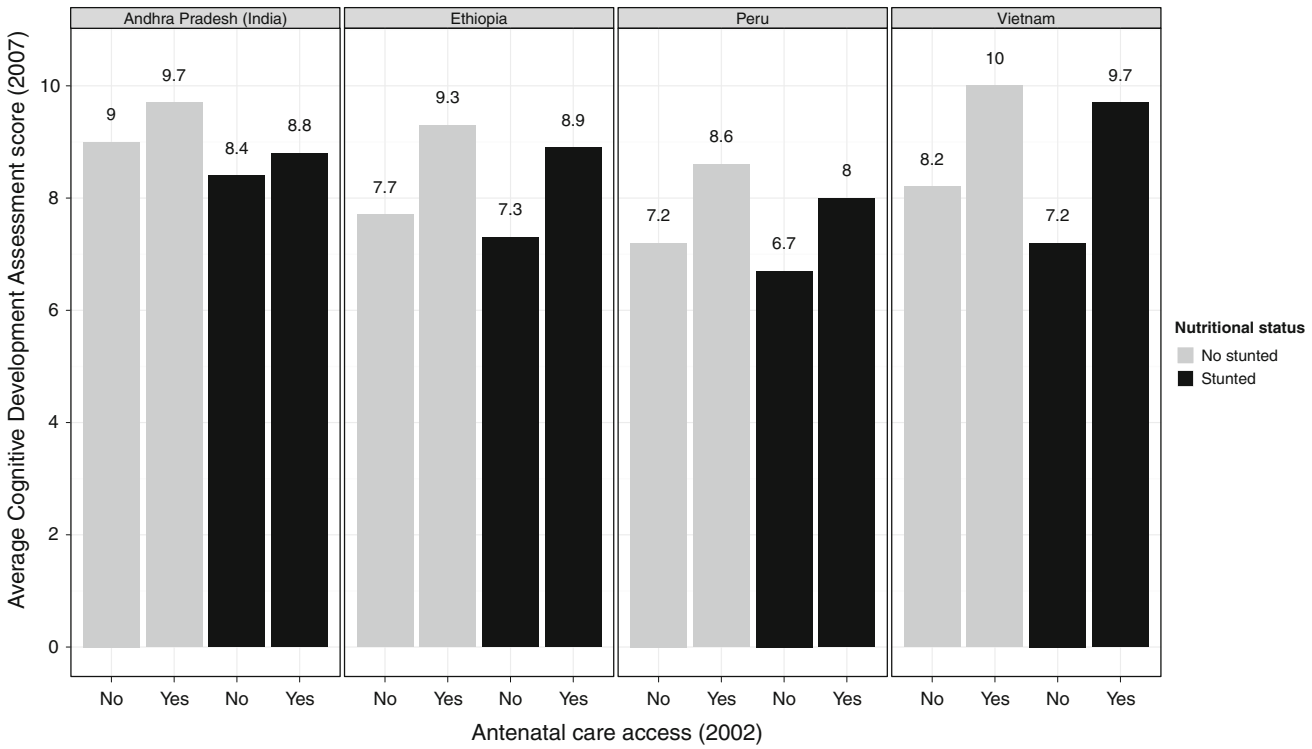

Fig. 1 Average cognitive development assessment score by nutritional status (stunted, no stunted), and antenatal care (access to antenatal care, poor/no access to antenatal care). Ethiopia, Andhra Pradesh (India), Peru, Vietnam. Young Lives Longitudinal Study 2002 and 2006/2007 (Year of Young Lives round included between brackets)

on subsequent cognitive development can be in part weakened if the mother had access to antenatal care services during pregnancy and birth, in Peru and Vietnam. In these countries, children who were stunted and whose mothers had access to antenatal care not only perform better than their counterparts whose mothers did not have access to ANC, but also they perform similarly to the group of children with access to ANC and without any nutritional deficiency during the first months of life. This result suggests that ANC services have the potential to reduce the impact of health inequalities on educational inequalities.

However, this evidence was not supported in all countries. In Andhra Pradesh (India) and in Ethiopia, we did not find this moderating effect of ANC. This raises the question: why? One possible explanation may lay in the quality of antenatal care services received in Andhra Pradesh and Ethiopia relative to that received in Peru and Vietnam. In Ethiopia, only 40 % of mothers had access to ANC services, as defined in the paper. In Andhra Pradesh, however, 82 % of women had access to ANC, which is comparable to the percentage of mothers who had access to ANC in Peru and Vietnam. An important distinction about the quality of ANC may be the proportion of women who were attended by a skilled health practitioner during their child's birth. Only 20 % of mothers were assisted by a skilled health practitioner in Ethiopia and 59 % in Andhra Pradesh (compared with 76 % in Peru and 80 % in Vietnam). It seems that better quality of ANC services in Peru and Vietnam may explain the role of this early intervention in reducing the persistence of inequalities. However, this remains a limitation for this study since no information is available on the quality of ANC in YL sample or the proximity of health services to the areas of the study.

This study also has other limitations. First, according to the WHO (WHO 2003) antenatal care should include a first visit within the first trimester, at least four visits and a skilled attendant at birth. However, as previously mentioned, only a small minority of women in the sample accessed antenatal care services following the WHO recommendations (for example only 89 out of 1,807 women in Ethiopia followed the WHO guidance). This had implications for the estimation of parameters using statistical models.

Second, it may be the case that each of the dimensions of antenatal care has implications for reducing the impact of health inequalities on educational inequalities over time. Since we do not have information on the quality of each of these services or on mother's perceptions on the use of these services, it is difficult to model their individual importance, and for this reason remains a topic of further research. Therefore, from a health policy perspective, our results do not provide evidence for the effectiveness of the

Table 2 Multilevel mixed-effect linear model coefficients (standard error) for access to antenatal care, stunting and controls on cognitive development assessment score

Variables	Ethiopia			Andhra Pradesh (India)			Peru			Vietnam		
	Base (1)	Controls (2)	Interaction (3)	Base (1)	Controls (2)	Interaction (3)	Base (1)	Controls (2)	Interaction (3)	Base (1)	Controls (2)	Interaction (3)
Access to antenatal care: Yes	0.55 (0.16)***	0.35 (0.16)**		0.51 (0.16)***	0.18 (0.15)		1.01 (0.19)***	0.68 (0.18)***		0.82 (0.16)**	0.40 (0.16)**	
Child nutritional status: Stunted	−0.19 (0.14)	−0.20 (0.15)		−0.66 (0.15)***	−0.62 (0.14)***		−0.14 (0.13)	−0.17 (0.12)		−0.28 (0.16)*	−0.26 (0.16)*	
Interactions: poor/no access to antenatal care—stunted (reference category)												
Poor/no access to antenatal care: no stunted			0.22 (0.18)			0.52 (0.31)*			0.64 (0.34)**			0.45 (0.29)
Access to antenatal care: no stunted			0.56 (0.22)**			0.76 (0.29)***			1.17 (0.31)***			0.78 (0.28)***
Access to antenatal care: stunted			0.40 (0.26)			0.15 (0.31)			1.07 (0.32)***			0.56 (0.32)*
Other covariates												
Child in pre-school: yes		1.02 (0.21)***	1.02 (0.21)***		0.44 (0.24)*	0.44 (0.24)*		0.55 (0.12)***	0.54 (0.12)***		0.94 (0.16)***	0.88 (0.16)***
Child gender: female		0.00 (0.13)	0.00 (0.13)		−0.09 (0.11)	−0.09 (0.11)		0.17 (0.09)*	0.17 (0.09)*		0.10 (0.09)	0.10 (0.09)
Child age		0.10 (0.02)***	0.10 (0.02)***		0.10 (0.01)***	0.10 (0.01)***		0.11 (0.01)***	0.11 (0.01)***		0.09 (0.01)***	0.09 (0.01)***
Mum education: >6 years		0.43 (0.19)**	0.43 (0.19)**		0.82 (0.15)***	0.82 (0.15)***		0.21 (0.12)*	0.21 (0.12)*		0.61 (0.12)***	0.60 (0.12)***
Mum age		0.02 (0.01)*	0.02 (0.01)*		0.04 (0.01)***	0.04 (0.01)***		0.01 (0.01)*	0.01 (0.01)*		0.00 (0.01)	0.00 (0.01)
Birth order: first born		−0.03 (0.18)	−0.03 (0.16)		0.33 (0.12)***	0.33 (0.12)***		0.07 (0.11)	−0.08 (0.11)		0.10 (0.11)	0.11 (0.11)
Child prematurity: yes		−0.18 (0.42)	−0.19 (0.42)		−0.54 (0.35)	−0.54 (0.35)		0.14 (0.17)	0.14 (0.17)		−0.13 (0.22)	−0.13 (0.22)
Birth size: average or larger		−0.14 (0.14)	−0.14 (0.14)		0.41 (0.13)	0.41 (0.13)		0.19 (0.10)*	0.18 (0.10)		0.20 (0.12)*	0.20 (0.12)*
Wealth index (reference category: lowest quintile)												
Lower middle quintile		0.13 (0.21)	0.13 (0.21)		0.29 (0.18)	0.29 (0.18)		0.10 (0.15)	0.10 (0.15)		0.54 (0.16)***	0.54 (0.16)***
Middle quintile		0.20 (0.23)	0.19 (0.23)		0.19 (0.19)	0.19 (0.19)		0.57 (0.16)***	0.58 (0.16)***		0.55 (0.18)***	0.55 (0.18)***
Upper middle quintile		0.83 (0.28)***	0.83 (0.28)***		0.55 (0.20)***	0.55 (0.20)***		0.72 (0.18)***	0.73 (0.18)***		0.65 (0.20)***	0.66 (0.20)***
Highest quintile		1.30 (0.32)***	1.30 (0.32)***		0.79 (0.24)***	0.79 (0.24)***		1.28 (0.19)***	1.29 (0.19)***		0.87 (0.24)***	0.88 (0.24)***
Household wealth change (2002–2006/2007): worsening		−0.31 (0.16)*	−0.31 (0.16)*		−0.15 (0.13)	−0.15 (0.14)		−0.15 (0.11)	−0.14 (0.11)		−0.29 (0.11)**	−0.28 (0.11)**
Constant	8.43 (0.30)***	1.22 (1.12)	1.00 (1.14)	8.98 (0.17)***	0.42 (1.03)	−0.12 (1.06)	7.04 (0.21)***	−1.04 (0.75)	−1.57 (0.81)*	8.84 (0.29)***	1.29 (0.91)	0.92 (0.95)
σ^2_{u0}	*1.42 (0.22)***	*0.80 (0.15)***	*0.80 (0.15)***	*0.82 (0.09)***	*0.68 (0.09)***	*0.68 (0.09)***	*0.87 (0.09)***	*0.50 (0.09)***	*0.49 (0.09)***	*1.42 (0.19)***	*1.17 (0.16)***	*1.17 (0.16)***
σ^2_e	*2.67 (0.04)***	*2.60 (0.04)***	*2.61 (0.04)***	*2.45 (0.04)***	*2.37 (0.04)***	*2.37 (0.04)***	*1.94 (0.03)***	*1.85 (0.03)***	*1.85 (0.03)***	*2.01 (0.03)***	*1.92 (0.03)***	*1.92 (0.03)***

Ethiopia, Andhra Pradesh (India), Peru, Vietnam. Young Lives Longitudinal Study 2002 and 2006/2007

Data: Young Lives

*, **, *** Statistical significance at 10, 5 and 1 % level, respectively

WHO antenatal care recommendations. However, our results sustain the positive consequences of any contact during antenatal care visits or at delivery between the mother and the health specialist.

Third, despite the fact that the height-for-age metric has been widely used as an indicator of child's health status (Stevens 2012) the variable does not capture diseases or disabilities. For example, poor vision has no effect on height but has strong impacts on the learning process (Glewwe 2005). Given the YL sample sizes we were unable to use specific disabilities or diseases in the statistical models. Our results have to be interpreted carefully as antenatal care may not be able to reduce the burden of some diseases or disabilities on child cognitive development.

Fourth, results from YL cannot be generalised at the country level. However, social and economic gaps between rich and poor households in the YL sample are underestimations of existing inequalities within countries. This limitation suggests that if any relation regarding inequalities is detected in the YL sample it is likely to be much stronger in the population; however, we are unable to estimate it.

Fifth, further qualitative research is needed to understand the mechanism behind the association between access to ANC, child nutrition and cognitive development. It will be important to understand intra-household dynamics and the decision making which leads families whose children are undernourished to mitigate the consequences on cognitive development and the role played by early life interventions in such processes.

Despite these limitations, our research provides us with a policy approach, which is in line with the advocacy of the Commission on the Social Determinants of Health (CSDH 2008), to intervene in early life, with universal support, to lay the critical foundations for the later life course. Differential care during pregnancy, combined with disparities in provision for infants during the first years of life, leads to marked gaps in health (Marmot and Wilkinson 1999) and cognitive development (Feinstein et al. 2008). Those children lucky enough to be well endowed with social and economic resources, as well as institutional support, are likely to avoid poverty, deprivation and ill health. The rest, a significant majority, is likely to struggle with the vicious cycle of disadvantage over their life cycles. However, according to our study, access to antenatal care could be one of the first steps to improving infants' health and development. It also has the capacity to reduce the burden of malnutrition on cognitive development and it may have the potential to interrupt the vicious cycle of the transmission of inequalities over time.

Acknowledgments This research was funded by a grant from The BUPA Foundation grant number TBF-509-034 titled: "Access to Education and Child Health". An earlier version of this paper was presented at the Society for Longitudinal and Life Course Studies 2010 Conference, Cambridge and at the British Psychological Society Annual Conference, Milton Keynes, UK, November 2010. We would like to thank Professor Peter Aggleton and Dr Kathryn Duckworth for their comments and suggestions on this paper. We also would like to thank the Young Lives group in Oxford, in particular Inka Barnett for her insights.

Conflict of interest None declared

References

Aber JL, Bennett NG, Conley DC, Li J (1997) The effects of poverty on child health and development. Annu Rev Public Health 18:463–483

Alderman H, Behrman JR, Lavy V, Menon R (2001) Child health and school enrollment—a longitudinal analysis. J Hum Resour 36(1):185–205

Alexander GR, Korenbrot CC (1995) The role of prenatal-care in preventing low-birth-weight. Future Child 5(1):103–120

Angelsen NK, Vik T, Jacobsen G, Bakketeig LS (2001) Breast feeding and cognitive development at age 1 and 5 years. Arch Dis Child 85(3):183–188

Barker DJ (1998) In utero programming of chronic disease. Clin Sci (Lond) 95(2):115–128

Blane D, Higgs P, Hyde M, Wiggins RD (2004) Life course influences on quality of life in early old age. Soc Sci Med 58(11):2171–2179

Boyden J (2006) Young Lives Project: conceptual framework

Brooks-Gunn J, Klebanov PK, Smith JR (2003) The black–white test score gap in young children: contributions of test and family characteristics. Appl Dev Sci 7(4):239–252

Caldwell JC (1979) Education as a factor in mortality decline—examination of nigerian data. Pop Stud-J Demog 33(3):395–413

Case A, Fertig A, Paxson C (2005) The lasting impact of childhood health and circumstance. J Health Econ 24(2):365–389

Caulfield LE, de Onis M, Blossner M, Black RE (2004) Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr 80(1):193–198

Cooper PJ et al (2009) Improving quality of mother–infant relationship and infant attachment in socioeconomically deprived community in South Africa: randomised controlled. British Med J 338:b974

CSDH (2008) Closing the gap in a generation : health equity through action on the social determinants of health. World health Organization, Geneva

Cueto S, Leon J, Guerrero G, Muñoz I (2009) Psychometric characteristics of cognitive development and achievement instruments in Round 2 of Young Lives. Young Lives Technical Note. vol 5

Desai S, Alva S (1998) Maternal education and child health: is there a strong causal relationship? Demography 35(1):71–81

Exworthy M, Blane D, Marmot M (2003) Tackling health inequalities in the United Kingdom: the progress and pitfalls of policy. Health Serv Res 38(6):1905–1921

Feinstein L et al (2008) Dietary patterns related to attainment in school: the importance of early eating patterns. J Epidemiol Commun H 62(8):734–739

Fergusson DM, Lynskey MT (1993) Maternal age and cognitive and behavioural outcomes in middle childhood. Paediatr Perinat Epidemiol 7(1):77–91

Fujiwara T, Kawachi I (2009) Is education causally related to better health? A twin fixed-effect study in the USA. Int J Epidemiol 38(5):1310–1322

Gilleskie DB, Harrison AL (1998) The effect of endogenous health inputs on the relationship between health and education. Econ Edu Rev 17(3):279–295

Gladstone M, White S, Kafulafula G, Neilson JP, van den Broek N (2011) Post-neonatal mortality, morbidity, and developmental outcome after ultrasound-dated preterm birth in rural Malawi: a community-based cohort study. PLoS Medicine 8(11):e1001121

Glewwe P (2005) The impact of child health and nutrition on education in developing countries: theory, econometric issues, and recent empirical evidence. Food Nutr Bull 26(2 Suppl 2):S235–S250

Gluckman P, Hanson M (2005) The Fetal Matrix. Evolution, development and disease. Cambridge University Press, Cambridge

Grantham-McGregor S et al (2007) Child development in developing countries 1—developmental potential in the first 5 years for children in developing countries. Lancet 369(9555):60–70

Handa S, Peterman A (2007) Child health and school enrollment—a replication. J Hum Resour 42(4):863–880

Heckman JJ (2007) The economics, technology, and neuroscience of human capability formation. P Natl Acad Sci USA 104(33): 13250–13255

Holland P, Berney L, Blane D, Smith GD, Gunnell DJ, Montgomery SM (2000) Life course accumulation of disadvantage: childhood health and hazard exposure during adulthood. Soc Sci Med 50(9):1285–1295

Jukes M (2007) Impact of early childhood health and nutrition on access to education in developing countries. Pediatr Child Health 17(12):485–491

Kristensen P, Bjerkedal T (2007) Explaining the relation between birth order and intelligence. Science 316(5832):1717

Marmot M (2005) Social determinants of health inequalities. Lancet 365(9464):1099–1104

Marmot MG, Wilkinson RG (1999) Social determinants of health. Oxford University Press, New York

Mendez MA, Adair LS (1999) Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. J Nutr 129(8):1555–1562

Noonan K, Reichman NE, Corman H, Schwartz-Soicher O (2010) Effects of prenatal care on maternal postpartum behaviors. Rev Econ Household 8(2):171–197

Palloni A, Milesi C, White RG, Turner A (2009) Early childhood health, reproduction of economic inequalities and the persistence of health and mortality differentials. Soc Sci Med 68(9):1574–1582

Richards M, Hardy R, Kuh D, Wadsworth ME (2002) Birthweight, postnatal growth and cognitive function in a national UK birth cohort. Int J Epidemiol 31(2):342–348

Sammons P, Elliot K, Sylva K, Melhuish E, Siraj-Blatchford I, Taggart B (2004) The impact of pre-school on young children's cognitive attainments at entry to reception. Brit Educ Res J 30(5):691–712

Sanchez A (2009) Early nutrition and later cognitive achievement in developing countries. Background paper for the Education for all global monitoring report 2010: Reaching the marginalized

Schady N (2011) Parents' education, mothers' vocabulary, and cognitive development in early childhood: longitudinal evidence from ecuador. Am J Public Health (N Y) 101(12):2299–2307

Stevens GA et al (2012) Trends in mild, moderate, and severe stunting and underweight, and progress towards MDG 1 in 141 developing countries: a systematic analysis of population representative data. Lancet 380(9844):824–834

Victora CG et al (2008) Maternal and child undernutrition: consequences for adult health and human capital. Lancet 371(9609): 340–357

Watanabe K, Flores R, Fujiwara J, Lien THT (2005) Early childhood development interventions and cognitive development of young children in rural Vietnam. J Nutr 135(8):1918–1925

WHO (2003) Antenatal care in developing countries: promises, achievements and missed opportunities: an analysis of trends, levels and differentials, 1990-2001

Wilkinson RG, Pickett KE (2006) Income inequality and population health: a review and explanation of the evidence. Soc Sci Med 62(7):1768–1784

Wilson I, Huttly S, Young Lives (Project) (2003) Young Lives : a case study of sample design for longitudinal research. Young Lives, London

Wisniewski SLW (2010) Child nutrition, health problems, and school achievement in Sri Lanka. World Dev 38(3):315–332

Wooldridge JM (2002) Econometric analysis of cross section and panel data. MIT Press, Cambridge