

# Mode of delivery and risk of allergic rhinitis and asthma

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**Background:** It has been hypothesized that cesarean section might increase the risk of developing allergic disease by depriving the fetus and newborn of exposure to maternal microflora. Furthermore, it has been suggested that complicated modes of delivery might be associated with an increased risk of asthma.

**Objective:** The purpose of this investigation was to study whether cesarean section and other complicated modes of delivery are associated with an increased risk of allergic rhinitis or asthma.

**Methods:** Information on self-reported allergic rhinitis, asthma ever, current asthma, and occupation was obtained from 9722 singleton women born in Denmark during the period 1973-1977 who participated in a national cohort study during the period 1997-2001. For these women, information was available on mode of delivery (spontaneous delivery, cesarean section, vacuum extraction, or other complicated mode of delivery, such as rotation/traction or use of forceps), gestational age, birth weight, and length at birth from the Danish Medical Birth Register. Information on parity and maternal age was obtained from the Danish Civil Registration System.

**Results:** The odds ratios (ORs) of allergic rhinitis were 1.16 (95% CI, 0.90-1.49) for cesarean section and 1.06 (95% CI, 0.85-1.32) for other complicated modes of delivery in comparison with spontaneous delivery. The corresponding ORs of asthma ever were 1.33 (95% CI, 1.02-1.74) and 1.18 (95% CI, 0.94-1.49) for cesarean section and other complicated modes of delivery, respectively, and the ORs of current asthma were 1.22 (95% CI, 0.87-1.73) and 1.26 (95% CI, 0.94-1.68), respectively, in comparison with spontaneous delivery.

**Conclusions:** Our findings do not support the hypothesis that cesarean section or other complicated modes of delivery are associated with the development of allergic rhinitis. However, there might be a positive association with development of asthma—in particular, for cesarean section—that was not explained by gestational age, birth weight, ponderal index, smallness for gestational age, parity, maternal age, or occupation. (*J Allergy Clin Immunol* 2003;111:51-6.)

**Key words:** Allergy, allergic rhinitis, asthma, cesarean section, risk factors, epidemiology, complications, obstetrics

## Abbreviations used

OR: Odds ratio

SGA: Small for gestational age

Cesarean section and other complicated modes of delivery have been suggested to influence the development of atopy and allergic disease.<sup>1-4</sup> The intestinal microflora of cesarean babies is differently colonized and less indigenous than that of vaginally delivered babies, and stimulation and maturation of their immune systems might therefore be different and/or reduced.<sup>1,5-7</sup> Changes of the indigenous flora have indeed been suggested to be one explanation for the rise in allergy; such changes might influence the balance between T<sub>H</sub>1/T<sub>H</sub>2 lymphocytes early in life.<sup>2,8</sup> Compatible with this are the results of several recent studies that have shown differences in intestinal flora between allergic and nonallergic infants and children.<sup>2,8-10</sup> Of the few studies on cesarean section and allergy, results have varied.<sup>3,4,11-16</sup> Four found no association with atopy, allergic rhinitis or atopic eczema,<sup>4,11-13</sup> whereas some<sup>3,4</sup> but not others<sup>11,12,14,15</sup> reported a positive association with asthma. Although the underlying biological mechanism remains unclear, some<sup>3,14</sup> but not all<sup>11</sup> studies have also indicated that obstetric complications or health complications during delivery might influence the development of asthma. Taken together, the present knowledge, which is based on few studies, appears inconsistent and needs to be substantiated.

We therefore addressed these issues by using data on allergic rhinitis and asthma collected for women in a large national cohort study as well as data from the Danish Medical Birth Register and Civil Registration System. We studied whether cesarean section or other complicated modes of delivery were associated with an increased risk of allergic rhinitis or asthma in young women.

## METHODS

The study was nested in an ongoing national cohort study of pregnant women known as the *Danish National Birth Cohort*.<sup>17</sup> Pregnant women were invited to participate in the study when they visited their general practitioners for the first time during pregnancy. An extensive telephone interview was conducted with each woman during pregnancy; it included a large variety of questions, among which were questions on asthma, allergy, and occupation. A total of 10,482 women from this cohort had been born in Denmark in the period 1973-77 and completed their first interviews in the period September 1997 to February 2001. The study population was restricted to women born during the years 1973 through 1977, because birth characteristics had been uniformly registered in the Danish Medical Birth Register during this period. For women whose mothers had been born in Denmark on April 1, 1935, or later

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(n = 10,089), information on singleton status was available from the Civil Registration System<sup>18</sup>; a total of 9,879 singletons were identified. Furthermore, information on the mother's age at the woman's birth (maternal age at birth), parity of the mother at the woman's birth, and place of residence of the woman was available from this register for 9,842 of these women. Complete information on birth characteristics was available from the Danish Medical Birth Register for 9,751 of the women.

Each woman had been asked whether she had ever had allergy and, if so, whether it had been diagnosed by a doctor. Any woman who answered in the affirmative to these 2 questions had then been asked what kind of allergy she had. Women who reported allergic rhinitis and/or hayfever were considered to be cases of allergic rhinitis. Each woman had also been asked whether she had ever had asthma and, if so, whether it had been diagnosed by a doctor. Women who answered in the affirmative to these 2 questions were considered to be cases of asthma ever. Those with asthma ever who further answered that they still had asthma were also considered to be subjects with current asthma. Finally, women who did not know whether they had had asthma and/or allergy (n = 29) were excluded; this left 9,722 women in the study.

Birth characteristics from the Medical Birth Register were mandatorily recorded at birth by midwives, who attend all deliveries in Denmark. Mode of delivery was divided into the following 4 categories: (1) spontaneous delivery, (2) cesarean section, (3) vacuum extraction, and (4) other complicated modes of delivery, including rotation, traction, and use of forceps or other assistance. Gestational age had been determined by the midwives on the basis of the mother's last menstruation period, and gestational ages were grouped into 3 categories ( $\leq 34$ , 35-36, and  $\geq 37$  gestational weeks). Birth weights had been recorded in the Medical Birth Register in 250-g intervals, and these were further grouped into 5 categories ( $< 2510$ , 2510-3009, 3010-3509, 3510-4009, and  $\geq 4010$  g). Ponderal index was calculated as weight/length<sup>3</sup> at birth; the index values were grouped in quartiles. We defined children small for gestational age (SGA) as those weighing  $< 2510$  g at term ( $\geq 37$  weeks), and we compared them with those weighing  $\geq 2510$  g and born at term. Information was also available on whether labor had been induced and whether labor-stimulating drugs had been administered.

We assessed the possible effect of mode of delivery on the risk of allergic rhinitis, asthma ever, and current asthma, respectively. In addition, we assessed the possible effect of the potential confounding factors gestational age, birth weight, ponderal index, SGA status, parity, and maternal age on the 3 outcomes. Risk ratios were calculated as odds ratios (ORs) in a logistic regression and were assessed unadjusted as well as adjusted for potential confounding by occupation (8 categories) and birth characteristics, as shown in the Tables. Finally, we assessed the effect of each birth characteristic on the risk of being delivered by cesarean section versus vaginally and of all complicated modes of delivery versus spontaneous delivery.

All variables entered into the logistic model were treated as categorical variables. *P* values were 2-tailed and based on likelihood ratio tests; 95% CIs were based on Wald's tests. Each trend was estimated as the slope when the categorical variable of interest was treated as a continuous variable. The statistical software program SAS version 6.12 was used for the analyses.<sup>19</sup>

## RESULTS

Of the 9722 women in the study, 1272 (14.0%) were cases of allergic rhinitis, 1038 (11.4%) were cases of asthma ever, and 644 (6.6%) were cases of current asthma. All of the women were between 20 and 28 years old, the median age being 25 years. In all, 87.9% of the

women had been delivered spontaneously, 5.1% by cesarean section, 4.2% by vacuum extraction, and 2.7% by other complicated modes of delivery.

Table I shows the risk of allergic rhinitis according to the birth characteristics mode of delivery, gestational age, birth weight, ponderal index, SGA status, parity, and maternal age. There was no association between mode of delivery and allergic rhinitis (Table I). When the data were grouped according to whether the child was delivered by cesarean section or vaginally, the OR of allergic rhinitis was 1.15 (95% CI, 0.90-1.48) for cesarean section compared with vaginal delivery. When the cases of cesarean delivery were divided into 2 groups according to whether or not labor had initially been induced and/or labor-stimulating drugs had been given, the ORs of allergic rhinitis were 1.11 (95% CI, 0.69-1.78;  $n/n_{\text{total}} = 21/130$ ) and 1.18 (95% CI, 0.88-1.57;  $n/n_{\text{total}} = 58/363$ ) for cesarean delivery with and without labor induction/labor-stimulating drugs, respectively, in comparison with spontaneous delivery.

Low gestational age ( $\leq 34$  weeks) was found to significantly decrease the risk of allergic rhinitis in comparison with a gestational age of  $\geq 37$  weeks (OR, 0.51; 95% CI, 0.27-0.96; Table I). There was no association between allergic rhinitis and birth weight, ponderal index, SGA status, or maternal age (Table I). There was a decreasing risk of allergic rhinitis with increasing parity ( $P_{\text{trend}} = .0001$ ).

Table II shows the risks of asthma ever and current asthma according to the birth characteristics used in Table I. After adjustment for gestational age, birth weight, parity, maternal age, and occupation, cesarean section was associated with a significantly increased risk of asthma ever in comparison with spontaneous delivery (OR, 1.33; 95% CI, 1.02-1.74; Table II). The OR of asthma ever was 1.18 (95% CI, 0.94-1.49) for other complicated modes of delivery combined (vacuum extraction and other modes) in comparison with spontaneous delivery. For cesarean section compared with vaginal delivery, the OR of asthma ever was 1.31 (95% CI, 1.01-1.71). The ORs of asthma ever were 1.35 (95% CI, 0.82-2.22,  $n/n_{\text{total}} = 19/130$ ) and 1.32 (95% CI, 0.97-1.81,  $n/n_{\text{total}} = 50/363$ ) for cesarean deliveries with and without labor induction/labor-stimulating drugs, respectively, in comparison with spontaneous delivery. There was no interaction between birth weight ( $P = .24$ ) or gestational age ( $P = .09$ ) and cesarean section on the risk of asthma ever.

As regards the risk of current asthma, the ORs were 1.22 (95% CI, 0.87-1.73) and 1.26 (95% CI, 0.94-1.68) for cesarean section and other modes of delivery combined, respectively, in comparison with spontaneous delivery. For cesarean section compared with vaginal delivery, the OR of current asthma was 1.20 (95% CI, 0.85-1.70). The OR of current asthma was 1.17 (95% CI, 0.61-2.25,  $n/n_{\text{total}} = 10/130$ ) and 1.24 (95% CI, 0.83-1.85,  $n/n_{\text{total}} = 28/363$ ) for cesarean deliveries with and without labor induction/labor-stimulating drugs, respectively, in comparison with spontaneous delivery.

Compared with a gestational age of  $\geq 37$  weeks, a gestational age of 35-36 weeks was found to decrease the risk of asthma ever (OR, 0.64; 95% CI, 0.41-0.99; Table II). Birth

**TABLE I.** Risk of allergic rhinitis among 9722 women (born 1973-77 in Denmark) according to their birth characteristics

	Cases/all	Allergic rhinitis	
		OR (95% CI)	Adjusted OR (95% CI)
Mode of delivery†			
Vaginal			
Spontaneous	1194/8549	1 (ref.)	1 (ref.)
Vacuum extraction	67/413	1.19 (0.91-1.56)	1.12 (0.85-1.46)
Other*	37/267	0.99 (0.70-1.41)	0.98 (0.69-1.40)
Cesarean section	79/493	1.18 (0.92-1.51)	1.16 (0.90-1.49)
Gestational age (wk)†			
≥37	1319/9254	1 (ref.)	1 (ref.)
35-36	45/326	0.96 (0.70-1.33)	0.90 (0.63-1.28)
≤34	13/142	0.61 (0.34-1.08)	0.51 (0.27-0.96)
Birth weight (g)†			
<2510	77/533	1.00 (0.77-1.29)	1.17 (0.86-1.59)
2510-3009	260/1944	0.91 (0.78-1.07)	0.92 (0.78-1.07)
3010-3509	569/3925	1 (ref.)	1 (ref.)
3510-4009	371/2616	0.97 (0.85-1.12)	0.98 (0.85-1.13)
≥4010	100/704	0.98 (0.78-1.23)	0.98 (0.78-1.24)
Ponderal index in quartiles‡			
First (lowest)	282/2130	1 (ref.)	1 (ref.)
Second	385/2731	1.08 (0.91-1.27)	1.07 (0.90-1.26)
Third	345/2251	1.19 (1.00-1.41)	1.18 (1.00-1.41)
Fourth	365/2610	1.07 (0.90-1.26)	1.06 (0.89-1.26)
SGA (born ≥37 gestational weeks)§			
No (≥2510 g)	1278/9006	1 (ref.)	1 (ref.)
Yes (<2510 g)	41/248	1.20 (0.85-1.68)	1.19 (0.85-1.67)
Parity†			
0	105/655	1 (ref.)	1 (ref.)
1	717/4572	0.97 (0.78-1.22)	0.99 (0.79-1.23)
2	402/3152	0.77 (0.61-0.97)	0.77 (0.61-0.98)
≥3	153/1343	0.67 (0.52-0.88)	0.69 (0.52-0.90)
Maternal age at birth (y)†			
≤19	92/628	1.06 (0.84-1.35)	1.11 (0.87-1.41)
20-24	518/3732	1 (ref.)	1 (ref.)
25-29	524/3594	1.06 (0.93-1.21)	1.06 (0.93-1.22)
30-34	190/1393	0.98 (0.82-1.17)	1.04 (0.86-1.24)
≥35	53/375	1.02 (0.75-1.39)	1.13 (0.83-1.55)

OR, Odds ratio; SGA, small for gestational age (ie, weighing < 2510 grams at term [≥37 weeks]).

\*Includes rotation and/or traction (n/ n<sub>total</sub> = 11/72), use of forceps (n/ n<sub>total</sub> = 11/61), and other assistance (n/ n<sub>total</sub> = 15/134).

†Adjusted OR is adjusted for occupation and other variables in the Table except ponderal index and SGA.

‡Adjusted OR is adjusted for occupation and other variables in the Table except birth weight and SGA.

§Adjusted OR is adjusted for occupation and other variables in the Table except gestational age, birth weight, and ponderal index.

weight, ponderal index, SGA status, and parity were not associated with asthma ever or current asthma. The risk of asthma ever ( $P_{\text{trend}} = .04$ ), but not that of current asthma ( $P_{\text{trend}} = .64$ ), increased with decreasing maternal age.

The risk of cesarean versus vaginal delivery was positively associated with low gestational age, high and low birth weight, decreasing ponderal index, smallness for gestational age, high maternal age, and low parity (data not shown). The use as outcome of all complicated modes of delivery combined versus spontaneous delivery gave similar results.

## DISCUSSION

In the present study, cesarean section was not associated with an increased risk of allergic rhinitis. This finding, together with the results of previous studies,<sup>4,11-13</sup>

gives little support to the hypothesis that a modified colonization of the microbial flora in babies delivered by cesarean section should distort the development of the immune system so as to increase the risk of atopy and allergic disease into adulthood.

As regards asthma ever, we found a positive association with cesarean section in comparison with spontaneous delivery. Although preterm birth, extremes of birth weight, high maternal age, and low parity were positively associated with cesarean section, none of these factors explained the positive association between asthma ever and cesarean section. A similar association for parent-reported current asthma and cesarean section was seen in a Finnish investigation by Xu et al<sup>3</sup> (the study encompassed 8,088 children aged 7 years), and a borderline association was found for doctor-diagnosed asthma in a study of 24,690 children aged 0-11 years.<sup>11</sup> In a study of 1,953 adults, Xu et al<sup>4</sup>

Asthma, rhinitis,  
other respiratory  
diseases

**TABLE II.** Risk of asthma ever and current asthma among 9722 women (born 1973-77 in Denmark) according to their birth characteristics

	Asthma ever			Current asthma		
	Cases/all	OR (95% CI)	Adjusted OR (95% CI)	Cases/all	OR (95% CI)	Adjusted OR (95% CI)
Mode of delivery†						
Vaginal						
Spontaneous	957/8549	1 (ref.)	1 (ref.)	551/8549	1 (ref.)	1 (ref.)
Vacuum extraction	56/413	1.24 (0.93-1.66)	1.21 (0.90-1.62)	33/413	1.26 (0.87-1.82)	1.24 (0.85-1.79)
Other*	34/267	1.16 (0.80-1.67)	1.15 (0.80-1.67)	22/267	1.30 (0.84-2.03)	1.29 (0.82-2.01)
Cesarean section	69/493	1.29 (0.99-1.68)	1.33 (1.02-1.74)	38/493	1.21 (0.86-1.71)	1.22 (0.87-1.73)
Gestational age (wk)†						
≥37	1074/9254	1 (ref.)	1 (ref.)	618/9254	1 (ref.)	1 (ref.)
35-36	27/326	0.69 (0.46-1.02)	0.64 (0.42-0.99)	19/326	0.86 (0.54-1.38)	0.77 (0.46-1.29)
≤34	15/142	0.90 (0.52-1.54)	0.80 (0.43-1.49)	7/142	0.72 (0.34-1.56)	0.59 (0.25-1.40)
Birth weight (g)†						
<2510	59/533	0.94 (0.71-1.26)	1.06 (0.75-1.50)	36/533	1.04 (0.73-1.50)	1.20 (0.78-1.85)
2510-3009	220/1944	0.97 (0.81-1.15)	0.97 (0.81-1.15)	132/1944	1.05 (0.84-1.30)	1.05 (0.84-1.31)
3010-3509	458/3925	1 (ref.)	1 (ref.)	255/3925	1 (ref.)	1 (ref.)
3510-4009	301/2616	0.98 (0.84-1.15)	0.99 (0.85-1.16)	173/2616	1.02 (0.83-1.24)	1.03 (0.85-1.26)
≥4010	78/704	0.94 (0.73-1.22)	0.96 (0.75-1.25)	48/704	1.05 (0.77-1.45)	1.07 (0.77-1.47)
Ponderal index in quartiles‡						
First (lowest)	242/2130	1 (ref.)	1 (ref.)	138/2130	1 (ref.)	1 (ref.)
Second	313/2731	1.01 (0.85-1.21)	1.01 (0.84-1.21)	174/2731	0.98 (0.78-1.24)	0.98 (0.78-1.24)
Third	251/2251	0.98 (0.81-1.18)	0.97 (0.80-1.17)	151/2251	1.04 (0.82-1.32)	1.03 (0.81-1.31)
Fourth	310/2610	1.05 (0.88-1.26)	1.05 (0.87-1.26)	181/2610	1.08 (0.86-1.35)	1.07 (0.85-1.36)
SGA (born ≥37 gestational weeks)§						
No (≥2510 g)	1043/9006	1 (ref.)	1 (ref.)	1278/9006	1 (ref.)	1 (ref.)
Yes (<2510 g)	31/248	1.09 (0.74-1.60)	1.04 (0.71-1.53)	41/248	1.10 (0.67-1.78)	1.05 (0.64-1.71)
Parity†						
0	78/655	1 (ref.)	1 (ref.)	42/655	1 (ref.)	1 (ref.)
1	530/4572	0.97 (0.75-1.25)	0.99 (0.77-1.28)	310/4572	1.06 (0.76-1.48)	1.09 (0.78-1.52)
2	350/3152	0.92 (0.71-1.20)	0.97 (0.74-1.26)	195/3152	0.96 (0.68-1.36)	1.00 (0.70-1.41)
≥3	158/1343	0.99 (0.74-1.32)	1.05 (0.79-1.41)	97/1343	1.14 (0.78-1.65)	1.18 (0.80-1.72)
Maternal age at birth (y)†						
≤19	82/628	1.08 (0.84-1.39)	1.08 (0.84-1.39)	52/628	1.24 (0.91-1.69)	1.23 (0.90-1.68)
20-24	457/3732	1 (ref.)	1 (ref.)	253/3732	1 (ref.)	1 (ref.)
25-29	395/3594	0.88 (0.77-1.02)	0.89 (0.77-1.03)	235/3594	0.96 (0.80-1.16)	0.98 (0.81-1.18)
30-34	137/1393	0.78 (0.64-0.96)	0.78 (0.64-0.96)	73/1393	0.76 (0.58-0.99)	0.77 (0.58-1.01)
≥35	45/375	0.98 (0.71-1.35)	0.96 (0.69-1.33)	31/375	1.24 (0.84-1.83)	1.21 (0.81-1.81)

OR, Odds ratio; SGA, small for gestational age (ie, weighing < 2510 grams at term [≥37 weeks]).

\*Includes rotation and/or traction ( $n_{\text{asthma ever}} = 7$ ,  $n_{\text{current asthma}} = 5$ ,  $n_{\text{total}} = 72$ ), use of forceps ( $n_{\text{asthma ever}} = 8$ ,  $n_{\text{current asthma}} = 4$ ,  $n_{\text{total}} = 61$ ) and other assistance ( $n_{\text{asthma ever}} = 19$ ,  $n_{\text{current asthma}} = 13$ ,  $n_{\text{total}} = 134$ ).

†Adjusted OR is adjusted for occupation and other variables in the Table except ponderal index and SGA.

‡Adjusted OR is adjusted for occupation and other variables in the Table except birth weight and SGA.

§Adjusted OR is adjusted for occupation and other variables in the Table except gestational age, birth weight, and ponderal index.

reported a strong association between doctor-diagnosed *current* asthma at age 28 years and cesarean section. In the present study, which included women aged 20-28 years, the risk of current asthma was not significantly increased. Our findings of a significant association with asthma ever but not with current asthma could suggest a particular association between the development of asthma in childhood and cesarean section. However, we did not have information on age at onset of asthma in the women and thus could not explore this further.

A recent British study of 4,065 children investigated a broad range of in utero and perinatal complications in relation to asthma in childhood.<sup>14</sup> Emergency cesarean

and early or threatened labor, as well as breech and face presentation and transverse lie of the fetus, were found to be positively associated with asthma.<sup>14</sup> The association with emergency cesarean was, however, explained by confounding factors. Data on child asthma for elective cesareans, on the other hand, were not presented. To explore the possible influence of emergency cesareans in our study population, we analyzed whether asthma was positively associated with cesarean deliveries when labor had been induced and/or labor-stimulating drugs had been given, indicating that the cesarean section was not elective but chosen because of an emergency situation. Being aware that only some of the

emergency sections would be detected in this way, we found no differential effect between asthma and cesarean deliveries with and without labor induction/labor-stimulating drugs.

As regards other complicated modes of delivery, the results by Xu et al<sup>3</sup> also indicated higher risks of asthma among 7-year-old children delivered by vacuum extraction and other special procedures, including use of forceps, manual auxiliary, and extraction breech, whereas another study of asthma in 0- to 11-year-old children found no such indications for forceps/vacuum extraction or breech delivery.<sup>11</sup> In our study there was no significant association between vacuum extraction and other special procedures, including use of forceps, rotation, and/or traction and current asthma or asthma ever in young women.

The mechanism underlying the association between cesarean section and asthma remains unclear. Cesarean section has long been known to cause respiratory problems in some newborns,<sup>20-23</sup> perhaps because of excess fluid in the lungs when there is no vaginal compression of the baby's chest and/or because of decreased stress and labor. Stress and labor during vaginal delivery in comparison with cesarean delivery induce a catecholamine surge<sup>24,25</sup> and increase levels of cortisol<sup>24,26</sup> and pulmonary surfactant,<sup>27</sup> all of which contribute considerably to a normal postnatal lung adaptation and development. Thus, one explanation for the association between cesarean section and asthma could be that some of these respiratory problems predispose to asthma.<sup>28</sup> This might also explain why asthma and not allergic rhinitis was associated with cesarean section, given that poor lung function in childhood is an important feature of asthma,<sup>29</sup> whereas allergic rhinitis manifests later in childhood and affects only nasal airways. This could also support a particular association with the development of asthma in childhood but not later in life.

In the present study, frequencies of cesarean section and other complicated modes of delivery were similar to national figures in the birth period of the cohort.<sup>30</sup> However, large variations in these figures exist between regions and hospitals, in time,<sup>30,31</sup> and between studies reporting on asthma in relation to cesarean section. Indeed, the birth periods of the cohorts in these studies, including ours, are widely distributed from 1958 to 1994, and frequencies of cesarean delivery range from 4% to 24%. We speculate that one explanation for the inconsistent results reported in these studies might be variations in time and between countries concerning obstetric practice for indications for cesarean section.<sup>32</sup> The occurrence and severity of health complications underlying cesarean section could have a long-term influence on respiratory problems arising during and after such an operation.

In conclusion, our findings do not support that cesarean section or other complicated modes of delivery are associated with the development of allergic rhinitis. However, there might be a positive association with the development of asthma—particularly for cesarean section—that was not explained by gestational age, birth weight, ponderal index, SGA status, parity, maternal age, or occupation.

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