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RESEARCH PAPER (ORIGINAL)
ARTIGO DE INVESTIGAÇÃO (ORIGINAL)

Vaginal delivery versus elective cesarean section and the impact on children's skill development

Parto eutócico *versus* cesariana eletiva e o impacto no desenvolvimento de competências da criança

Parto eutócico frente a cesárea electiva e impacto en el desarrollo de las competencias del niño

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Abstract

Background: Caesarean section is associated with different development outcomes in children. In this way, the type of delivery can influence the health of the child.
Objectives: To investigate the existence of differences in skill development up to the age of 2 between children who were born by vaginal delivery and those born by elective cesarean section.
Methodology: Observational and cross-sectional study with a sample composed of 400 dyads, using a quantitative methodology based on a multivariate analysis with Generalized Linear Models in IBM SPSS Statistics, version 18.0.
Results: Children born by cesarean delivery scored lower in the locomotor skill domain, but still within the normal parameters for their age. They also scored lower in the manipulative, visual, speech and language, and self-care skill domains than those born by vaginal delivery. No differences were found between groups in the cognitive, hearing and language, and interactive-social skills.
Conclusion: Significant differences were found in the development of some skills at 2 years of age between children born by elective cesarean section and those born by normal delivery.

Keywords: child development; parturition

Resumo

Enquadramento: A cesariana é associada a diferente desenvolvimento de competências na criança. Deste modo, o tipo de parto pode influenciar a saúde da criança.
Objetivos: Verificar se existem diferenças significativas entre os nascidos de parto eutócico e os nascidos de cesariana eletiva no desenvolvimento de competências aos 2 anos.
Metodologia: Estudo do tipo observacional e transversal. Amostra constituída por 400 díades. Utilizada a metodologia quantitativa, através da análise multivariada com o Generalized Linear Models no IBM SPSS Statistics, *version* 18.0.
Resultados: Os nascidos de cesariana apresentam menor índice de competências locomotoras mas entre os parâmetros normais para a idade. Apresentam um menor índice de competências manipulativas, visuais, de fala e linguagem e de autonomia pessoal comparativamente aos de parto eutócico. Nos índices de competências cognitivas, de audição e linguagem e de interação social não existem diferenças entre os grupos.
Conclusão: Verificam-se diferenças significativas entre o desenvolvimento de algumas competências aos 2 anos de idade entre os nascidos de cesariana eletiva e os nascidos de parto eutócico.

Palavras-chave: desenvolvimento infantil; parto

Resumen

Marco contextual: La cesárea se asocia con el diferente desarrollo de las competencias en el niño. De este modo, el tipo de parto puede influir en la salud del mismo.
Objetivos: Comprobar si existen diferencias significativas entre los nacidos por parto eutócico y los nacidos por cesárea electiva en el desarrollo de las competencias a los 2 años.
Metodología: Estudio de tipo observacional y transversal. Muestra constituida por 400 díadas. Se utilizó la metodología cuantitativa, a través del análisis multivariado con el Generalized Linear Models en el IBM SPSS Statistics, versión 18.0.
Resultados: Los nacidos por cesárea presentan un menor índice de competencias locomotoras aunque se encuentran dentro de los parámetros normales para la edad. Asimismo, presentan un menor índice de competencias manipulativas, visuales, de habla y lenguaje, y de autonomía personal en comparación con los nacidos por parto eutócico. En los índices de competencias cognitivas, de audición y lenguaje, y de interacción social no existen diferencias entre los grupos.
Conclusión: Se observan diferencias significativas entre el desarrollo de algunas competencias a los 2 años de edad entre los nacidos por cesárea electiva y los nacidos por parto eutócico.

Palabras clave: desarrollo infantil; parto

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Introduction

In recent decades, cesarean section rates have increased worldwide. For example, in England and Wales, the cesarean section rate rose from 16% in 1995 to 21.5% in 2000 (Dobson, 2001). According to the activity report of the Regional Health Administration - North (Administração Regional de Saúde do Norte, 2011), the cesarean section rate in the North region of Portugal was at 30% in 2011, after having reached 36% in 2010. For this reason, Portugal is among the European countries with the highest cesarean section rates.

According to the World Health Organization (2015), cesarean section rates above 10-15% do not contribute to the reduction of maternal or neonatal mortality rates, so there is no justification for rates above 15%. According to Khalaf et al. (2015), cesarean section is associated with delayed cognitive and motor development at the age of 9 months. On the other hand, Khadem and Khadivzadeh (2010) and Li, Ye, and Pei et al. (2011) found no significant differences when comparing the intelligence quotient (IQ) of children born by vaginal delivery to those born by cesarean section.

However, "vaginal delivery is generally regarded as the most natural form of birth, with fewer complications and less severity for the low-risk woman and fetus" (Campos et al., 2010, p. 8).

The objective of this study is to investigate the existence of significant differences in skill development up to the age of 2 between children born by vaginal delivery and those born by elective cesarean.

Background

Children's correct development of skills contributes to their well-being and health, and the method of delivery may be associated with skill development. As regards the IQ, in a study conducted in Germany, Hohlweg-Majert, Goyert, and Schmitt (1979) found no differences in the psychomotor development of children born by cesarean section, assisted delivery (using an instrument for fetal extraction), and vaginal delivery. On the other hand, in a study conducted in China, Li, Ye, and Pei et al. (2011) reported an increase in full-scale IQ and verbal IQ at the age of 4 to 6 years in children who had been born by cesarean section. Li, Ye and Achenbach et al. (2011) add that children born by cesarean section on maternal request have a lower risk of developing psychopathological problems than those born by vaginal delivery or assisted delivery. Kelmanson (2013) argued that children born by cesarean section may face more emotional disturbances and sleep problems at preschool age.

Hypotheses

H1: At the age of 2, children born by cesarean section scored lower in the locomotor skill domain than those born by vaginal delivery.

H2: At the age of 2, children born by cesarean section scored lower in the manipulative skill domain than those born by vaginal delivery.

H3: At the age of 2, children born by cesarean section scored lower in the visual skill domain than those born by vaginal delivery.

H4: At the age of 2, children born by cesarean section scored lower in the hearing and language skill domain than those born by vaginal delivery.

H5: At the age of 2, children born by cesarean section scored lower in the speech and language skill domain than those born by vaginal delivery.

H6: At the age of 2, children born by cesarean section scored lower in the self-care skill domain than those born by vaginal delivery.

H7: At the age of 2, children born by cesarean section scored lower in the social-interactive skill domain than those born by vaginal delivery.

H8: At the age of 2, children born by cesarean section scored lower in the cognitive skill domain than those born by vaginal delivery.

Methodology

The sample consisted of 400 mother-child dyads. More specifically, it was composed of in-

fants born in 2011 at a hospital in the northern region of Portugal and their mothers. The inclusion criteria were: infants born by vaginal delivery or elective cesarean section, after a gestational period equal to or higher than 37 weeks, weighing more than 2.5 kg, single birth. The exclusion criteria were: infants born by emergency and urgent cesarean section, multiple births, with chromosomal abnormalities or congenital malformation.

Data were collected in two phases. In a first phase, data were collected from the mothers and infants' clinical records, having requested and obtained prior authorization from the institution to check the records. The following data were collected from the mothers' records: age, education level, occupation, marital status, body mass index, participation in childbirth preparation classes, planned pregnancy, parity, folic acid intake before and during pregnancy, smoking habits, diseases during current pregnancy (gestational diabetes, gestational hypertension, and pre-eclampsia), and method of delivery in previous pregnancy. In addition, the following data were collected from the infants' records: gestational age, gender, Apgar score, type of first feeding, birth weight, and need for immediate hospitalization after birth in the neonatal unit.

In a second phase, data were collected using structured interviews with the mothers through closed-ended questions. The purpose of the interview was to collect data on the duration of exclusive breastfeeding, maintenance of breastfeeding up to 2 years of age, development of chronic diseases up to 2 years of age, and the child's main caregiver. Finally, the locomotor, manipulative, visual, hearing and language, speech and language, social-interactive, self-care, and cognitive skills of children at 2 years of age were assessed using the Portuguese version of the Schedule of Growing Skills II (SGS II) developed by Bellman, Lingam, and Aukett (2003). A meeting was agreed beforehand with the mothers for the assessment of their children's skills because it required the child's presence and material for the application of the scale. Subsequently, the mothers were taught how to use the material and describe the child's behavior during task completion.

A multivariate analysis was performed using the Generalized Linear Models (GLM) in IBM SPSS Statistics, version 18.0. Eight regressions were performed. In each of them, the dependent variable was one of the skills to be analyzed. Each dependent variable was adjusted for the independent variables (characteristics of the mothers, the pregnancy, and the children), with the purpose of verifying if the independent variable - method of delivery - had an impact on the dependent variable in the presence of other independent variables. These statistical techniques could be applied given the sample size and the compliance with the assumptions of normality and homoscedasticity. During the study, the following norms and recommendations were followed: the Declaration of Helsinki (with the amendments of Tokyo 1975, Venice 1983, Hong Kong 1989, Somerset West 1996, Edinburgh 2000, Washington 2002, Tokyo 2004, and Seoul 2008), the Directive 95/46/EC of the European Parliament and of the Council, the Guideline for Good Clinical Practice of the European Medicines Agency (London 2000), the World Health Organization International Ethical Guidelines for Health-related Research Involving Humans (Geneva 2002), the International Ethical Guidelines for Epidemiological Studies of the Council for International Organizations of Medical Sciences (Geneva 2009), and the Resolution of the Assembly of the Republic no. 1/2001.

Results

Description of the sample

The majority of women in both groups were older than 25 years, had no undergraduate degree, had non-scientific professions, were married, and had an adequate weight. Table 1 describes the sample based on the mothers' characteristics, divided into the groups of infants born by vaginal delivery or elective cesarean section.

Table 1
Mothers' characteristics

		Vaginal delivery		Elective cesarean section	
Variables		*N*	%	*N*	%
Mother's characteristics					
Age	≤ 25 years	47	21	15	8
	> 25 years	174	79	164	92
Academic qualifications	12th grade	176	80	145	81
	Bachelor's degree	44	20	34	19
Profession	Non-scientific	188	85	151	84
	Scientific and intellectual	33	15	28	16
Marital status	Married	202	91	173	97
	Single	15	9	5	3
BMI	Weight (>18 kg/m² and <35 kg/m²)	181	83	159	91
	Overweight (≥35 kg/m²)	37	17	17	9

In both groups, the majority of women was multiparous, planned the pregnancy, and did not attend childbirth preparation classes. With regard to folic acid intake before pregnancy, most women who underwent vaginal delivery started taking folic acid before pregnancy, unlike the women undergoing elective cesarean section; however, in both groups, the majority of women continued taking folic acid during pregnancy. In addition, the majority of women in both groups did not smoke and did not have hypertension, gestational diabetes, or pre-eclampsia. As can be seen in Table 2, with regard to the method of delivery in previous pregnancies, the majority of women who underwent elective cesarean section had already a cesarean section, unlike most women who underwent a vaginal delivery, who had no previous delivery.

Table 2
Pregnancy's characteristics

		Vaginal delivery		Elective cesarean section	
Variables		*N*	%	*N*	%
Pregnancy's characteristics					
Participation in childbirth preparation classes	Yes	89	38	50	28
	No	132	62	129	72
Planned pregnancy	Yes	183	83	145	81
	No	38	17	34	19
Parity	Nulliparous	108	49	41	23
	Multiparous	113	51	138	77
Folic acid intake before pregnancy	Yes	141	64	71	40
	No	80	36	108	80

Folic acid intake during pregnancy	Yes	207	94	176	98
	No	14	6	3	2
Smoking habits	Yes	29	13	13	7
	No	191	87	166	93
Gestational hypertension	Yes	5	2	2	1
	No	216	98	177	99
Gestational diabetes	Yes	14	6	23	13
	No	207	94	156	87
Pre-eclampsia	Yes	1	0.5	0	0
	No	220	99.5	179	100
Delivery mode in previous pregnancies	No previous delivery	108	49	40	22
	Vaginal	104	47	13	7
	Cesarean section	9	4	126	71

The majority of children who were born by elective cesarean section were born before the 39th week of pregnancy, unlike those born by vaginal delivery who were born at the 39th week of pregnancy or after. In addition, most infants born by elective cesarean section were male, while most of those born by vaginal delivery were female. In both groups, most infants weighed less than 4 kg at birth and had a 5-minute Apgar score of 8-10. Similarly, in both groups, the majority of infants were not admitted to the neonatal unit immediately after birth and were breastfed in their first feeding. The majority of infants born by vaginal delivery was breastfed up to 6 months of age, unlike elective cesarean infants who were not breastfed up to 6 months of age. However, none of the infants in both groups continued to be breastfed up to 2 years of age. The majority of children born by vaginal delivery attended daycare or a nanny, while the majority of infants born by elective cesarean section was cared for by their mothers. None of the infants in both groups was diagnosed with chronic diseases, as can be seen in Table 3.

Table 3
Children's characteristics

		Vaginal delivery		Elective cesarean section	
Variables		*N*	%	*N*	%
Children's characteristics					
Gestational age	<39 weeks	52	24	124	69
	≥39 weeks	169	76	55	31
Gender	Female	113	51	84	47
	Male	108	49	95	53
Birth weight	<4 kg	212	96	170	95
	≥4 kg	9	4	9	5
5-minute Apgar score	0-7	2	0.9	2	0.1
	8-10	219	99.1	177	99.9
Immediate hospitalization after delivery	Yes	10	0.5	12	0.6
	No	211	99.5	167	99.4

First feeding	Formula	2	0.9	56	31
	Breastfeeding	219	99.1	123	69
Breastfeeding up to the age of 6 months	Yes	134	61	55	31
	No	87	39	84	69
Breastfeeding maintenance up to the age of 2 years	Yes	52	24	10	5
	No	169	76	169	95
Attending daycare or nanny	Yes	134	61	72	40
	No	87	39	107	26.8
Chronic diseases	Yes	0	0	0	0
	No	221	55.3	179	60
Delivery mode	Vaginal delivery	221	55.3		
	Elective cesarean section			179	44.7

In inferential data analysis, the GLM statistical test was used, in which each dependent variable (skill domain) was adjusted to all independent variables (characteristics of the mothers, pregnancy, and children). However, only the independent variable - delivery mode - showed significant differences in the dependent variables (locomotor, manipulative, visual, speech and language, and self-care skills). With regard to the dependent variables (hearing and language and cognitive skills), none of the independent variables produced significant differences. In this way, infants born by elective cesarean section scored lower in the locomotor skill domain than infants born by vaginal delivery, although they remain within the expected parameters for their age. In relation to the manipulative, visual, and speech and language skills at 2 years of age, children born by elective cesarean section scored significantly lower, but both groups were below the expected levels for their age. Finally, children born by elective cesarean section scored lower in the self-care skill domain and below the expected levels at the age of 2 years, unlike those born by vaginal delivery who were within the parameters expected for their age, as can be seen in Table 4.

Table 4
Development of skills at 2 years of age of children born by vaginal delivery or elective cesarean section

Domain	Vaginal delivery *M* (*SD*)	Elective cesarean *M* (*SD*)	Mean difference	Adjusted mean differences	B	95% Confidence Interval	*p*
Locomotor Skills	11.47 (1.10)	10.61 (1.10)	0.86	0.57	0.576	0.286/0.866	<0.0001
Manipulative Skills	14.98 (1.01)	14.65 (1.31)	0.33	0.68	0.683	0.162/1.204	0.010
Visual Skills	12.57 (0.77)	12.24 (0.45)	0.33	0.29	0.290	0.465/0.999	<0.0001
Hearing and Language Skills	12.09 (0.97)	11.84 (0.68)	0.25	0.08	0.089	0.286/0.107	0.374
Speech and Language Skills	11.90 (1.03)	11.01 (1.07)	0.89	0.73	0.732	0.465/0.999	<0.0001

Self-Care Skills	11.72 (2.27)	10.63 (1.89)	1.09	0.08	0.089	0.107/0.286	0.010
Social-Interactive Skills	18.17 (1.01)	18.37 (0.67)	0.20	0.12	0.122	-0.055/0.299	0.176
Cognitive Skills	17.84 (5.76)	15.92 (5.76)	1.92	0.59	0.598	0.839/2.035	0.414

Discussion

With regard to the development of locomotor, manipulative, visual, speech and language, hearing and language, social-interactive, self-care, and cognitive skills, children born by vaginal delivery and those born by elective cesarean section scored 11.47 (1.10) and 10.61 (1.10), respectively, in the locomotor skill domain at the age of 2 years. After adjustment for other variables in the multivariate analysis, infants born by vaginal delivery scored higher in the locomotor skill domain ($p < 0.0001$; 95% CI [0.286/0.866]) than those born by elective cesarean section. In this way, infants born by elective cesarean section scored lower in the locomotor skill domain, but within the parameters expected for their age. In addition, infants born by vaginal delivery and those born by elective cesarean section scored 14.98 (1.01) and 14.65 (1.31), respectively, in the manipulative skill domain at the age of 2 years. Similarly, infants born by vaginal delivery and those born by elective cesarean section scored 12.57 (0.77) and 12.24 (0.45), respectively, in the visual skill domain at the age of 2 years. In the speech and language skill domain, infants born by vaginal delivery and those born by elective cesarean section scored 11.90 (1.03) and 11.01 (1.01), respectively. So, after adjustment for other variables in the multivariate analysis, children born by vaginal delivery scored higher in the manipulative skill domain ($p = 0.010$; 95% CI [0.162/1.204]), visual skills ($p < 0.0001$; 95% CI [0.144/0.436]), and speech and language skills ($p < 0.0001$; 95% CI [0.465/0.999]) at 2 years of age than those born by elective cesarean section. Both groups were below the expected parameters for their age. In fact, no studies were found that established a relationship between the method of delivery and the development of these skills in childhood.

In fact, McBride et al. (1979) only found an association between the development of skills and the type of fetus presentation. According to the authors, children delivered in breech presentation performed less well in terms of balance, fine motor coordination, visual acuity, and stereopsis than those delivered in cephalic presentation. Thus, the variable - method of delivery - had no impact on the outcome.

In the self-care skill domain, infants born by vaginal delivery and those born by elective cesarean section scored 11.72 (2.27) and 10.63 (1.89), respectively. After adjustment for other variables in the multivariate analysis, in the self-care skill domain, children born by vaginal delivery scored significantly higher than those born by elective cesarean section ($p = 0.010$; 95% CI [0.107/0.286]). On the other hand, in addition to this lower scores, children born by elective cesarean section were also below the expected parameters for their age. In the same way, none of the previous studies analyzed were in line or even contrary to our results.

In this study, in the cognitive skill domain, infants born by vaginal delivery and those born by elective cesarean section scored 17.84 (5.76) and 15.92 (5.76), respectively. However, when adjusted for other variables in the multivariate analysis, the scores of infants born by vaginal delivery and of those born by elective cesarean section in the cognitive skill domain were not significantly different ($p = 0.414$; 95% CI [0.839/2.035]). On the other hand, Li, Ye, and Pei et al. (2011) found an association between cesarean section and increased IQ and language skills in children aged between 4 and 6 years, and the results remained significant, although less, when adjusted for the mother's IQ, qualifications, and profession, and the infant's gender, and birth weight. In addition, Li, Ye, and Achenbach et al. (2011) argue that the likelihood of psychopathological problems can be lower

in infants born by elective cesarean section than in those born by vaginal delivery. In the same line, Roemer, Rowland, and Nuamah (1991) added that school-aged children who had been born by vaginal delivery after their mothers were in labor for more than 12 hours had a lower IQ than those born by vaginal delivery after a shorter labor. In addition, when compared to those born by elective cesarean section, these infants had a significantly lower quotient, which may suggest that prolonged labor can affect the child's IQ.

Moreover, Khadem and Khadivzadeh (2010) found an association between children's higher IQ scores and cesarean section. However, the rate of cesarean sections was higher among women with more academic qualifications, so the child's higher IQ could be associated with the mother's academic qualifications, rather than the method of delivery. After adjustment for other variables, the differences in IQ between children born by elective cesarean section and those born by vaginal delivery were no longer statistically significant. On the contrary, in the sample of this study, the mothers' academic qualifications showed no statistically significant differences. However, the variables related to breastfeeding were also added to the multivariate analysis, because, according to Bernard et al. (2013), the duration of breastfeeding is associated with better cognitive and motor development at age 2 and 3.

Whyte et al. (2004) and Eide et al. (2005) also compared infants born by vaginal delivery and those born by cesarean section in breech presentation. Whyte et al. (2004) compared the neurodevelopment of infants born by cesarean section with those born by vaginal delivery in breech presentation at 2 years of age and showed that children born by elective cesarean section had a neurodevelopmental delay. In another approach, Eide et al. (2005) investigated the intellectual performance of 18-year-olds who had been born by cesarean section and those born by vaginal delivery, both in breech presentation, and found that cesarean delivery of breech-presented infants did not improve adult intellectual performance. Thus, not even the higher rate of perinatal risk of breech presentation in vaginal delivery had an impact on adult intellectual performance. This study took into account fetal presentation. In this sample, fetuses in breech presentation (11.3%) were born by elective cesarean section, while fetuses in the cephalic presentation were born either through vaginal delivery (54.9%) or elective cesarean section (33.8%). Breech presentation was exclusive of infants born by elective cesarean section, but they do not represent the majority of infants born by elective cesarean section in the sample. The majority of infants born by elective cesarean section and vaginal delivery were in cephalic presentation. However, given the characteristics of the sample under analysis, no conclusion can be drawn based on the type of fetal presentation. On the other hand, the scores in the social-interactive skill domain were not significantly different between children born by elective cesarean section and those born by vaginal delivery (p = 0.176; 95% CI [-0.055/0.299]). In the same way, the scores in the hearing and language skill domain were not significantly different between infants born by vaginal delivery and those born by elective cesarean section (p = 0.374; 95% CI [-0.286/0.107]).

Even so, in a meta-analysis by Hankins, Clark, and Munn (2006), elective cesarean section was considered as a protective factor against the development of neonatal encephalopathy. However, no evidence was found that it is a protective factor against long-term neurological conditions such as cerebral palsy with or without mental retardation and/or convulsive disorders. This study took into account infants' Apgar score and the immediate hospitalization in the neonatal intensive care unit. However, the inferential data analysis showed no differences in the Apgar scores and the immediate hospitalization between both groups, so it cannot be concluded that elective cesarean section is a protective factor against the development of neonatal encephalopathy.

In summary, the sampled infants born by cesarean section scored lower in the locomotor skill domain at 2 years of age than those born by vaginal delivery, but these parameters were normal at that age. With regard to manipulative, visual, and speech and language skills, infants born by cesarean section also scored

lower at 2 years of age than those born by vaginal delivery. Despite this, both groups were below the expected parameters for their age. With respect to the self-care skill domain, infants born by elective cesarean section scored significantly lower, which is also below the expected parameters for their age, whereas the scores of those born by vaginal delivery were within the expected parameters. The scores in the cognitive, hearing and language, and social-interactive skill domains were not significantly different between infants born by elective cesarean section and those born by vaginal delivery.

The results found in this study suggest that there are differences in the development of skills between infants born by elective cesarean section and those born by vaginal delivery. These results also improve the knowledge about some skills which remain understudied. One of the limitations of this study was the fact that the homogeneity of both samples in the analyzed variables was not determined. Other limitations were the lack of data on the prenatal period and the possibility that other variables could have been added during the children's first 2 years of life. In this way, the results are in line with the international recommendations toward the reduction of the cesarean section rates and, consequently, the prevention of unnecessary cesarean sections. This study corroborates the need to maintain and disseminate the measures implemented at both national and international levels, as well as to recreate new forms of intervention aimed to reduce the rate of unnecessary cesarean sections, focusing on the child's best interests. However, further research is needed on the development of skills in children, including the collection of specimens from both children and parents and the use of other measurement instruments.

Conclusion

As regards the development of skills, infants born by elective cesarean section scored lower in the locomotor skill domain than those born by vaginal delivery, although remaining within the expected parameters for their age. In relation to the manipulative, visual, and speech and language skill domains at 2 years of age, children born by elective cesarean section scored significantly lower, but both groups were below the expected parameters for their age. Finally, infants born by elective cesarean section scored slower in the self-care skill domain and below the expected parameters for the age of 2 years. On the contrary, children born by vaginal delivery scored within the expected parameters for their age. In fact, no studies were found that corroborated this evidence.

To sum up, more strategies should be developed in the area of child health and integrated into the holistic approach to health education. Therefore, there is an opportunity for research aimed at the design and implementation of health education programs with the purpose of developing children's skills and supporting parents in the development of their children's skills.

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