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# Planned cesarean versus planned vaginal delivery at term: Comparison of newborn infant outcomes

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**KEY WORDS**
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**Objective:** The purpose of this study was to examine neonatal outcomes among women with a planned cesarean and a planned vaginal delivery at term.
**Study design:** This prospective survey was conducted on 18,653 singleton deliveries that represent 24 maternity units during a 6-month period. The data were retrieved from the Medical Birth Registry of Norway and analyzed according to intended mode of delivery.
**Results:** Compared with planned vaginal deliveries, planned cesarean delivery increased transfer rates to the neonatal intensive care unit from 5.2% to 9.8% ($P < .001$). The risk for pulmonary disorders (transient tachypnea of the newborn infant and respiratory distress syndrome) rose from 0.8% to 1.6% ($P = .01$). There were no significant differences in the risks for low Apgar score and neurologic symptoms.
**Conclusion:** A planned cesarean delivery doubled both the rate of transfer to the neonatal intensive care unit and the risk for pulmonary disorders, compared with a planned vaginal delivery.
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The appropriateness of the rising rate of cesarean delivery worldwide has been debated widely. Issues that relate to maternal choice,[1,2] mode of delivery for breech presentation at term,[3] and vaginal birth after previous scar[4] have been emphasized; and much debate has focused on subsequent maternal and neonatal morbidity.[1-3,5-8] Some studies favor elective cesarean delivery because of a fear of childbirth,[9] urinary and fecal incontinence after delivery,[10] breech deliveries at term,[3] and neonatal outcome as unexplained fetal death and complications of labor.[3,9,11] Other surveys benefit vaginal delivery because cesarean delivery implied a higher risk of maternal death,[12] a longer recovery time and operative complications,[13] a higher risk of unexplained stillbirths in subsequent pregnancies,[4] and respiratory problems of the newborn infant.[6,14-16] In 1999, a Swedish survey concluded that an increase in the cesarean delivery rate

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did not reduce the perinatal mortality rate or lower the rate of asphyxia.[7]

Morbidity and death in the neonatal period are mostly due to respiratory and cerebral disorders, particularly in preterm births. Significant respiratory morbidity after elective cesarean delivery is well known, even in term babies up to 40 weeks of gestation.[6,14-16]

In 1972, the cesarean delivery rate in Norway was 2.5%. In 1987, it had risen to 12.8% and remained stable for several years. However, a slight raise has been observed in recent years; it was 15.7 % in 2002.[17] There have been wide variations in cesarean delivery rates among obstetric departments in Norway (6%-20%), even when departments of comparable size and patient populations are compared.[18] Thus, Norway has a lower cesarean delivery rate than other countries such as the United Kingdom (22% in 2002) and the United States (25% in 2002).[19,20]

In 1998 the Norwegian Medical Association invited maternity units in the country to participate in a "Breakthrough Project" on cesarean deliveries. Recently, 2 studies from this project have been published.[5,18] In the present study, we aimed to find how neonatal outcomes relate to intended mode of delivery in term pregnancies (vaginal vs cesarean delivery).

## Material and methods

Data for this study were compiled from the records of 24 obstetric units that participated in the Breakthrough Project from January 1, 1999, to June 30, 1999.[18] Ten of these units had >2000 births per year, and 9 units had between 1000 and 2000 births in 1999.

The Breakthrough Project included only cesarean deliveries and used a comprehensive form that contained more detailed obstetric and neonatal information compared with the form used by the Medical Birth Registry of Norway (MBRN). However, for the purposes of this study, we wanted to use the same data source for comparison of all deliveries. Therefore, all data (both from vaginal and cesarean deliveries) in the analyses were derived from the MBRN. The form used for all births in this country gives information about the medical and obstetric history, complications during pregnancy, delivery, and perinatal events. Neonatal events were prespecified. The forms were filled in before the mother and the child were discharged from the hospital, and additional information about the child was collected, if appropriate. The pediatricians at the hospitals gave the neonatal diagnoses.

This survey covered 19,288 term singleton deliveries, which according to the MBRN database represented 70.7% of all term singleton deliveries in Norway during the same period. We excluded congenital malformations (n = 546 deliveries) and cases with unspecified mode of delivery (n = 89 deliveries). Thus, this survey included 18,653 term deliveries (Figure).

Term infants were defined as those who were delivered by a gestational age of ≥259 days, as estimated by routine ultrasound examination in the second trimester.

In this study we present the result according to 3 intended mode of delivery groups: Group 1 (planned vaginal delivery group that included all vaginal deliveries [an unselected population] and all emergency cesarean deliveries, prelabor, or in labor after a planned vaginal delivery [n = 17,828]); group 2 (planned cesarean delivery group that included all elective cesarean deliveries [defined as all cesarean deliveries that were performed >8 hours after the decision for operation] and all emergency cesarean deliveries in those women with a planned cesarean [n = 825]); and group 3 (subgroup of group 2: It could be argued that neonatal outcome for group 2 should be worse than in group 1 because of risk pregnancies [such as outcomes <2500 g] and fetal problems [such as growth restriction, immunization, and signs of chronic fetal stress]. Therefore, 11 cases were excluded due to International Classification of Diseases 10th revision O35.0-O36.9, which left 814 cases in this subgroup).

The following neonatal diagnostic criteria were used: Hypoglycemia (defined as blood glucose <2 mmol/L); pulmonary disorders (included transient tachypnoea of the newborn and respiratory distress syndrome, as defined by Hjalmarson[21]); bacterial infections (included pneumonia and sepsis, diagnosed clinically with or without confirmation by blood cultures); abnormal neurologic status (cerebral irritation, cerebral depression, and encephalopathy were included in this category, defined by Sarnat and Sarnat[22]); neonatal convulsions (noted separately); intracranial hemorrhage (included all classes of intraventricular hemorrhage, epidural hemorrhage, and subdural hemorrhage); neurologic symptoms (included the 3 diagnoses mentioned earlier: abnormal neurologic status, neonatal convulsions, and intracranial hemorrhage).

Statistical analysis was conducted with the Student *t* test and crosstabs with chi-square statistics (SPSS, version 11.5; SPSS Inc, Chicago, IL). Two-tailed probability values of <.05 were considered statistically significant. Adjustment for gestational age was performed with unconditional logistic regression analysis, where gestational age was represented with the number of gestational weeks as a linear term. Because of small numbers in some of the strata, we also analyzed the results in Table I by computing exact confidence intervals and corresponding probability values for the odds ratio.[23] The results from this analysis did not differ from the results that were based on chi-square statistics and therefore are not presented. This study was approved by the Norwegian Data Inspectorate and the Regional Ethical Committees for Medical Research.

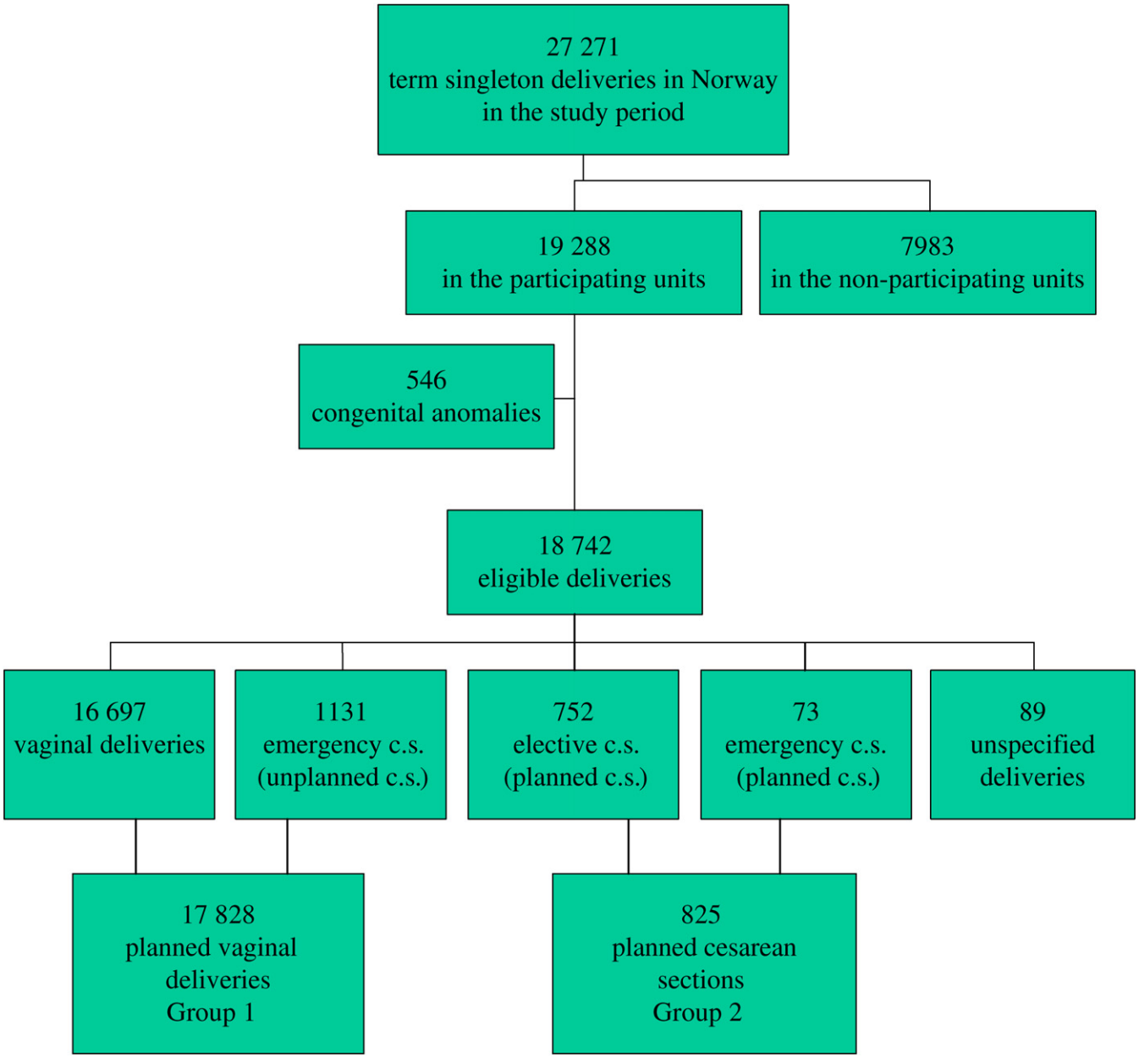


**Figure** Summary characteristics of study population.

## Results

### Cesarean delivery rates

During this study period, the overall cesarean delivery rate in Norway was 13.6%, compared with 13.4% (range, 9.1%-21.3%) among participating departments. The overall cesarean delivery rate among women carrying male fetuses was 14.2%, compared with 13.0% among those with female fetuses ($P < .001$).

In singleton pregnancies among participating units, the cesarean delivery rate was 12·4% (range, 8.3%-18.3%); breech deliveries averaged 57.8% (range, 40.8%-70.0%).

### Intended mode of delivery

The number of vaginal deliveries that was included was 16,697; there were 1956 cesarean deliveries. The detailed distribution of vaginal deliveries and cesarean deliveries in the groups are shown in the Figure.

### Population characteristics

A summary of the characteristics that compare the planned vaginal group and the planned cesarean group is given in Table II. There is a significant difference regarding gestational age between the 2 groups. For each neonatal outcome analysis, the result is adjusted

**Table I** Neonatal outcome in raw numbers and relative risk in term outcomes, according to intended mode of delivery

| Variable | Planned vaginal group (n)* | Planned cesarean delivery group (n)† | Relative risk (CI)‡ | Planned cesarean group with excluded fetal indications (n)§ | Relative risk (CI)‖ |
|---|---|---|---|---|---|
| Apgar 5 min <7 | 175 (1.0%) | 3 (0.4%) | 0.37 (0.12-1.16) | 3 (0.4%) | 0.38 (0.12-1.17) |
| Apgar 5 min <4 | 49 (0.3%) | 2 (0.2%) | 0.88 (0.22-3.62) | 2 (0.3%) | 0.89 (0.22-3.67) |
| Transfer to neonatal intensive care unit | 934 (5.2%) | 81 (9.8%) | 1.87 (1.51-2.32) | 74 (9.1%) | 1.74 (1.38-2.18) |
| Pulmonary disorders | 136 (0.8%) | 13 (1.6%) | 2.07 (1.17-3.63) | 13 (1.6%) | 2.09 (1.19-3.68) |
| Abnormal neurologic status | 39 (0.2%) | 1 (0.1%) | 0.55 (0.08-4.03) | 1 (0.1%) | 0.56 (0.08-4.08) |
| Intracranial hemorrhage | 5 (0) | 1 (0.1%) | 4.32 (0.51-37.00) | 1 (0.1%) | 4.38 (0.51-37.45) |
| Neonatal convulsions | 29 (0.2%) | 1 (0.1%) | 0.75 (0.10-5.46) | 1 (0.1%) | 0.75 (0.10-5.54) |
| Bacterial infections | 138 (0.8%) | 4 (0.5%) | 0.63 (0.23-1.69) | 4 (0.5%) | 0.64 (0.24-1.71) |

* Group 1: n = 17,828.
† Group 2: n = 825.
‡ Observed relative risk for group 2 in relation to group 1.
§ Group 3: n = 814.
‖ Observed relative risk for group 3 in relation to group 1.

for differences in gestational age by logistic regression analysis.

### Low Apgar score

The frequencies of Apgar score <7 and <4 after 5 minutes, respectively, in relation to intended mode of delivery are shown in Table I. The comparison between the planned cesarean delivery group and the planned vaginal delivery group showed no significant difference in the risk for Apgar score <7 and <4 after 5 minutes in any of the comparisons (1.0% vs 0.4% and 0.3% vs 0.2%, respectively; Table I). The mean gestational age in the vaginal and cesarean delivery groups did not differ significantly.

### Transferals to the neonatal intensive care unit (NICU)

The transfer rate to NICU was 5.8% for all term deliveries. More children from the 2 planned cesarean delivery groups were transferred to the NICU than from the planned vaginal group (9.8% vs 5.2%, $P < .001$; 9.1% vs 5.2%, $P < .001$; Table I). Adjustment for gestational age slightly reduced the association between intended mode of delivery and transferal to NICU (observed relative risk, 1.87, vs adjusted odds ratio, 1.76, in the logistic regression analysis) but remained highly significant after the adjustment ($P < .001$).

### Neonatal diagnoses

Pulmonary disorders were observed in 0.8% of all term deliveries. There were significantly more pulmonary disorders in the planned cesarean delivery groups than in the planned vaginal delivery group (1.6% vs 0.8%, $P = .01$; 1.6% vs 0.8, $P = .008$; Table I). For pulmonary disorders, the association with intended mode of delivery was slightly reduced after adjustment for gestational age (observed relative risk, 2.07, vs adjusted odds ratio, 1.82) but remained statistically significant ($P = .047$). For term infants with a gestational age of ≥39 weeks, there were no differences in the outcomes between these groups.

The overall percentage of abnormal neurologic status was 0.2%. There were no significant differences in these outcomes between the planned vaginal and the planned cesarean delivery groups. The same was true for intracranial hemorrhage and neonatal convulsions (Table I).

### Neonatal outcomes in the group 3

We performed the same analyses on neonatal outcomes between group 1 and this subgroup on planned cesarean deliveries (excluding fetal indications). The results are seen in Table I and did not change significantly.

## Comment

To our knowledge, there are no previous cohort studies concerning morbidity during the neonatal period that have presented the outcomes according to intended mode of delivery. The present study describes more than two thirds of all births and cesarean deliveries in Norway during the study period and gives detailed information on cesarean deliveries and neonatal outcome in our country.

The most important findings of our study were that significantly more infants who were born after planned cesarean delivery needed special care in the NICU compared with infants planned for vaginal birth, irrespective of actual route of delivery. This difference was also true after adjustment for the difference in gestational age.

Moreover, we found that a planned cesarean delivery resulted in a 2-fold higher risk for pulmonary disorders

**Table II** Characteristics of the planned vaginal group (group 1) and the planned cesarean group (group 2) in the study

| Characteristic | Planned vaginal group (n = 17,828) | Planned cesarean group (n = 825) | *P* value* |
|---|---|---|---|
| Nulliparous women (n) | 8205 (46.0%) | 247 (29.9%) | <.001 |
| Maternal age (y)† | 28.8 ± 4.9 | 31.4 ± 4.9 | <.001 |
| Gestational age (wk)† | 39.7 ± 1.3 | 38.5 ± 1.1 | <.001 |
| Previous cesarean delivery (n)‡ | 516 (5.1%) | 244 (40.1%) | <.001 |
| Sex, male (n) | 9127 (51.2%) | 405 (49·1%) | .24 |
| Birthweight (g)† | 3648 ± 504.5 | 3561 ± 533.3 | <.001 |
| Breech presentation (n) | 368 (2.1%) | 191 (23.2%) | <.001 |

* Statistical significance based on Pearson's chi-square statistics for categoric variables and the Student *t* test for continuous variables.
† Data are given as mean ± SD.
‡ Proportion among multiparous women.

for the infant, compared with a planned vaginal delivery, even when we adjusted for the difference in gestational age. The likelihood of low 5-minute Apgar scores, however, was not significantly different between groups (Table I).

It could be argued that in high-risk pregnancies that were identified before labor, planned cesarean delivery would often be elected, thereby potentially skewing the outcomes in this group. We therefore further analyzed a subgroup of the planned cesarean delivery group (group 2) excluding fetal indications such as growth restriction, immunization, and fetal stress (group 3). This did not change the results of any of the perinatal events significantly (ie, the risk for neonatal complications was still higher in the planned cesarean delivery group [Table I]).

The findings in this study imply that, compared with planned vaginal deliveries, planned cesarean deliveries increased the workload and costs in neonatal units because a significantly higher transfer rate to the NICU was observed in this group. A recent survey from the United States reported that a reduced hospital admission rate in neonates resulted in significant cost savings.[24]

Our findings stress the importance of limiting the planned cesarean deliveries to cases in which good evidence has shown that the outcome is superior to planned vaginal birth. Data from our Breakthrough Project on cesarean deliveries showed an overall maternal complication rate of 21.4%. After electively performed cesarean deliveries, this rate was 16.3%.[5] The first choice indications that are cited most frequently for elective cesarean deliveries were previous scar, maternal request, and breech presentation, which combined accounted for approximately 55% of all elective cesarean deliveries. Several of these cases were inevitable, such as breech deliveries, which did not comply with the guidelines for vaginal delivery, and cases with ≥2 previous scars. But in approximately 20% of these operations, the first choice indication was maternal request where a trial of labor might have been an alternative.[18] If the maternal request group could be reduced, then the number of transfers to the NICU probably would be reduced as well. We think that a successful reduction of the maternal request group will depend mainly on the handling of nulliparous women and strategies to avoid unnecessary cesarean deliveries after 1 previous scar.

The timing of the cesarean delivery turned out to be an important factor for the prevention of pulmonary disorders. When we analyzed infants with a gestational age of ≥39 weeks, there was no significant difference in the risk for pulmonary disorders among the groups. This indicates that a planned operation should be performed as near to term as possible, as has been stated in several reports.[6,14-16] In Norway elective cesarean deliveries are performed mainly 1 to 2 weeks before term. The reason is probably to reduce the risk for a planned cesarean delivery to end up as an emergency cesarean delivery. By performing elective cesarean deliveries at 39 to 40 weeks of gestation rather than at 37 or 38 weeks of gestation, the overall respiratory morbidity and severe respiratory failure with its associated mortality rates will be reduced.

The neonatal respiratory problems are more common when the cesarean delivery is performed before the onset of spontaneous labor.[6,14] The infants who are born by cesarean delivery without preceding spontaneous uterine contractions lack the thoracic compression effect during labor and thus do not have the benefit of clearing fetal lung fluid. This thoracic compression effect is essential for normal respiration adaptation.

The low number of cases with neurologic symptoms precludes a meaningful formal test of the differences. However, the comparison between the planned vaginal and the planned cesarean delivery groups disclosed no difference in the risk for any of the neurologic symptoms. Recent review articles on this topic do not offer a clear fetal benefit to elective cesarean delivery.[1,2]

Devendra and Arulkumaran[25] report that, despite dramatic improvements in the safety of anesthesia and surgery, mortality and morbidity rates for both mother and child are greater for elective cesarean deliveries compared with vaginal deliveries. There exists an association between pelvic floor damage and childbirth, but

this cannot be attributed entirely to vaginal deliveries and does occur even after a cesarean birth.[25,26] The incidence of perinatal death probably will not be reduced by a policy of universal elective cesarean delivery, because this procedure carries a risk of iatrogenic neonatal morbidity and death. The legal and ethical issues of request cesarean deliveries are complex, and the validity of informed consent for nonindicated surgery is unclear.[1,2,25] All these aspects regarding maternal and neonatal short-term and long-term complications are important and should be taken into account when women ask for a cesarean delivery.

In summary, significantly more children in the planned cesarean group were transferred to the NICU ($P < .001$) and had pulmonary disorders ($P < .01$) than those in the planned vaginal group. This remained true after fetal indications, such as growth restriction and fetal stress, were excluded from the planned cesarean group. There was no difference in the risk for any of the neurologic symptoms.

For the child, the stress of vaginal delivery seems superior to elective cesarean delivery in many situations. Therefore, we emphasize the importance of limiting planned cesarean deliveries to cases with proven benefit for the mother and/or child. When a planned cesarean delivery is chosen, the operation should be as close to term as possible.

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## References

1. Wax JR, Cartin A, Pinette MG, Blackstone J. Patient choice cesarean: an evidence-based review. Obstet Gynecol Surv 2004;59:601-16.
2. Grisaru S, Samueloff A. Primary nonmedically indicated cesarean section ("section on request"): Evidence based or modern vogue? Clin Perinatol 2004;31:409-30.
3. Hannah ME, Hannah WJ, Hewson SA, Hodnett ED, Saigal S, Willan AR. The Term Breech Trial Collaborative group: planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Lancet 2000;356:1375-83.
4. Smith GC, Pell JP, Dobbie R. Caesarean section and risk of unexplained stillbirth in subsequent pregnancy. Lancet 2003;362:1179-84.
5. Häger R, Daltveit AK, Hofoss D, Nilsen ST, Kolaas T, Øian P, et al. Complications in cesarean deliveries: rates and risk factors. Am J Obstet Gynecol 2004;190:428-34.
6. Morrison JJ, Rennie JM, Milton PJ. Neonatal respiratory morbidity and mode of delivery at term: influence of timing of elective caesarean section. BJOG 1995;102:101-10.
7. Eckerlund I, Gerdtham UG. Estimating the effect of cesarean section rate on health outcome: evidence from Swedish hospital data. Int J Technol Health Care 1999;15:123-35.
8. Ecker JL. Once a pregnancy, always a cesarean? Rationale and feasibility of a randomized controlled trial. Am J Obstet Gynecol 2004;190:314-8.
9. Schindl M, Birner P, Reingrabner M, Joura EA, Husslein P, Langer M. Elective cesarean section vs spontaneous delivery: a comparative study of birth experience. Acta Obstet Gynecol Scand 2003;82:834-40.
10. Heit M, Mudd K, Culligan P. Prevention of childbirth injuries to the pelvic floor. Curr Womens Health Rep 2001;1:72-80.
11. Matthews TG, Crowley O, Chong A, McKenna P, McGarvey C, O'Regan M. Rising caesarean section rates: A cause for concern? BJOG 2003;110:346-9.
12. Harper MA, Byington RP, Espeland MA, Naughton M, Meyer R, Lane K. Pregnancy-related death and health care services. Obstet Gynecol 2003;102:273-8.
13. Bergholt T, Stenderup JK, Vedsted-Jakobsen A, Helm P, Lenstrup C. Intraoperative surgical complications during cesarean section: an observational study of the incidence and risk factors. Acta Obstet Gynecol Scand 2003;82:251-6.
14. Madar J, Richmond S, Hey E. Surfactant-deficient respiratory distress after elective delivery at "term". Acta Pædiatr 1999;88: 1244-8.
15. Zanardo V, Simbi AK, Franzoi M, Soldà G, Salvadori A, Trevisanuto D. Neonatal respiratory morbidity risk and mode of delivery at term: influence of timing of elective caesarean delivery. Acta Paediatr 2004;93:643-7.
16. Nicoll AE, Black C, Powls A, Macenzie F. An audit of neonatal respiratory morbidity following elective caesarean section at term. Scott Med J 2004;49:22-5.
17. Medical Birth Registry of Norway: Annual Report 2001-2002. Bergen, Norway: University of Bergen; 2004.
18. Kolås T, Hofoss D, Daltveit AK, Nilsen ST, Häger R, Henriksen T, et al. Indications for cesarean deliveries in Norway. Am J Obstet Gynecol 2003;188:864-70.
19. Department of Health: National Health Service Maternity Statistics, England 2003-04. Available at: www.dh.gov.uk/PublicationsAndStatistics/PublicationsStatistics/PublicationsStatisticsArticleCONTENT_ID=4107060&chk=IY7Bqu. Accessed March 31, 2005.
20. Zelop C, Heffner LC. The downside of cesarean delivery: short- and long-term complications. Clin Obstet Gynecol 2004;47:386-93.
21. Hjalmarsson O. Epidemiology and classification of acute, neonatal respiratory disorders: a prospective study. Acta Paediatr Scand 1981;70:773-83.
22. Sarnat HB, Sarnat MS. Neonatal encephalopathy following fetal distress: a clinical and electroencephalographic study. Arch Neurol 1976;33:696-705.
23. Vollset SE, Hirji KF. A microcomputer program for exact and asymptotic analysis of several $2 \times 2$ tables. Epidemiology 1991;2:217-9.
24. Reece EA, Lequizamon G, Silva J, Whiteman V, Smith D. Intensive interventional maternity care reduces infant morbidity and hospital costs. J Matern Fetal Neonatal Med 2002;11:204-10.
25. Devendra K, Arulkumaran S. Should doctors perform an elective caesarean section on request? Ann Acad Med Singapore 2004;32: 577-81.
26. Rortveit G, Daltveit AK, Hannestad YS, Hunskaar S. Urinary incontinence after vaginal delivery or cesarean section. N Engl J Med 2003;10:900-7.