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Original Article

Differences in rate and medical indication of caesarean section between Germany and Japan

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Abstract ***Background*: There are growing concerns about the increasing rate of caesarean section (CS) worldwide. Various strategies have been implemented to reduce the proportion of CS to a reasonable level. Most research on medical indications for CS focuses on nationwide evaluations. Comparative research between different countries is sparse. The aim of this study was to evaluate differences in the rate and indications for CS between Japan and Germany in 2012 and 2013.

***Methods*:** Comparison of the overall rate and medical indications for CS in two cohort studies from Germany and Japan. We used data from the German Perinatal Survey and the Japan Environment and Children's Study (JECS).

***Results*:** We analyzed data of 1 335 150 participants from the German perinatal survey and of 62 533 participants from JECS and found significant differences between the two countries in CS rate (30.6% vs 20.6%) and main medical indications: cephalopelvic disproportion (3.2% vs 1.3%; OR: 2.4 [95% CI: 2.2–2.6]), fetal distress (7.3% vs 2.3%; OR: 3.4 [95%-CI: 3.2–3.6]), and past uterine surgery/repeat CS (8.4% vs 8.8%; OR: 0.9 [95%-CI: 0.9–1]).

***Conclusion*:** There are differences in the rate and medical indications for CS between Germany and Japan at the population level. Fetal distress was identified as a medical indication for CS more often Germany than in Japan. Considering the substantial diagnostic uncertainty of electronic fetal monitoring (EFM) as the major indicator for fetal distress, it would seem to be reasonable to rethink CS decision algorithms.

Key words birth mode, caesarean section, epidemiology, indication, neonates.

Over the past three decades, increasing rates of caesarean section (CS) have continued to be an issue of great concern among health care professionals and public health experts. A CS rate <10% is suggestive of poor access to medically indicated CS in low-resource settings,[1-3] but rates >20% have failed to show improved perinatal and neonatal outcomes.[1,2,4] There are large differences in CS rates between countries belonging to the Organization for Economic Co-operation and Development (OECD), ranging from 10–40%.[5-7] The rise of CS rates is particularly alarming in emerging economies such as Brazil, Egypt, and China.[4]

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Since 1984, as the World Health Organization (WHO) recommended a CS rate of 10–15% as adequate for the contemporary population level,[8] there has been ongoing debate around the appropriate rate,[9,10] while the use of CS has increased to unprecedented levels.[3,4,10] In a recent statement, WHO corroborates that CS, as a major abdominal surgery, is effective in terms of reducing maternal and perinatal morbidity and mortality, but only when medically indicated.[7] Considering the adverse effects of CS for the mother and newborn in a subsequent pregnancy, such as higher potential for repeat CS, abnormal placentation, stillbirth, preterm birth, and high blood loss,[11] the benefit–risk balance remains poor for CS without medical indications.[12,13] However, the reasons of the global increase in CS are multifactorial and include medical as well as non-medical aspects such as personal, cultural, institutional, legal, and financial factors. A change in the risk profiles of women giving birth, especially an increase in the age of primiparae, only partly explains this rise.[6,14–16] Factors related to medical staff, such as the lack of medical personnel who can confidently and competently attend a vaginal delivery, or the convenience of scheduling a CS compared with unplanned vaginal deliveries of varying duration, may make CS more

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favorable to obstetricians. Furthermore, financial incentives for both doctors and hospitals lead to an institutional preference for CS over vaginal delivery.[17] Besides this, there is an increasing number of women requesting CS because of anxiety about labor pain, pelvic floor damage, urinary incontinence, and reduced quality of sexual satisfaction.[18–21]

Most research on indications for CS focuses on nationwide evaluations.[22–25] Comparative research on indications for CS between different countries is sparse. Therefore, the aim of this study was to identify the differences in the overall rate and medical indications for CS between Germany and Japan at the population level for 2012 and 2013. While Japan and Germany have comparable levels of economic development and comparable health systems, there is a surprising difference in CS rates. This provides a unique opportunity to study the impact of conditions associated with CS.

Methods

This was a retrospective study using data sets of two cohorts from Germany and Japan. As part of the nationwide mandatory instrument of quality assurance, since 2001 every childbirth is included in the German perinatal survey for benchmark comparison. Before that time, perinatal outcomes were first analyzed on a voluntary and regional federal states basis in the Munich perinatal survey in 1975.[26] For our study period (2012–2013) the Institute for Applied Quality Promotion and Research in Healthcare an independent institute commissioned by the German government, organized this evaluation. All hospitals involved in the care of patients with statutory health insurance in Germany are obliged to participate in external quality assurance within the framework of the perinatal survey. Data from 764 hospitals in 2012 and 744 hospitals in 2013 were included in the survey. All levels of care and all geographical areas are included. The data are transferred to a central institute by the hospitals via a standardized data collection form that contains several biological and socio-economic items, usually extracted from final medical reports of the mother and child by documentation specialists.[27] The transmitted data are statistically checked for completeness, plausibility, and integrity and for correctness on the basis of random samples, according to a directive on quality assurance measures in hospitals.[28] In 2015, the Ministry of Health launched the Institute for Quality Assurance and Transparency in Healthcare, which currently performs all German cross-sectoral quality assurances in healthcare.[29]

The Japan Environment and Children's Study (JECS) is a nationwide, epidemiological cohort study involving 100 000 mother–child pairs living throughout Japan from births between 2011 and 2014. JECS aims to identify environmental factors influencing children's health and development. Standard operating procedures for medical record transcription and self-administered questionnaires were designed by the Program Office of JECS (National Institute for Environmental Studies) in cooperation with the Medical Support Center (the National Center for Child Health and Development). According to the procedures of the study, physicians, midwives, nurses, or research coordinators transcribed relevant information from medical records.[30,31] A total of 417 obstetric facilities in 15 geographical study regions across Japan cooperated with JECS. The Program Office verified the plausibility and integrity of the data transmitted from the regional centers and validated the data set. We used the "jecs-ag-20160424" and the "allbirth_revice001_ver001" data sets, which were released in June 2016 and October 2016 respectively, containing the baseline characteristics of the cohort.

Every childbirth between January 2012 and December 2013 was used from both data sets. We extracted the number of all live births per year and the cases of CS, as well as the indications for the CS. Choosing multiple answers concerning the indication for CS was possible within both data sets. We assumed that the indication that contributed most to the decision was coded, being aware of the remaining uncertainty. Since mode of delivery for stillbirths and miscarriages was not reported in the German perinatal survey, they could not be considered within the secondary analysis.

For comparison of specific indication rates, we matched indications into comparable groupings. There were 34 possible indications in the German Perinatal Survey and 13 possible indications in JECS. A list of all items and how we matched them can be found in Table 3. After matching we identified 12 main indications for CS: cephalopelvic disproportion, fetal distress, past uterine surgery/ repeat CS, abnormal position, prolonged labor, premature rupture of membranes, pregnancy-induced hypertension, multiple gestation pregnancy, intrauterine infection, placenta praevia, post-term pregnancy, and other indications. To illustrate the difference between proportions of CS based on the respective indication among all women receiving CS and among all deliveries (natural delivery + CS), respectively, we calculated the odds ratios (OR) with 95% confidence intervals (95% CI) with country as independent variable (Germany vs Japan).

In both countries, fetal distress is defined in accordance with the International Federation of Gynecology and Obstetrics (FIGO) guidelines as evidence of fetal hypoxia by means of non-reassuring fetal heart rates or fetal blood sampling in.[32] The statistical package SPSS, version 25.0, (IBM, New York) was used estimating ORs with 95% CIs. Descriptive statistics were used for comparison of proportions between the two data sets. The chi-square test was used for testing relationships between CS indications in Germany and Japan; significant difference was considered at $P < 0.05$.

Results

In the JECS, 63 806 infants were born by 63 181 mothers in 2012 and 2013, while within the German Perinatal survey for the same period, 1 335 150 infants were born to 1 310 431 women. The percentage of mothers aged 35–39 years were similar between the two cohorts, while there was a higher percentage of very young (<18 years) or very old (>40 years) mothers in Germany, as compared to Japan (Table 1). The

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German cohort also had a higher percentage of primiparae and multiple gestation pregnancies. There were also differences in the distribution of gestational age and birthweight, while the sex ratio did not differ significantly. Rates of CS were 20.2% in the Japanese cohort and 32.9% in the German cohort.

For assessing the differences in medical indications for CS between Germany and Japan, we established two approaches. First, we compared the respective indications for CS for all deliveries in general, following the assumption that reasons for CS do not differ between countries. Second, we compared the rates of individual indications for CS to all deliveries performed by CS. For the first approach, the three main indications for CS in both countries were past uterine surgery/repeat CS (8.4% vs 8.8%; OR: 0.9 [95% CI: 0.9–1]), fetal distress (7.3% vs 2.3%; OR: 3.4 [95%-CI: 3.2–3.6]), and abnormal position (6% vs 2.6%; OR: 2.4 [95% CI: 2.3–2.5]). Compared

Table 1 General characteristics of mothers and infants

Year		Germany			Japan		
		2012 N (%)	2013 N (%)	2012 + 2013 N (%)	2012 N (%)	2013 N (%)	2012 + 2013 N (%)
Mothers		651 696 (100)	658 735 (100)	1 310 431 (100)	27 960 (100)	35 221 (100)	63 181 (100)
Age of mother	<18	3,870 (0.6)	3,843 (0.6)	7,713 (0.6)	38 (0.1)	52 (0.1)	90 (0.1)
	18–29	281 432 (43.2)	276 636 (42)	558 068 (42.6)	8,454 (30.2)	10 294 (29.2)	18 748 (29.7)
	30–34	222 964 (34.2)	229 805 (34.9)	452 769 (34.6)	7,991 (28.6)	9,587 (27.2)	17 578 (27.8)
	35–39	115 230 (17.7)	120 586 (18.3)	235 816 (18)	5,158 (18.4)	6,256 (17.8)	11 414 (18.1)
	≥40	28 200 (4.3)	27 865 (4.2)	56 065 (4.3)	994 (3.6)	1,353 (3.8)	2,347 (3.7)
	Missing				5,325 (19)	7,679 (21.8)	13 004 (20.6)
Parity	Primipara	324 070 (49.7)	327 701 (49.7)	651 771 (49.7)	10 784 (38.6)	13 794 (39.2)	24 578 (38.9)
	Multipara	327 626 (50.3)	331 034 (50.3)	658 660 (50.3)	16 308 (58.3)	20 650 (58.6)	36 958 (58.5)
	Missing				871 (3.1)	786 (2.2)	1,657 (2.6)
Singleton pregnancy		639 802 (98.2)	646 344 (98.1)	1 286 146 (98.1)	27 692 (99)	34 841 (98.9)	62 533 (99)
Multiple gestation pregnancy	11 894 (1.8)	12 391 (1.9)	24 285 (1.9)		266 (1)	365 (1)	631 (1)
Missing					2 (0.01)	15 (0.04)	17 (0.03)
Infants		663 796 (100)	671 354 (100)	1 335 150 (100)	28 219 (100)	35 587 (100)	63 806 (100)
Birth mode	Spontaneous	400 756 (60.4)	405 716 (60.4)	806 472 (60.4)	16 110 (57.1)	19 903 (55.9)	36 013 (56.4)
	Caesarean Section	218 940 (33)	219 863 (32.7)	438 803 (32.9)	5,685 (20.1)	7,221 (20.3)	12 906 (20.2)
	Operative vaginal	43 261 (6.5)	44 872 (6.7)	88 133 (6.6)	1,399 (5)	2,061 (5.8)	3,460 (5.4)
	Other	839 (0.1)	903 (0.1)	1,742 (0.1)	4,931 (17.5)	6,314 (17.7)	11 245 (17.6)
	Missing			(0)	94 (0.3)	88 (0.2)	182 (0.3)
Labor induction		143 522 (21.6)	144 807 (21.6)	288 329 (21.6)	4,931 (17.5)	6,314 (17.7)	11 245 (17.6)
Sex	Male	340 406 (51.3)	342 865 (51.1)	683 271 (51.2)	14 471 (51.3)	18 242 (51.3)	32 713 (51.3)
	Female	323 390 (48.7)	328 489 (48.9)	651 879 (48.8)	13 731 (48.7)	17 323 (48.7)	31 054 (48.7)
	Missing				17 (0.1)	22 (0.1)	39 (0.1)
Singletons		639 802 (96.4)	646 344 (96.3)	1 286 146 (96.3)	27 692 (98.1)	34 841 (97.9)	62 533 (98)
Multiples		23 994 (3.6)	25 010 (3.7)	49 004 (3.7)	525 (1.9)	731 (2.1)	1,256 (2)
Missing					2 (0)	15 (0)	17 (0)
Gestational age Completed weeks	< 28	3,938 (0.6)	4,102 (0.6)	8,040 (0.6)	66 (0.2)	96 (0.3)	162 (0.3)
	28–31	6,160 (0.9)	6,163 (0.9)	12 323 (0.9)	145 (0.5)	182 (0.5)	327 (0.5)
	32–36	49 282 (7.4)	49 573 (7.4)	98 855 (7.4)	1,435 (5.1)	1,711 (4.8)	3,146 (4.9)
	37–41	600 728 (90.5)	607 701 (90.5)	1 208 429 (90.5)	26 493 (93.9)	33 512 (94.2)	60 005 (94)
	>41	3,688 (0.6)	3,815 (0.6)	7,503 (0.6)	71 (0.3)	73 (0.2)	144 (0.2)
	Missing				75 (0.3)	109 (0.3)	22 (0)
Birthweight	<1,000	4,439 (0.7)	4,539 (0.7)	8,978 (0.7)	90 (0.3)	116 (0.3)	206 (0.3)
	1,000–1,499	5,135 (0.8)	5,209 (0.8)	10 344 (0.8)	123 (0.4)	156 (0.4)	279 (0.4)
	1,500–1,999	9,620 (1.4)	9,960 (1.5)	19 580 (1.5)	338 (1.2)	431 (1.2)	769 (1.2)
	2,000–2,499	28 512 (4.3)	29 136 (4.3)	57 648 (4.3)	2,126 (7.5)	2,638 (7.4)	4,764 (7.5)
	2,500–2,999	105 840 (15.9)	107 535 (16)	213 375 (16)	10 919 (38.7)	13 608 (38.2)	24 527 (38.4)
	3,000–3,999	444 962 (67)	449 321 (66.9)	894 283 (67)	14 333 (50.8)	18 307 (51.4)	32 640 (51.2)
	4,000–4,499	57 371 (8.6)	57 865 (8.6)	115 236 (8.6)	240 (0.9)	267 (0.8)	507 (0.8)
	≥4,500	7,917 (1.2)	7,789 (1.2)	15 706 (1.2)	12 (0)	15 (0)	27 (0)
	Missing				38 (0.1)	49 (0.1)	87 (0.1)

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to Japan, the proportion of CS indicated by fetal distress or abnormal position was significantly higher in Germany. The distribution of indications over the 2 years by country was constant, only abnormal position was more frequently stated in 2012 among Japanese women, as compared to 2013 (3.4% vs 1.9%). Apart from past uterine surgery/repeat CS and intrauterine infection, all other indications for CS were more frequent in Germany than in Japan. Of note, not all effects were constant depending on the analytical approach. Compared to all deliveries (vaginal and CS), CS due to pregnancy-induced hypertension and placenta previa was performed significantly more often in Germany than in Japan. This effect was, however, no longer significant when compared to all deliveries by CS. In Germany, CS due to premature rupture of the membranes was performed significantly more frequently when compared to all deliveries in general (vaginal and CS), but became insignificant when compared to the other indications for CS (Table 2).

Since the German list of possible indications was more detailed than the Japanese one, we had to consider a large number of indications from the German population that could not be matched, such as others (5.6%), maternal disease (1.5%), placental insufficiency (1%), diabetes (0.5%), umbilical cord complications (0.6%), lack of cooperation (0.5%), uterine rupture (0.3%), uterine hemorrhages (0.3%), miscarriage (0.2%), umbilical cord prolapse (0.1%), intrauterine fetal death (0.04%), and rh-incompatibility (0.02%) (Table 3).

Discussion

In this study, we identified the differences in rates and medical indications of CS between Germany and Japan on a population level. The overall rate of CS in all childbirths differed significantly between both countries, with a substantially higher rate of CS in Germany than in Japan. Most of the indications were equally distributed between both countries; however, we found a major difference in CS performed because of fetal distress. In Germany, 7.3% of childbirths occurred through CS because of fetal distress, whereas in Japan this proportion was only 2.3%.

Since the data sets used for this study were not initially created for comparative analyses, relevant methodological limitations must be considered, and conclusions should be made with caution. Choosing multiple answers concerning the indication for CS was possible within both data sets; therefore, we cannot determine a single main reason for deciding to use CS. Furthermore, we had to combine indications that were used either in the one or the other data set exclusively within the item “other”. This method resulted in an unneglectable group of CS but which is not categorized in detail. The data from the German perinatal survey are based on aggregated data so we were not able to calculate point estimates and could only compare proportions.

There are several established risk factors for CS such as high-resource settings, high level of education of mother, higher age of mother, previous CS, and multiple gestation pregnancy.[33] Considering the reported information in the two analyzed data sets, it is difficult to blame these factors for the difference in total CS rate. Mothers in Germany were younger and had lower rates of past uterine surgery or repeat CS, as compared to Japanese mothers. Only cephalopelvic disproportion, abnormal position, and multiple gestation pregnancy were more frequent among the German, as compared to the Japanese population. Considering that not only the total CS rate but also the proportion of CS performed because of fetal distress is higher in Germany, it seems more likely that this is an expression of major differences in clinical judgement, even though both countries use the same FIGO definition. One important indicator for fetal distress is non-reassuring patterns seen in electronic fetal heart monitoring (EFM). EFM was designed to provide an early warning that permits caregivers to recognize the onset of fetal hypoxia to prevent neurological impairment; however, its diagnostic accuracy for detecting asphyxia is weak.[34]

Table 2 Medical indications for caesarean section by country with odds ratio (OR) and 95% confidence intervals (95% CI) for Germany versus Japan (reference)

	Germany	Japan	All deliveries		All CS	
	N (of all deliveries, of all CS)	N (of all deliveries, of all CS)	OR‡ (95 CI)	p-value	OR§ (95 CI)	*P*-value
Cephalopelvic Disproportion	42 287 (3.2–10.4)	838 (1.3– 6.5)	2.4 (2.2–2.6)	<0.001	1.5 (1.4–1.6)	<0.001
Fetal Distress	96 811 (7.3, 23.7)	1,413 (2.3– 10.9)	3.4 (3.2–3.6)	<0.001	2.3 (2.2–2.4)	<0.001
Past uterine surgery/ Repeat CS	112 180 (8.4– 27.5)	5,525 (8.8– 42.8)	0.9 (0.9–1)	<0.001	0.5 (0.4–0.5)	<0.001
Abnormal Position	79 944 (6– 19.6)	1,602 (2.6– 12.4)	2.4 (2.3–2.5)	<0.001	1.6 (1.5–1.7)	<0.001
Prolonged Labor	75 226 (5.6, 18.4)	1,051 (1.7– 8.1)	3.5 (3.3–3.7)	<0.001	2.3 (2.2–2.5)	<0.001
Premature rupture of membranes	27 280 (2, 6.7)	968 (1.5– 7.5)	1.3 (1.2–1.4)	<0.001	0.8 (0.8–0.9)	< 0.001
Pregnancy-induced hypertension	18 837 (1.4–4.6)	573 (0.9– 4.4)	1.5 (1.4–1.7)	<0.001	1 (0.9–1.1)	n. s.
Multiple conception	29 207 (2.2–7.2)	255 (0.4– 2)	5.5 (4.8–6.2)	<0.001	3.5 (3.1–4)	<0.001
Intrauterine infection	11 069 (0.8–2.7)	863 (1.4– 6.7)	0.6 (0.6–0.6)	<0.001	0.4 (0.3–0.4)	<0.001
Placenta praevia	4,632 (0.3– 1.1)	132 (0.2–1)	1.6 (1.4–2)	<0.001	1 (0.9–1.2)	n. s.
Postdate	13 483 (1– 3.3)	352 (0.6– 2.7)	1.8 (1.6–2)	<0.001	1.1 (1–1.3)	<0.05
Others	139 731 (10.5–34.2)	2,076 (3.3– 16.1)	3.4 (3.3–3.6)	<0.001	2.4 (2.3–2.6)	<0.001

†Cases with missing data concerning birth mode excluded. ‡Germany versus Japan. §German. CS, cesarean section.

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Table 3 Matching of variables for medical indication for caesarean section

Data set		Germany			Japan	
Years		2012 N (%)	2013 N (%)		2012 N (%)	2013 N (%)
Cephalopelvic disproportion		22 039 (3.3)	20 248 (3)		456 (1.6)	382 (1.1)
Fetal distress		48 450 (7.3)	48 361 (7.2)		793 (2.9)	620 (1.8)
	Abnormal findings in fetal heart rate monitoring	45 286 (6.8)	45 331 (6.8)			
	Pathological Doppler findings	2,219 (0.3)	2,070 (0.3)			
	Fetal acidosis (in fetal blood sampling)	945 (0.1)	960 (0.1)			
Previous CS/ Past uterine surgery		55 491 (8.4)	56 689 (8.4)		2,437 (8.8)	3,088 (8.9)
				Previous CS	2,299 (8.3)	2,920 (8.4)
				Past uterine surgery	120 (0.4)	142 (0.4)
Abnormal position		40 164 (6.1)	39 780 (5.9)		928 (3.4)	674 (1.9)
	Transverse/oblique lie	2,925 (0.4)	2,876 (0.4)			
	Breech presentation	27 618 (4.2)	27 549 (4.1)			
	Face/brow presentation	576 (0.1)	540 (0.1)			
	Deep transverse arrest	29 (0)	36 (0)			
	High longitudinal position	5,798 (0.9)	5,620 (0.8)			
	Other irregular presentation	3,218 (0.5)	3,159 (0.5)			
Prolonged Labor		37 650 (5.7)	37 576 (5.6)		587 (2.1)	464 (1.3)
	Prolonged labor (first stage)	24 264 (3.7)	24 141 (3.6)			
	Prolonged labor (second stage)	13 386 (2)	13 435 (2)			
Premature rupture of membranes		13 820 (2.1)	13 460 (2)		573 (2.1)	395 (1.1)
	Preterm birth	10 806 (1.6)	10 489 (1.6)			
	Premature placental separation	3,014 (0.5)	2,971 (0.4)			
Pregnancy-induced hypertension		9,439 (1.4)	9,398 (1.4)		323 (1.2)	250 (0.7)
	Gestosis/eclampsia	7,040 (1.1)	6,882 (1)			
	HELLP-syndrome	2,399 (0.4)	2,516 (0.4)			
Multiple conception		14 430 (2.2)	14 777 (2.2)		146 (0.5)	109 (0.3)
Intrauterine infection		5,442 (0.8)	5,627 (0.8)		533 (1.9)	330 (0.9)
	Amnion infection syndrome	4,312 (0.6)	4,417 (0.7)			
	Fever during labor	1,130 (0.2)	1,210 (0.2)			
Placenta praevia		2,268 (0.3)	2,364 (0.4)		87 (0.3)	45 (0.1)
Postdate		6,820 (1)	6,663 (1)		198 (0.7)	154 (0.4)
Others		69 693 (10.5)	70 038 (10.4)		1,195 (4.3)	881 (2.5)
	Others	36 755 (5.5)	37 761 (5.6)			
	Maternal disease	10 144 (1.5)	10 022 (1.5)			
	Placental insufficiency	6,613 (1)	6,442 (1)			
	diabetes	3,798 (0.6)	3,516 (0.5)			
	Umbilical cord complications	3,793 (0.6)	3,703 (0.6)			
	Lack of cooperation (mother)	3,109 (0.5)	3,105 (0.5)			
	Uterine rupture	1,986 (0.3)	1,980 (0.3)			
	Uterine hemorrhages	1,608 (0.2)	1,731 (0.3)			
	Malformation	1,096 (0.2)	1,022 (0.2)			
	Umbilical cord prolapse	420 (0.1)	389 (0.1)			
	Intrauterine fetal death	265 (0)	271 (0)			
	rh-incompatibility	106 (0)	96 (0)			

CS, cesarean section; HELLP, hemolysis, elevated liver enzyme levels, and low platelet levels.

The most recent systematic review on cerebral palsy (CP) prevalence in population-based studies reported a prevalence of 2.11 per 1,000 live births (95% CI: 1.98–2.25), pooling data from 19 studies.[43] The pooled estimate in the review was not significantly different from the first included study by Hagberg in 1996, suggesting a stable incidence of CP in developed countries over the last decades.[41] A minor decline in overall prevalence of CP (1.90 to 1.77 per 1,000 live births) was reported for Europe in 2015 by Sellier *et al.*[44] This decline is mainly influenced by substantial improvements in neonatal care of very-preterm infants. In an Australian case control study, only 4% of CP cases were attributable to intrapartum risk factors, whereas the major risks for neonatal encephalopathy were related to antepartum or intrapartum factors for fetal hypoxemia.[45] Considering this level of uncertainty with EFM, it seems reasonable to rethink the position

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of this diagnostic method for decisions on birth mode. Assessing fetal heart rate by cardiotocography is a well-established form of EFM in labor, sometimes aided by fetal blood sampling, while fetal electrocardiography (fetal ECG) with ST wave analysis is considered to be more experimental. However, there is no consensus on whether these modalities, alone or in concert, clearly indicate the need for urgent delivery of the baby.[46–48]

Furthermore, the term "fetal distress" is sometimes not clearly defined and covers a wide range of clinical conditions. The American College of Obstetrics and Gynecology pointed out in 2005 that the term is imprecise and unspecific and proposed to replace it with “non-reassuring fetal status”, followed by a further description of findings (e.g. repetitive variable decelerations, fetal tachycardia or bradycardia, late decelerations, or a low biophysical profile).[49] This could lead to a more precise description of the clinical symptoms that may require a change in the choice of birth mode, or explain an urgent delivery. We assume that a more precise description and subsequent de-escalation of the language may also lead to a reduction in the CS rate.

Several non-clinical strategies have been implemented to reduce the evitable use of CS, but only a few of these interventions have been shown to be effective with moderate- or high-certainty evidence.[50] The lack of experience and supervision of medical personnel, caused by reduced working time for trainees and other factors, is a contributing factor, leading to reduced confidence in making decisions for CS.[51] Many decisions to abandon labor are driven by uncertainty regarding fetal risk, leading physicians to resort to CS, even in the absence of an appropriate benefit for mother or infant.[39] Besides improvement of health professionals training and eliminating financial incentives for CS that exist in several countries including Germany, it is essential to address the role played by fear of litigation among medical staff and ways to mitigate this.[52,53] Collective international efforts are needed to standardize the definitions for indications for CS to allow for better comparisons of data sets.

Conclusion

The rate of CS has increased over the last decades. The comparison between data from Germany and Japan shows a higher rate of CS in Germany. Most indications were equally distributed, but fetal distress as the reason to perform CS was three times more frequent in Germany than in Japan. As a diagnosis of fetal distress is often derived from fetal heart rate patterns considered non-reassuring, addressing the diagnostic uncertainty of fetal heart rate monitoring may help to reduce the rate of unnecessary CS.

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Disclosure

The authors declare no conflict of interest.

Author contributions

M.F. and C.B. designed the study, C.K. and M.F. performed acquisition and analysis of data and drafted the manuscript and figures; C.B., C.M., and L.H. supervised research process and gave conceptual advice; JECSG provided data of JECS; C.K., C.B., C.M., M.Y., K.S., L.H., and JECSG edited the manuscript and gave methodological advice. All authors read and approved the final manuscript.

References

1 Betran AP, Torloni MR, Zhang JJ, Gulmezoglu AM. WHO statement on caesarean section rates. *BJOG* 2016; **123**: 667–70.
2 Molina G, Weiser TG, Lipsitz SR *et al*. Relationship between cesarean delivery rate and maternal and neonatal mortality. *JAMA* 2015; **314**: 2263–70.
3 Ye J, Betran AP, Guerrero Vela M, Souza JP, Zhang J. Searching for the optimal rate of medically necessary cesarean delivery. *Birth* 2014; **41**: 237–44.
4 Betran AP, Ye J, Moller AB, Zhang J, Gulmezoglu AM, Torloni MR. The increasing trend in caesarean section rates: global, regional and national estimates: 1990–2014. *PLoS One* 2016; **11**: e0148343.
5 Gibbons L, Belizan JM, Lauer JA, Betran AP, Merialdi M, Althabe F. Inequities in the use of cesarean section deliveries in the world. *Am. J. Obstet. Gynecol.* 2012; **206** (331): e1–e19.
6 Vogel JP, Betran AP, Vindevoghel N *et al*. Use of the Robson classification to assess caesarean section trends in 21 countries: a secondary analysis of two WHO multicountry surveys. *Lancet Global Health* 2015; **3**: e260–e70.
7 World Health Organization (WHO). Statement on caesarean section rates. *Reprod. Health Matters* 2015; **23**: 149–50.
8 World Health Organization (WHO). Appropriate technology for birth. *Lancet* 1985; **2**: 436–7.
9 Cavallaro FL, Cresswell JA, Ronsmans C. Obstetricians’ opinions of the optimal caesarean rate: a global survey. *PLoS One* 2016; **11**: e0152779.
10 Betran AP, Torloni MR, Zhang J *et al*. What is the optimal rate of caesarean section at population level? A systematic review of ecologic studies. *Reprod. Health* 2015; **12**: 57.
11 Sandall J, Tribe RM, Avery L *et al*. Short-term and long-term effects of caesarean section on the health of women and children. *Lancet* 2018; **392**: 1349–57.
12 Abdelazim I, Alanwar A, Svetlana S *et al*. Complications associated with higher order compared to lower order cesarean sections. *J. Matern. Fetal. Neonatal. Med.* 2018; 1–161.
13 Silver RM, Landon MB, Rouse DJ *et al*. Maternal morbidity associated with multiple repeat cesarean deliveries. *Obstet. Gynecol.* 2006; **107**: 1226–32.
14 Barros AJ, Santos IS, Matijasevich A *et al*. Patterns of deliveries in a Brazilian birth cohort: almost universal cesarean sections for the better-off. *Rev. Saude Publica.* 2011; **45**: 635–43.

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15 Hoxha I, Syrogiannouli L, Luta X *et al*. Caesarean sections and for-profit status of hospitals: systematic review and meta-analysis. *BMJ Open* 2017; **7**: e013670.
16 Liang J, Mu Y, Li X *et al*. Relaxation of the one child policy and trends in caesarean section rates and birth outcomes in China between 2012 and 2016: observational study of nearly seven million health facility births. *BMJ* (Clinical research ed) 2018; **360**: k817.
17 Visser GHA, Ayres-de-Campos D, Barnea ER *et al*. FIGO position paper: how to stop the caesarean section epidemic. *Lancet* 2018; **392**: 1286–87.
18 Bracken JN, Dryfhout VL, Goldenhar LM, Pauls RN. Preferences and concerns for delivery: an antepartum survey. *Int. Urogynecol. J. Pelvic Floor Dysfunct* 2008; **19**: 1527–31.
19 Ghotbi F, Akbari Sene A, Azargashb E *et al*. Women's knowledge and attitude towards mode of delivery and frequency of cesarean section on mother's request in six public and private hospitals in Tehran, Iran, 2012. *J Obstet Gynaecol Res.* 2014; **40**: 1257–66.
20 Hopkins K. Are Brazilian women really choosing to deliver by cesarean? *Soc. Sci. Med.* 2000; **51**: 725–40.
21 Loke AY, Davies L, Li SF. Factors influencing the decision that women make on their mode of delivery: the Health Belief Model. *BMC Health Serv. Res.* 2015; **15**: 274.
22 Barber EL, Lundsberg LS, Belanger K, Pettker CM, Funai EF, Illuzzi JL. Indications contributing to the increasing cesarean delivery rate. *Obstet Gynecol.* 2011; **118**: 29–38.
23 Costa A, Policiano C, Clode N, Graca LM. Indications for cesarean deliveries during a 7-year period in a tertiary hospital. *Acta Med. Port.* 2013; **26**: 649–54.
24 Kawakita T, Reddy UM, Landy HJ, Iqbal SN, Huang CC, Grantz KL. Indications for primary cesarean delivery relative to body mass index. *Am. J. Obstet. Gynecol.* 2016; **215** (515): e1–e9.
25 Lurie S, Shalev A, Sadan O, Golan A. The changing indications and rates of cesarean section in one academic center over a 16-year period (1997–2012). *Taiwan J. Obstet. Gynecol.* 2016; **55**: 499–502.
26 Conrad F. Die Münchner Perinatalstudie. *Dtsch Arztebl Int.* 1977; **74**: 3015–20.
27 AQUA Institut. Bundesauswertung zum Erfassungsjahr 2013. Accessed: 04.07.2019, Online: https://www.sqg.de/downloads/Bundesauswertungen/2013/bu_Gesamt_16N1-GEBH_2013.pdf, 2014; 1-123.
28 Federal Joint Committee - Gemeinsamer Bundesausschuss (G-BA). Directive on Quality assurance measures in hospitals - Richtlinie über Maßnahmen der Qualitätssicherung in Krankenhäusern (QSKHRL). 2006.
29 IQTIG – Institut für Qualitätssicherung und Transparenz im Gesundheitswesen. Bundesauswertung zum Erfassungsjahr 2015 Geburtshilfe. 2016.
30 Michikawa T, Nitta H, Nakayama SF *et al*. Baseline Profile of Participants in the Japan Environment and Children's Study (JECS). *J. Epidemiol.* 2018; **28**: 99–104.
31 Kawamoto T, Nitta H, Murata K *et al*. Rationale and study design of the Japan environment and children's study (JECS). *BMC Public Health* 2014; **14**: 25.
32 Ayres-de-Campos D, Spong CY, Chandraharan E. FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. *Int. J. Gynaecol. Obstet.* 2015; **131**: 13–24.
33 Boerma T, Ronsmans C, Melesse DY *et al*. Global epidemiology of use of and disparities in caesarean sections. *Lancet* 2018; **392**: 1341–48.
34 Nelson KB. Can we prevent cerebral palsy? *N. Engl. J. Med.* 2003; **349**: 1765–9.
35 Cahill AG, Tuuli MG, Stout MJ, Lopez JD, Macones GA. A prospective cohort study of fetal heart rate monitoring: deceleration area is predictive of fetal acidemia. *Am. J. Obstet. Gynecol.* 2018; **218** (523): e1–23.e12.
36 Nielsen PV, Stigsby B, Nickelsen C, Nim J. Intra- and inter-observer variability in the assessment of intrapartum cardiotocograms. *Acta Obstet. Gynecol. Scand.* 1987; **66**: 421–4.
37 Zain HA, Wright JW, Parrish GE, Diehl SJ. Interpreting the fetal heart rate tracing. Effect of knowledge of neonatal outcome. *J. Reprod. Med.* 1998; **43**: 367–70.
38 Sabiani L, Le Du R, Loundou A *et al*. Intra- and interobserver agreement among obstetric experts in court regarding the review of abnormal fetal heart rate tracings and obstetrical management. *Am. J. Obstet. Gynecol.* 2015; **213**: 856.e1–8.
39 Stout MJ, Cahill AG. Electronic fetal monitoring: past, present, and future. *Clin. Perinatol.* 2011; **38**: 127–142**,** vii.
40 American College of Obstetricians and Gynecologists. ACOG Practice Bulletin No. 106: Intrapartum fetal heart rate monitoring: nomenclature, interpretation, and general management principles. *Obstet. Gynecol.* 2009; **114**: 192–202.
41 American College of Obstetricians and Gynecologists' Task Force on Neonatal Encephalopathy. Neonatal encephalopathy and neurologic outcome. *Obstet Gynecol.* 2014; **123**: 896–901.
42 Hirsch E. Electronic fetal monitoring to prevent fetal brain injury: a ubiquitous yet Flawed Tool. *JAMA* 2019; **322** (7): 611.
43 Oskoui M, Coutinho F, Dykeman J, Jette N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Dev. Med. Child Neurol.* 2013; **55**: 509–19.
44 Sellier E, Platt MJ, Andersen GL *et al*. Decreasing prevalence in cerebral palsy: a multi-site European population-based study, 1980 to 2003. *Dev. Med. Child Neurol.* 2016; **58**: 85–92.
45 Badawi N, Kurinczuk JJ, Keogh JM *et al*. Intrapartum risk factors for newborn encephalopathy: the Western Australian case-control study. *BMJ* (Clinical research ed). 1998; **317**: 1554–8.
46 Hilal Z, Mrkvicka J, Rezniczek GA, Dogan A, Tempfer CB. Accuracy of intrapartum fetal blood gas analysis by scalp sampling: A retrospective cohort study. *Medicine* 2017; **96**: e8839.
47 Neilson JP. Fetal electrocardiogram (ECG) for fetal monitoring during labour. *Cochrane Database Syst. Rev*. 2015; Cd000116.
48 Grivell RM, Alfirevic Z, Gyte GM, Devane D. Antenatal cardiotocography for fetal assessment. *Cochrane Database Syst. Rev.* 2015; CD007863.
49 Committee on Obstetric Practice, American College of Obstetricians and Gynecologists. ACOG Committee Opinion. Number 326, December 2005. Inappropriate use of the terms fetal distress and birth asphyxia. *Obstet. Gynecol.* 2005; **2005** (106): 1469–70.
50 Chen I, Opiyo N, Tavender E *et al*. Non-clinical interventions for reducing unnecessary caesarean section. *Cochrane Database Syst. Rev*. 2018; **9**: Cd005528.
51 Loudon JAZ, Groom KM, Hinkson L, Harrington D, Paterson-Brown S. Changing trends in operative delivery performed at full dilatation over a 10-year period. *J. Obstet. Gynaecol.* 2010; **30**: 370–75.
52 Betran AP, Temmerman M, Kingdon C *et al*. Interventions to reduce unnecessary caesarean sections in healthy women and babies. *Lancet* 2018; **392**: 1358–68.
53 Nelson KB, Sartwelle TP, Rouse DJ. Electronic fetal monitoring, cerebral palsy, and caesarean section: assumptions versus evidence. *BMJ* (Clinical research ed) 2016; **355**: i6405.

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Appendix 1

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