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Does child labour affect final height?

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Background Although the negative effects of child labour on health are well known, the impact of child labour on final height is still controversial.

Aims To assess the effect of child labour on the final height of young adults.

Methods The study included 2063 adults aged 23–25 years from a cohort study of all live births (6827) in Ribeirão Preto, Brazil (1978–79). Height was measured in centimetres. Information on work, physical activity and smoking was obtained retrospectively and the other variables were obtained at cohort baseline. Work was classified according to age at first job: <14 (child labour), 14–16 and ≥17 years. Analyses were performed separately for males and females. Multiple linear regression analysis followed bivariate and stratified analysis.

Results The average height for males and females were respectively 176.0 cm [95% confidence interval (CI) 175.6–176.4] and 162.7 cm (95% CI 162.3–163.0). Labour before the age of 14 years was performed by 20% of males and 12% of females. In the bivariate analysis, child labour was statistically associated with final height for both males ($P < 0.01$) and females ($P < 0.01$). However, the association was not maintained after adjusting for confounders.

Conclusion We were not able to demonstrate significant height differences between those previously employed or not employed as a child, other than differences explained by other social and biological factors.

Key words Child labour; cohort study; height; human growth.

Introduction

The current estimate is that ~150–200 million children aged 5–14 years work full-time around the world [1]. Although Brazilian law prohibits child labour, 7.7 million children aged 5–17 years were working in Brazil in 1998 [2] and recent data indicate that ~5.4 million children and adolescents continue to work in the country [3].

Deleterious health effects of child labour such as injuries, hazardous exposures and the deleterious effect on general health status are well known [4–6]. However, the effect of child labour on growth is still controversial [7–9]. It has been assumed that the chronic physical strain of work on growing bones and joints could lead to stunting, spinal injury and lifelong deformations [1]. Moreover, the effects of job strain could be increased in children whose physiology has already been weakened through malnourishment [7]. Another hypothesis is that work would not directly affect the child's growth but indirectly by causing other health problems [6].

The deleterious effect of child labour found in cross-sectional studies conducted in India [7,8] and Jordan [9] contrasts with no association found in a study conducted in Lebanon [10]. In addition, adolescents involved in full-time work were taller than those with part-time work and unemployed in a study in poor urban and rural areas of Brazil [11]. The two longitudinal studies found in the literature also show contradictory results [6,7]. While Satyanarayana *et al.* [7] found significant growth deficit among children who worked in burdensome activities in India, O'Donnell *et al.* [6] were not able to find such association among children working in rural areas in Vietnam. However, one of the shortcomings of the Satyanarayana (1986) study is the lack of control of confounders.

The controversy among studies may in part be explained by different study designs, different control of confounders and small sample sizes. Difficulties distinguishing between the effects of labour and the effects

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of socio-economic situation on the health of these children remain [6,10,12–14]. Moreover, most of the studies addressing the association between child labour and health are cross-sectional and even the longitudinal ones evaluate only the height at some moment during puberty when the final height is not yet established.

Since cohort studies are complex and expensive there are few of them currently being undertaken in the world and rarely in developing countries where child labour is still a social problem. The population cohort of live births from Ribeirão Preto, Brazil, which began in 1978–79, is a unique opportunity to study the effect of child labour on height in adult life.

Thus, the objective of the present study was to determine whether child labour has a deleterious effect on the final height of young adults using the data from a population cohort of live births [15], after adjustment for potential confounding factors.

Methods

This was a study of a cohort of live births from Ribeirão Preto who were born between 1 June 1978 and 31 May 1979. The rural population, which comprises <1% of the total municipal population, was not included in our study [16]. Participants of the cohort were re-evaluated prospectively at school age, on the occasion of recruitment for military service (males at 18 years of age) and from 23 to 25 years of age during the period from April 2002 to May 2004. Only data obtained at birth and at 23/25 years of age were used for this study.

Ribeirão Preto, with ∼504 923 inhabitants, is located 320 km northeast of the city of São Paulo in the southeast region of Brazil, one of the richest and most industrialized in Brazil. The municipality has social and economic indicators above the state and national mean in the three dimensions that are part of the Human Development Index (HDI) (gross internal per capita product, life expectancy and schooling), reaching a rate of 0.855 on the maximum scale of 1.0, which qualifies the city as having a high HDI (>0.8) [17].

Infants whose family was not residing in Ribeirão Preto at the time of delivery were excluded from the 9067 live births of the original cohort (98% of the total number of live births during the period), with 6973 live births remaining, 6827 of these being single births. At the time of the last follow-up 343 individuals had died, resulting in 6484 eligible individuals for this study.

The potential participants in this study were identified by the name and address of the mother on the birth card. The current address and the telephone numbers of each participant were identified from evaluation charts of children at school age [19], from military service (only for males) and from registrations from public and private health services in the municipality [20]. A total of 5665 individuals were identified with address and/or telephone. From the original cohort, ∼30% of individuals were selected to participate in the follow-up. This sample size was enough to test the planned hypothesis. To guarantee a representative sample of socio-economic groups, individuals were classified according to the geoeconomic classification defined by income of the head of the family. Then, one in three individuals belonging to the same geographic area were randomly selected and invited to participate in the study [21]. During this process, 705 individuals had to be replaced because of refusal (209), imprisonment (31), death after 20 years of age (34) and failure to show up for interview (431). Thus, 2063 young adults, 995 males and 1068 females effectively participated in the study, a number corresponding to 32% of the original sample. Informed consent was obtained from each participant of the study. The study was approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo.

In order to detect a 2.0 cm difference in height between the individuals who had carried out child labour and those who had not, assuming a standard deviation of 10.0 cm, a power of 0.80 and a probability of Type I error of 0.05, a sample of 392 persons in each group would be necessary. The sample size reached permitted a separate analysis by sex.

Information for this study was obtained through questionnaires and physical examination both at baseline and at 23/25 years old. Height was measured in centimetres using a standardized instrument and techniques [22]. Information on work was obtained using a standardized occupational survey, modified for the objectives of the present study [23]. Child labour was classified into three categories: (i) working for at least one continuous year before 14 years of age, (ii) working for at least 1 year between 14 and 16 years of age or with the sum of work before 14 and between 14 and 16 being >1 year and (iii) work started at 17 years or more, working <1 year up to 16 years of age, or never having worked until the date of evaluation. Work was defined as any type of job carried out for others with or without financial remuneration. Moreover, jobs were classified according to the occupation as: industrial (excluding services and office jobs), farming and services (such as domestic, office jobs and clerks).

Factors known to be determinants of final height and possible confounding factors were also considered in the multivariate analysis. The birth covariates were socioeconomic condition of the family measured by the occupation of the head of the family [24], maternal schooling and maternal smoking during pregnancy. The individual covariates were race/ethnicity (according to official classification used in Brazilian Census based on skin colour white, black, mulattos and oriental descendance [25], birth length (divided into quintiles), intrauterine growth

(weight for gestational age based on the cutoff points proposed by Williams *et al.*) [26], birth order, number of siblings, smoking habit and reported physical activity (according to the International Physical Activity Questionnaire) [27,28]. Intrauterine growth was categorized as small for gestational age (SGA), adequate for gestational age and large for gestational age, with SGA children being considered to have intrauterine growth restriction (IUGR). Physical activity was classified into two groups: very active or active and irregularly active or sedentary.

For the girls, age at menarche according to the recall method (<12 years, 12 years and >12 years) was also considered in the analysis [29].

Birth characteristics were compared between participants and non-participants by the chi-square test, and birth and current factors in relation to final height were submitted to bivariate analysis of variance. Characteristics between non-participants and participants of the final survey were compared through the chi-square test.

All the analyses were performed separately for males and females. Bivariate analysis between exposure variable and covariates were performed using analysis of variance. Multiple linear regression analysis was carried out after stratified analysis.

The models were built using step-by-step analysis with backward elimination of the variables. Factors known to be determinants of height and confounding factors that modified the coefficient for the 'child labour' variable by >10% or that altered the precision of the confidence interval of the same variable were kept in the models. Plausible interactions were tested and residual analyses were performed for the models.

Results

When compared to the initial cohort, the sample obtained in 2002–4 consisted mainly of individuals belonging to families with a better socio-economic position. Women, preterm babies, non-smokers, married individuals and individuals whose mothers had a higher educational level were more frequent in the sample. No statistically significant difference was detected regarding birth length, weight or IUGR (Table 1).

Mean height was 176.0 cm [95% confidence interval (CI) 175.6–176.4] for males and 162.7 cm (95% CI 162.3–163.0) for females. Table 2 contains the bivariate analysis between height and the variables obtained at birth, stratified for males and females. Table 3 shows that child labour was associated with shorter height. Blacks and mulattos were significantly shorter than whites. Physical activity was associated with a greater final height only among females.

In multivariate analysis, child labour was not statistically associated with final height for either sex (Table

Table 1. Follow-up rates in 2004, according to the baseline characteristics of the cohort, Ribeirão Preto, 1978–79 and 2002–4

	Initial population 1978–79 (n = 6484)	2002–4 Sample % (n = 2063)	P*
Sex			
Female	3185	34	0.004
Male	3299	30	
Birth weight (g)			
<2500	380	34	0.618
2500–2999	1349	31	
3000–3499	2644	32	
3500–3999	1673	31	
≥4000	438	34	
Birth length (cm)			
<47	723	31	0.507
47–49	1612	31	
49–51	2664	31	
51–53	1170	34	
≥53	281	34	
Ignored	34	32	
Prematurity			
<37	388	37	0.037
≥37	6096	32	
Intrauterine growth			
SGA	655	31	0.513
AGA-LGA	5829	32	
Occupation of the head of the family			
Non-manual	1079	31	<0.001
S and SS Manual	3685	34	
US Manual and U	1514	26	
Ignored	206	29	
Maternal schooling (years)			
≥12	655	33	<0.001
5–11	2483	36	
0–4	3186	29	
Ignored	160	25	
Maternal age (years)			
20–35	4998	33	0.065
≥35	537	32	
<20	889	29	
Ignored	60	20	
Marital status			
Married	5375	34	<0.001
Cohabiting	613	22	
No partner	422	25	
Ignored	74	22	
Maternal smoking habit			
No	4494	34	<0.001
Yes	1810	28	
Ignored	180	22	
Category of admission for delivery			
Private	458	33	0.469
Public	5765	32	
Ignored	261	35	

The 'excluded' categories were not included in the χ^2 test.

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age. S, skilled; SS, semi-skilled; US, unskilled; U, unemployed.

*Probability value of the χ^2 test.

Table 2. Bivariate analysis of birth factors associated with final height, Ribeirão Preto, 1978–79 and 2002–4

	Height (cm)					
	Men			Women		
	n[a] (%)	Mean	95% CI[b]	*n* (%)	Mean	95% CI
Maternal age (completed years)						
<20	108 (11)	173.8	172.6–176.0	142 (14)	161.4	160.3–162.0
20–24	290 (30)	176.1	175.4–176.8	352 (34)	162.3	161.6–163.0
25–30	307 (32)	176.5	175.7–177.2	294 (28)	163.2	162.5–164.0
>30	268 (28)	176.3	176.3–177.1	257 (25)	163.2	162.4–164.0
P value*	0.003			0.012		
Maternal schooling (years)						
0–4	441 (45)	175.3	174.7–175.9	483 (46)	161.9	161.3–162.4
5–8	257 (26)	176.3	175.5–177.1	295 (28)	162.6	161.9–163.3
9–11	171 (18)	176.4	175.4–177.4	169 (16)	163.4	162.5–164.4
12+	104 (11)	177.9	176.9–179.1	105 (10)	165.4	164.2–166.6
P value*	0.002			<0.001		
Occupation of the head of the family						
Non-manual	157 (16)	178.1	177.1–179.1	175 (17)	164.5	163.6–165.4
S and SS manual	609 (62)	175.9	175.4–176.4	629 (60)	162.4	161.9–162.9
US manual and U	156 (16)	174.9	173.9–176.0	181 (17)	161.7	160.7–162.6
Ignored	55 (6)	174.7	172.9–176.4	67 (6)	163.4	161.8–164.9
P value*	<0.001			<0.001		
Birth length (quintiles)[c]						
1st	157 (16)	173.4	172.4–174.3	228 (22)	160.4	159.6–161.2
2nd	265 (27)	174.3	173.3–175.0	203 (19)	161.7	160.9–162.6
3rd	243 (25)	175.8	175.0–176.6	208 (20)	162.4	161.6–163.3
4th	138 (14)	177.6	176.6–78.6	202 (19)	163.4	162.5–164.2
5th	171 (18)	180.1	179.2–81.1	203 (19)	165.8	165.0–166.7
P value*	<0.001			<0.001		
Intrauterine growth						
SGA	89 (9)	172.8	171.5–174.1	110 (11)	159.5	158.3–160.6
AGA	819 (84)	176.6	156.6–176.5	884 (84)	162.9	162.5–163.3
LGA	67 (7)	179.7	178.2–181.2	57 (4)	165.9	165.9–164.2
P value*	<0.001			<0.001		

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age; S, skilled; SS, semi-skilled; US, unskilled; U, unemployed.

[a]The total number may vary according to the variable due to missing values.

[b]95% Confidence interval.

[c]Quintile values for boys: 1st: <47.9; 2nd: 48.0–49.49; 3rd: 49.50–50.49; 4th: 50.5–51.49; 5th: 51.5+. Girls: 1st: <47.5; 2nd: 47.5–48.9; 3rd: 49.0–49.9; 4th: 50.0–50.49; 5th: 50.5+.

*Probability value of analysis of variance.

4). No plausible interaction was statistically significant. IUGR, shorter birth length and larger number of siblings were associated with a shorter final height both in males and females. Men born to adolescent mothers were shorter than all others and late menarche was associated with greater height in females. Occupation of head of the family involving unskilled labour and being unemployed were associated with higher final height only among males. The variables that remained in the final model explained 18% of the variation in height for males and 13% of the variation for females (Table 4).

Regarding the type of work performed before 14 years of age, 90% of the males and 92% of the females worked in services. Only 7% of males and females worked in industry and only 4% of the males and 2% of the females were farming workers. The most frequent type of child labour day (<14 years) was a full shift (67% of the boys and 55% of the females); 27% of the males and 37% of the females worked in part-time jobs and <10% of both sexes worked in the evening shift.

Discussion

Our results showed that child labour was associated with final adult height in crude analysis, but this association did not hold after adjustments for confounders.

The mean height of young adult males in Ribeirão Preto was 176.0 cm, a value only a little lower than the mean for British males in 1990 (176.4 cm) [30] and the

Table 3. Bivariate analysis of current factors associated with final height, Ribeirão Preto, 1978–79 and 2002–4

	Males			Females		
	n[a] (%)	Mean	95% CI[b]	*n* (%)	Mean	95% CI
Work (years)						
<14	199 (20)	175.5	174.6–176.4	130 (12)	161.3	160.2–162.4
14–17	407 (42)	175.5	175.5–176.1	386 (37)	162.5	161.9–163.2
≥17	370 (38)	176.8	176.2–177.5	535 (51)	163.1	162.6–163.7
P value*	0.007			0.004		
Race/ethnicity						
White	631 (65)	176.4	175.9–176.9	733 (70)	163.0	162.5–163.5
Black/Mulatto	344 (35)	175.4	174.7–176.1	318 (30)	161.9	161.2–162.6
P value*	0.023			0.0096		
Physical activity						
Very active	359 (37)	176.2	175.6–176.9	241 (23)	163.4	162.6–164.2
Irregularly active/sedentary	616 (63)	175.9	175.4–176.4	810 (77)	162.5	162.0–162.9
P value*	0.422			0.049		
No. of siblings						
0–1	295 (30)	177.1	176.4–177.9	296 (28)	163.1	162.4–163.8
2	320 (33)	176.3	175.5–177.0	346 (33)	163.5	162.9–164.2
3	173 (18)	175.3	174.4–176.3	194 (19)	162.0	161.0–162.9
>3	188 (19)	174.5	173.5–175.5	214 (20)	161.3	160.5–162.2
P value*	<0.001			<0.001		
Menarche (years)						
<12				287 (28)	162.8	162.0–163.5
=12				350 (34)	162.1	161.5–162.8
>12				403 (39)	163.1	162.9–163.8
P value*				0.13		

[a]The total number may vary depending on the variable due to missing values.

[b]95% Confidence interval.

*Probability value of analysis of variance.

mean reported by the National Center for Health Statistics (NCHS) in the US (176.8 cm) [31]. This value was 0.5 cm higher than the mean for conscripts from the same cohort analysed at 18 years of age [20], a fact possibly reflecting the growth of some individuals after this age although not all participants in the analysis at 18 years old were included in the current sample. The mean height for females was 162.7 cm, also a little lower than the mean for British females, 163.6 cm, [30] and for American females, 163.3 cm [31].

Comparison of our results with other studies should be made with caution because of methodological differences and also because of background characteristics of our population. While most other studies are cross-sectional, our study is the only one that is a population-based cohort initiated at birth. The only other longitudinal study in which confounders had been controlled could also not demonstrate a negative association between child labour and growth among Vietnamese children working in a rural area [6]. The authors, however, found evidence of healthy worker selection among that population, which may have masked the deleterious effect of labour on child growth.

In fact, healthy worker selection and the positive effects of labour in child's life such as increased access to food may play a role in this complex association. A study conducted in two poor cities of Brazil, with 10- to 19-years-old students from public schools showed that those working full-time reached greater height than those who worked part-time or those who were unemployed [11]. The authors suggested that a greater possibility of buying food confers a better nutritional situation and therefore results in increased height. Moreover, there are some theories that height *per se* is a self-selector for jobs. A recent study showed that height during adolescence is an individual predictor of higher income in adulthood [32].

Another important issue in the association between child labour and health effects is the context in which child labour happens and the characteristics of that population. For example, it is possible that in rural areas, helping out with family farming duties is part of their culture and may not characterize strenuous work, resulting in no deleterious effect on the child's height. Besides methodological differences this may explain different findings in the literature. Studies showing an association between child labour and height were performed in very poor areas where children perform more strenuous work than that observed in our study. For example, Ambadekar *et al.* [8] in a study conducted in India

Table 4. Multivariate analysis of the factors associated with final height, 1978–79 cohort, Ribeirão Preto 2002–4

	Males			Females		
	n[a] (%)	Beta	CI[b]	*n* (%)	Beta	CI
Work (years)						
≥17 (ref.[c])	370 (38)	0.00	0.00	535 (51)	0.00	
14–17	407 (42)	−0.40	−1.26–0.46	386 (37)	0.19	−0.65–1.03
<14	199 (20)	0.17	−0.91–1.25	130 (12)	−0.65	−1.83–0.53
P value*	0.473			0.399		
Birth length (quintiles)[d]						
1st (ref.)	157 (16)	0.00		228 (22)	0.00	
2nd	265 (27)	0.28	−0.86–1.42	203 (19)	1.22	0.04–2.40
3rd	243 (25)	1.74	0.52–2.96	208 (20	1.74	0.51–2.97
4th	138 (14)	3.45	2.10–4.80	202 (19)	2.45	1.23–3.67
5th	171 (18)	5.83	4.42–7.24	203 (19)	4.38	3.18–5.58
P value*	<0.001			<0.001		
Intrauterine growth						
SGA	89 (9)	−1.20	−1.20–0.13	110 (11)	−1.88	−3.17–0.59
AGA (ref.)	819 (84)	0.00	0.00	884 (84)	0.00	0.00
LGA	67 (7)	1.62	−0.01–3.25	57 (4)	1.36	−0.15–2.87
P value*	0.031			0.003		
Occupation of the head of the family						
Non-manual (ref.)	157 (16)	0.00	0.00	175 (17)	0.00	
S and SS manual	609 (62)	−1.68	−2.84 to −0.52	629 (60)	−0.86	−1.89–0.17
US manual and U	156 (16)	−2.30	−3.77 to −0.83	181 (17)	−1.24	−2.54–0.06
Ignored	55 (6)	−1.71	−2.74–0.68	67 (6)	0.47	−1.47–2.41
P value*	0.018			0.118		
No. of siblings						
0–1 (ref.)	295 (30)	0.00	0.00	296 (28)		
2	320 (33)	−1.41	−2.04–−0.47	346 (33)	0.34	−0.60–1.28
3	173 (18)	−1.35	−2.49–−0.21	194 (19)	−0.98	−2.10–0.14
>3	188 (19)	−2.17	−3.35 to −0.99	214 (20)	−1.10	−2.30–0.10
P value*	0.001			0.024		
Maternal age (completed years)						
<20 (ref.)	108 (11)	0.00	0.00	142 (14)	0.00	
20–30	597 (61)	2.51	1.21–3.82	646 (62)	0.80	−0.42–1.84
>30	268 (28)	2.49	1.06–3.92	257 (25)	0.75	−0.64–2.14
P value*	<0.001			0.421		
Maternal schooling (years)						
0–4	441 (45)	0.00	0.00	483 (46)	0.00	
5–8	257 (26)	0.70	−0.28–1.68	295 (28)	0.29	−0.63–1.21
9–11	171 (18)	−0.42	−1.56–0.72	169 (16)	0.65	−0.49–1.79
12+	104 (11)	0.23	−1.79–1.34	105 (10)	1.71	0.30–3.12
P value*	0.290			0.123		
Menarche (years)						
<12				287 (28)	0.38	−0.58–1.34
=12				350 (34)	0.00	0.00
>12				403 (39)	1.15	0.27–2.03
P value*				0.033		
Physical activity						
Yes	359	0.00		241	0.00	
No	616	−0.53	−1.27–0.21	810	−0.49	−1.39–0.41
P value*	0.1667			0.2895		
R^2	0.18			0.13		

R^2, coefficient of determination.

SGA, small for gestational age; AGA, adequate for gestational age; LGA, large for gestational age; S, skilled; SS, semi-skilled; US, unskilled; U, unemployed.

[a]The total number may vary depending on the variable due to missing values.

[b]95% Confidence interval of the regression coefficient (beta).

[c]Ref. is the reference value.

[d]Quintile values for boys: 1st: <47.9; 2nd: 48.0–49.49; 3rd: 49.50–50.49; 4th: 50.5–51.49; 5th: 51.5+. Girls: 1st: <47.5; 2nd: 47.5–48.9; 3rd: 49.0–49.9; 4th: 50.0–50.49; 5th: 50.5+.

*Probability value.

observed lower z-scores for height-for-age only for male workers (shops, artisan work, garages etc.), aged 14 years or less compared to the controls. In turn, Hawamdeh and Spencer [9] studied male workers aged 10–16 years employed in industry (52%), services (30%) and farming (18%). Schoolchildren (n = 405) matched for age and residence were used as controls. After adjustment for per capita family income, it was observed that young workers had lower z-scores for height-for-age at 14 years than non-workers. By contrast, Nuwayhid *et al.* [10] in a recent study on an urban population of children and adolescents aged 10–17 years in Lebanon could also not find an association between child labour and height. However, the relatively small sample size (78 workers and 54 students as a control group) may explain the lack of association.

The lack of information on parental height is one of the shortcomings of our study; however, it might have been partially controlled by adjusting for some variables associated with socio-economic level [20]. Unfortunately, parental height was not collected at the baseline and during the follow-up because only a few knew the exact height of their parents. It is also possible that the type of work performed by most of individuals in this study has contributed to the lack of association. About 90% of individuals worked in jobs with low physical stress (services).

It is important to point out that in spite of the major determinants of final height, the final models only explained ~18% of the variation in height for males and 13% for females. These values are close to those observed (14.9%) in the assessment of factors related to height at 18 years of age of conscripts belonging to the same cohort when child labour was not included [20]. This may suggest that other unobservable variables may play an important role in height determination.

In spite of some limitations, this study has several strengths such as being a population-based cohort with a large sample for the study of long-term effect of child labour on final height, a pioneering investigation in Brazil. Information was available about well established and important determinants of height, which have a lasting effect on final height, such as birth length and weight. In addition, it was possible to assess other important variables such as the socio-economic condition of the family. Almost all individuals eligible for the study were recruited in the initial evaluation, trained personnel made the measurements and the information was collected concurrently, minimizing the possibility of bias. Another important aspect is the fact that final height was analysed and not height in adolescence when full growth has not yet been reached.

In conclusion, we were not able to demonstrate significant height differences between those previously employed or not employed as a child, other than differences explained by other social and biological factors. The type of work performed by the participants, which was limited to services in >90% of cases, may explain why there was no association between child labour and height after adjustment for the confounding factors.

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Conflicts of interest

None declared.

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