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The Intergenerational Predisposition to Operative Delivery

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Objective: **To determine the risk of cesarean delivery for women who themselves were born via operative delivery.**

Methods: **A linked data base was constructed between the birth certificates of individuals born in Utah during 1947–1957 (parental cohort) and who subsequently became a parent of offspring born in Utah between 1970–1991 (offspring cohort). Parental cohort women (cases) who had been delivered operatively (cesarean delivery, mid- or high forceps) as well as women who had a sibling delivered by an operative procedure were matched (1:2) with parental-cohort women born by spontaneous vaginal delivery (controls). Both cases and controls were selected based on having a record of at least one delivery in Utah during 1970–1991.**

Results: **Women who were delivered by cesarean were at increased risk of subsequently delivering their children by cesarean (odds ratio [OR] 1.41, 95% confidence interval [CI] 1.18–1.70; $P < .001$). Progressive risk was associated with parental delivery by mid- or high forceps (OR 1.72, 95% CI 1.20–2.47; $P = .004$), parental cesarean because of cephalopelvic disproportion alone (OR 1.83, 95% CI 1.16–2.88; $P = .01$), or parental cesarean for dysfunctional labor (OR 5.97, 95% CI 1.5–23.6; $P < .001$). The attributable risk for cesarean delivery to the contemporary population is 3.5%.**

Conclusion: **An intergenerational predisposition to cesarean delivery exists.** *(Obstet Gynecol 1996;87:905–11)*

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Cesarean delivery rates have consistently increased in the past decades in the United States.[1] The most common indication for primary cesarean in this country has been dystocia, a term that includes failure to progress in labor (prolonged or dysfunctional labor) as well as cephalopelvic disproportion. This has been attributed to a more cautious approach to the management of dystocia, increased utilization of regional anesthetics, and increasing medical indications for induction of labor. In addition, it is well recognized that these factors are often interrelated.

Another possible explanation for this increase in the primary cesarean rate may be a familial tendency toward inefficient labor. Previously, familial associations have been identified for numerous other obstetric and gynecologic conditions, including preeclampsia,[2] endometriosis,[3] postdates pregnancy,[4] low birth weight,[5] and ovarian cancer.[6] In addition, social, cultural, or economic pressures may also result in familial clustering.

If such a familial tendency toward inefficient labor

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exists, then improved maternal and perinatal survival rates combined with more liberal indications for cesarean delivery and a less aggressive approach to operative vaginal delivery might be an explanation for the recent increase in dystocia-related cesarean delivery rates. Thus, the purpose of this study was to test the null hypothesis that there is no difference in the risk of cesarean delivery for women who were born via operative delivery relative to women themselves born via spontaneous vaginal delivery. The alternative hypothesis was that a woman who was born via an operative delivery is at an increased risk of requiring an operative delivery.

Materials and Methods

A linked data base of Utah birth certificates was established that encompasses two distinct cohorts: an offspring cohort comprised of births occurring between 1970–1991 and a parental cohort comprised of births occurring between 1947–1957. This protocol was approved by the University of Utah Institutional Review Board in agreement with the Utah State Department of Health.

The offspring cohort initially consisted of all live births occurring between 1970–1986. The original suitability of these records for linkage was compromised because the middle name information and state of birth were not consistently available. As a result, all birth certificates were manually keyed from microfilm records.

This original offspring cohort was then extended to include computerized birth certificates for 1987–1991. These latter data were merged with the original offspring cohort data, maintaining a similar data format across the entire offspring cohort time period.

The parental cohort was defined as all birth certificates retrievable from microfilm in the state of Utah for the period 1947–1957. By confirmation with the original Utah State Department of Health copies, over 90% of the 1947–1954 birth records from this period are included.

The microfilm birth certificates from 1955–1957 contained only index information, and the bottom portion of the record containing medical information relating to that birth was not recorded. Although 92% of the 1957 birth information was eventually recovered and entered, only about 27% of the 1955–1956 data could be recovered. Therefore, the 1955 and 1956 births were not included in the current data base. Thus, the parental cohort consists of 197,466 birth records.

For the time period 1947–1957, 99,801 mother-offspring links were formed by linking the birth certificates of mothers to the birth certificates of one or more of their children. After adjusting for missing name information in the parental cohort, the current data base of mother-offspring links represents approximately 58% of all possible links between mothers and children for this time period.

A one-to-two case-to-control cohort design was selected to control for those demographic variables recorded on the Utah birth certificate known to be associated with operative delivery and also to maximize statistical power. Using power analysis procedures for case-control studies,[7] we determined that 500 cases with 1000 controls would provide 73% power to detect an odds ratio (OR) of 1.5 and 99% power to detect an OR of 2.0.

During the 45-year study period, seven different birth certificate forms have been used by the Utah State Department of Health. The format used from 1989 onward contains a set of 19 specific criteria for medical risk factors for the current pregnancy, nine attributes that define the method of delivery, and 20 attributes that identify complications of labor and/or delivery. To create a uniform data system, these specific criteria were applied to the entire study period as follows.

For birth certificates dated 1947–1957, information on pregnancy and labor complications as well as type of delivery was initially recorded as free text on the original document. Each birth certificate was reviewed and coded using the 1989–1993 birth certificate format.

For birth certificates dated 1970–1977, the method of delivery was the only computerized obstetric information available during the data base development. Consequently, the birth certificates of offspring of all identified cases and controls during this period were reviewed from original records and coded by the 1989–1993 criteria.

From 1978 through 1988, medical information concerning complications was available as a four-digit ICD code, whereas the method of delivery was coded into one of five categories (spontaneous, low forceps, midforceps, primary cesarean, repeat cesarean). These codes and records were reviewed individually and entered into the data base. In all cases, the diagnoses were restricted to those that were recorded on the Utah birth certificate by the attending physician.

Patients selected as "cases" were female children of the parental cohort who were known to have had at least one live birth in the offspring cohort. All cases were either delivered by cesarean, midforceps, or high forceps or had sisters who were delivered by cesarean, midforceps, or high forceps. The classifications as midforceps or high forceps were taken directly from the individual birth certificates.

Patients selected as "controls" were female children of the parental cohort who were known to have had at least one live birth in the offspring cohort and who delivered via spontaneous vaginal or low forceps delivery. In addition, women selected as controls had no record of any sisters who were delivered by cesarean, midforceps or high forceps.

Entry criteria were the following: 1) either the present birth or a previous birth was a cesarean; 2) there was a sibling born by cesarean; 3) the birth was by mid- or high forceps from a cephalic presentation, and 4) there was a sibling of a mid- or high forceps birth from a cephalic presentation. To avoid duplication of cases, available birth certificate records were assigned to categories in a stepwise fashion, beginning with entry criterion 1.

The diagnosis of cephalopelvic disproportion was limited to pregnancies with vertex presentation. Dystocia was not a coded indication for operative delivery in either cohort. In an attempt to apply current practice standards to this era, any cesarean performed for cephalopelvic disproportion or prolonged labor or dysfunctional labor was included in a category subsequently referred to as dystocia. There were no exclusion criteria.

Female infants from the parental cohort who were delivered by spontaneous vaginal delivery and who subsequently had at least one delivery in Utah during 1970–1991 were identified as controls on a one-to-two basis as outlined previously. Control patients were matched by birth certificate data for maternal age, county in which the delivery occurred, multiplicity, and parity.

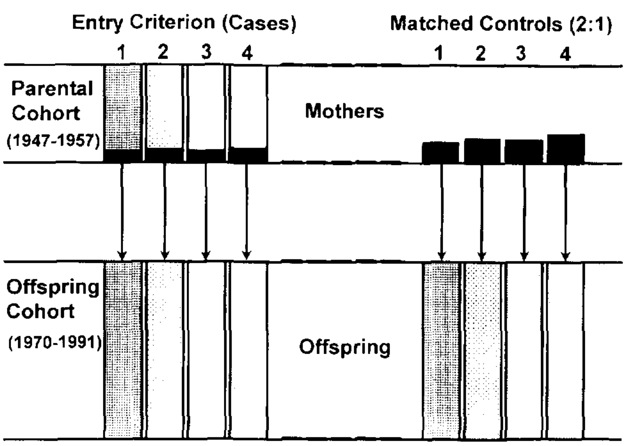

Figure 1. Schematic diagram of the study design. The entry criteria are: 1) mother delivered by cesarean, 2) maternal sibling with cesarean, 3) mother delivered by mid- or high forceps, 4) maternal sibling delivered by mid- or high forceps. The dark portion of the four entry criterion groups (method of maternal delivery) represent the percentage of each group that fulfilled the definition of "cases." The dark portions under matched controls represent the 2:1 matched "controls." Both cases and controls were then linked to their respective pregnancies in the offspring cohort.

Table 1. Distribution of Cases and Controls

Entry criterion	Total eligible birth certificates*	Linked female birth certificates* (mothers)	Linked birth certificates† (offspring)
1) Cesarean delivery			
Cases	4010	509	1708
Controls		1018	3461
2) Sibling born via cesarean delivery			
Cases	1661	235	859
Controls		470	1642
3) Mid- or high forceps			
Cases	944	114	387
Controls		228	768
4) Sibling born via mid- or high forceps			
Cases	896	131	440
Controls		262	838

* Born during parental cohort (1947–1957).
† Born during offspring cohort (1970–1991).

Figure 1 represents the development of the parental and offspring cohort populations, the selection of case and control mothers (parental cohort), and the linkage to case and control offspring (offspring cohort).

The method of delivery of the offspring mothers was cross-classified by that of the parental mothers. Log-linear analysis with likelihood ratio test statistics[8] was used to determine the significance of association between delivery methods of the two generations.[9] Odds ratios and 95% confidence intervals (CI) were calculated from the estimated model parameters and the standard errors. The same method was used to determine separate ORs for the offspring mothers who had mothers with cephalopelvic disproportion and those whose mothers did not have cephalopelvic disproportion. Three-way log-linear analysis was used to determine whether the ORs differed between the two groups. Likelihood ratio test statistics and parameter estimates were generated using generalized linear interactive modeling.[9]

Results

There were 5671 birth certificates (female and male newborns) which satisfied one of the first two criteria (ie, born by cesarean or had a sibling born by cesarean). These included 4010 cesarean births (entry criterion 1) and 1661 who had a sibling delivered by cesarean but were not themselves delivered by cesarean (entry criterion 2). The 5671 newborns were delivered from 3226 women (grandmothers).

There were 1840 birth certificates (female and male

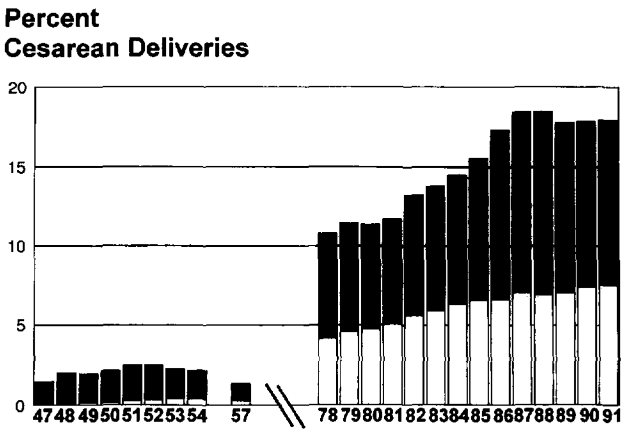

Figure 2. Schematic diagram of cesarean section rates during the course of the study. *Dark bars* = primary cesarean rates; *open bars* = repeat cesarean rates.

newborns) that satisfied one of the last two criteria, ie, born by mid- or high forceps or had a sibling born by mid- or high forceps. These included 944 mid- or high forceps births (entry criterion 3) and 896 newborns who had a sibling delivered by mid- or high forceps but were not themselves delivered by cesarean or forceps (entry criterion 4). The 1840 newborns were delivered from 928 women (grandmothers).

Of the 4010 newborns delivered by cesarean (entry criterion 1), 509 females were linked to one or more births (total 1708 male and female) in the offspring cohort. Of the 1661 newborns who had a sibling delivered by cesarean but were not themselves delivered by cesarean (entry criterion 2), 235 females were linked to one or more births (total 859 male and female) in the offspring cohort.

Of the 944 newborns delivered by mid- or high forceps (entry criterion 3), 114 were linked to one or more births (total 387 male and female) in the offspring cohort. Of the 896 newborns who had a sibling delivered by mid- or high forceps but were not themselves delivered by mid- or high forceps or cesarean (entry criterion 4), 131 were linked to one or more births (total 440 male and female) in the offspring cohort. The total distribution of cases and controls is summarized in Table 1.

Of all the controls, 54% matched exactly on age, 60% matched exactly on parity, 59% matched exactly on county of birth. The remainder were matched within 2 years of maternal age, within two births for parity, and matched to a similar county in terms of urban, rural, or frontier classification.

The distribution in this data base of key demographic attributes, including race, county of birth, multiplicity, maternal age and parity, marital status, and adequacy of prenatal care is similar to the entire Utah population. Figure 2 presents the distribution of cesarean deliveries in both cohorts. Table 2 presents representative labor and/or delivery complications by cohort population.

The maternal cesarean entry criterion group was compared with the subset that was selected as cases. There were no significant differences noted between year of delivery, maternal or paternal age, multiplicity, parity, birth weight or malpresentation. In addition, there were no significant differences in the diagnosis of cephalopelvic disproportion, dysfunctional labor, or prolonged labor.

The offspring of case and control women were compared for average maternal and paternal education, maternal and paternal race, and marital status. There were no significant differences.

Table 3 presents a cross-tabulation of the parental groups and their controls versus the methods and frequency of delivery for female offspring. A woman who was herself delivered by cesarean (entry criterion 1) had a significantly increased likelihood of delivering by cesarean (OR 1.41, 95% CI 1.18–1.70; $P < .001$). In addition, a woman who was herself delivered by mid- or high forceps (entry criterion 3) also had a significantly increased likelihood of delivering by cesarean (OR 1.72, 95% CI 1.20–2.47; $P = .004$). When these groups were combined, a maternal history of operative delivery (cesarean, mid- or high forceps) was highly associated with an increased probability of cesarean in the next generation (OR 1.45, 95% CI 1.25–1.72; $P < .001$). These results are shown in Figure 3.

The subpopulation of women (mothers) who themselves were delivered by cesarean was further examined (Table 4). The subgroup delivered because of cephalopelvic disproportion was significantly more likely to require cesarean delivery when they had their children (OR 1.83, 95% CI 1.16–2.88; $P = .01$).

The women delivered by cesarean because of indications other than cephalopelvic disproportion were compared with their matched controls. A significant intergenerational association was also identified (OR 1.29,

Table 2. Distribution of Representative Complications of Labor and/or Delivery by Cohort

	Parental cohort, 1947–1957 (N = 197,466)	Offspring cohort, 1978–1991 (N = 359,069)
Prolonged labor (>20 h)	300 (0.14%)	1624 (0.29%)
Dysfunctional labor	447 (0.22%)	8216 (1.49%)
Cephalopelvic disproportion	758 (0.37)	14,048 (2.54%)

* Data not available for 1970–1977.

Table 3. Maternal Method of Delivery as a Predictor of Female Offspring's Delivery

Group	SVD	Pri CD	R CD	LF	MF	Other	Unknown	Total
A) Maternal CD (entry criterion 1)								
Case	1368	103	126	12	75	7	17	1708
Control	2874	179	161	38	128	22	59	3461
B) Maternal sister with CD (entry criterion 2)								
Case	711	40	60	5	29	5	9	859
Control	1418	64	66	12	61	7	14	1642
C) Maternal forceps (entry criterion 3)								
Case	297	28	34	4	21	1	2	387
Control	635	40	37	6	32	6	9	768
D) Maternal sister with forceps delivery (entry criterion 4)								
Case	367	27	18	3	20	0	4	440
Control	698	44	36	12	30	3	13	838

SVD = spontaneous vaginal delivery; Pri CD = primary cesarean delivery; R CD = repeat cesarean delivery; LF = low forceps; MF = midforceps; Other = vaginal birth after cesarean, vacuum extraction; CD = cesarean delivery.

95% CI 1.06–1.58; P = .01). The ORs between the cephalopelvic disproportion and noncephalopelvic disproportion groups are not significantly different (P = .22) (Table 4).

The women (mothers) who themselves were delivered by cesarean because of prolonged labor or dysfunctional labor or cephalopelvic disproportion (dystocia) had an even higher likelihood of requiring a cesarean delivery when they had their children (OR 2.11, 95% CI 1.38–3.24; $P < .001$). After taking into account the three-way interactions between modes of delivery in mother and offspring, this OR of 2.11 was higher than the OR of 1.29 for mothers whose cesarean birth was not associated with dystocia (P = .04). This increased risk is partly attributable to the fact that, for mothers who have offspring by cesarean delivery, there is a significant association between maternal dystocia and maternal cesarean delivery (OR 1.62, 95% CI 1.04–2.50; P = .032).

To confirm a familial predisposition to operative delivery, we studied the reproductive outcomes of female infants whose maternal aunts had been deliv-

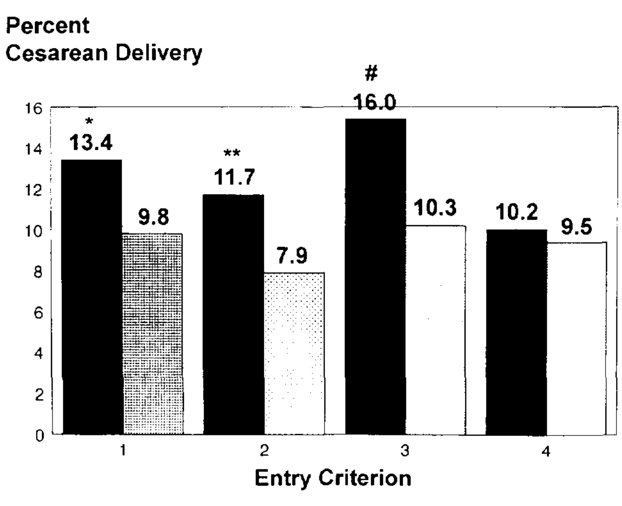

Figure 3. Percent cesarean delivery in women who themselves were delivered by operative delivery (*dark bars*) compared with matched controls. Group 1 = mother delivered by cesarean (*odds ratio [OR] 1.41, 95% confidence interval [CI] 1.2–1.7; $P < .001$); group 2 = maternal sibling with cesarean (**OR 1.53, 95% CI 1.2–2.0; P = .003); group 3 = mother delivered by mid- or high forceps (#OR 1.72, 95% CI 1.2–2.5; $P < .001$); group 4 = maternal sibling delivered by mid- or high forceps (not significant).

Table 4. Odds Ratios and 95% Confidence Intervals for Risk of Cesarean Delivery Among Case Versus Control Offspring

	Odds ratio	95% CI	P
A) Stratification by entry criterion			
1 (maternal cesarean)	1.41	(1.2–1.7)	<.001
2 (maternal aunt-cesarean)	1.53	(1.2–2.0)	.003
3 (maternal forceps)	1.72	(1.2–2.5)	.004
4 (maternal aunt-forceps)	1.07	(0.7–1.6)	NS
1 or 3	1.47	(1.3–1.7)	<.001
B) Stratification by selected subgroups of entry criterion 1*			
Maternal cesarean with dystocia†	2.11	(1.4–3.2)	<.001
Maternal cesarean without dystocia†	1.30	(1.1–1.6)	.01
Maternal cesarean with cephalopelvic disproportion‡	1.83	(1.2–2.9)	.01
Maternal cesarean without cephalopelvic disproportion‡	1.35	(1.1–1.6)	.003
Maternal cesarean with prolonged labor	5.18	(0.5–56.1)	NS
Maternal cesarean with dysfunctional labor	5.97	(1.5–23.6)	<.001

CI = confidence interval; NS = not significant.
* Compared with their previously assigned 1:2 controls.
† Dystocia: cephalopelvic disproportion or prolonged labor or dysfunctional labor. Odds ratios for the dystocia group were significantly higher than that for the non-dystocia group (P = .04).
‡ No evidence that the odds ratios differed between the cephalopelvic disproportion and non-cephalopelvic disproportion groups (P = .22).

ered by cesarean (entry criterion 2) and mid- or high-forceps (entry criterion 4). These data are also presented in a cross-tabulated form in Table 4. Women whose maternal aunt delivered by cesarean had a significantly increased risk for cesarean delivery (OR 1.53, 95% CI 1.16–2.02; $P = .003$). However, a history of a maternal aunt being delivered by mid- or high forceps was not associated with an increased risk of a woman requiring a cesarean delivery ($P = .73$) (Figure 3).

With an overall cesarean rate of approximately 2.5% in the parental cohort, the relative risk of 1.41 for these women results in an attributable fraction of only 3.5%. In other words, 96.5% of the women experiencing a cesarean in the offspring cohort were themselves delivered vaginally.

Discussion

The creation of this linked multigenerational data base containing specific obstetric indices has allowed the first systematic study of the intergenerational predisposition to operative delivery. Our data show that women who were born via operative delivery have a significantly increased likelihood of requiring a cesarean delivery during their own pregnancies, particularly if the mother was born by mid- or high forceps or if the maternal cesarean was needed because of cephalopelvic disproportion or dystocia. The case-control design of the study has minimized ascertainment bias in this population.

We recognize that clinical obstetrics during the parental cohort era (1947–1957) was different from current practice. Improved knowledge and medical-legal concerns have led to an increased frequency of diagnosis of most labor and/or delivery complications (Table 2). Specifically, obstetricians are now more aware of the potential risks of prolonged labor.[10] As shown in Table 1, the diagnosis of cephalopelvic disproportion has increased 6.9-fold, and the diagnosis of dysfunctional labor has also increased 9.9-fold. However, the diagnosis of prolonged labor has increased only twofold, suggesting that physicians no longer tolerate prolonged labor and are more likely to intervene operatively with a clinical diagnosis of dysfunctional labor or cephalopelvic disproportion.

Previously, the possibility of a familial reproductive factor predisposing to operative delivery was considered. X-ray pelvimetry series suggest that 98% of pelvic configurations are normal growth variants, probably on a hereditary basis.[11] Preconceptional maternal nutrition also plays an important part in maternal pelvic development.[12]

More recently, Harrison[13] predicted that, in Africa, improved nutrition of pregnant women will initially result in a higher cesarean rate because of cephalopelvic disproportion. However, this initial increase will decline as more women, who were optimally nourished both in utero and in childhood, reach their reproductive epoch. In part, these predictions confirm the earlier observations of Ounsted and Ounsted,[14] who suggested that the maternal mechanisms constraining fetal growth are quantitatively set as each generation of mothers pass through their intrauterine life.

Although these considerations are important in any discussion of longitudinal population trends, we believe that the historic socioeconomic homogeneity of the Utah population should minimize any such effects in these data (Report to the Governor: Poverty in Utah 1993, State Community Services Office, Utah Department of Community and Economic Development, Salt Lake City, Utah, December 1993). Likewise, dietary patterns in Utah are similar to those of the United States as a whole.[15] The population of Utah is ethnically, educationally, and economically homogeneous, but not genetically different from other white American populations.[16] Utah still maintains the highest fecundity rate (2.6 births per woman), has the lowest median age (26.2 years), and has the highest dependency ratio (82 dependents per 100 working persons) of any state.[17] Utah thus provides an optimum background for evaluation of the null hypothesis of this study. Although this may limit the applicability of these findings to other populations, the low-risk nature of the Utah population may be more likely to reveal genetic effects, because environmental pressures such as malnutrition have been minimal over the course of this study. Demographic variables also change with time and any consideration of intergenerational effects should control for maternal age and parity, as in this study.

Marital status is also correlated with risk for cesarean delivery. The offspring cohort's lower percentage of married women is consistent with national trends of births to unmarried women, especially teenagers.[18] There were no significant differences between any of our case and control groups for marital status.

Our attributable risk calculations suggest that the majority of the recent increase in cesarean rates is due to changes in practice management[19–21] rather than to the survival of women with functional reproductive inadequacy. Nonetheless, our data identify a real biologic phenomenon. The precise mechanism(s) of this biologic imperative remain unknown. The likelihood of a vertically transmissible absolute cephalopelvic disproportion trait is highly improbable. However, these data are compatible with an inheritable tendency toward poor uterine contraction or soft tissue relaxation. Several previous cross-sectional studies have provided suggestive evidence for such a mechanism. Rechberger et al[22] showed that primigravidas whose cervices had high levels of collagen and hyaluronic acid had longer cervical dilation times. Granstrom et al[23] demonstrated that, compared with controls, women delivered by cesarean because of protracted labor had a significantly higher concentration of collagen in the uterine isthmus and cervix as well as a decrease in solubility of the collagen. Both Granstrom et al[23] and Uldbjerg et al[24] concluded that insufficient remodeling of uterine tissue during pregnancy may contribute to protracted labor, ie, operative delivery. These alterations in collagen mechanics may be due to changes in the ratio of collagen types or to isomorphisms,[25] either of which may be hereditary.[26]

Our data demonstrate an intergenerational predisposition to operative delivery, particularly if the parental cesarean was performed for cephalopelvic disproportion or dysfunctional labor. Although the current attributable risk is low, continued amplification of this trend may have a substantial impact on future obstetric practice.

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