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MATERNAL-FETAL MEDICINE

Long interpregnancy interval and mode of delivery

Uzma Ishaque[1] · Diane Korb[2,3] · Adèle Poincare[2,4] · Thomas Schmitz[2,3] · Cécile Morin[2] · Olivier Sibony[2]

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Abstract

Purpose WHO sets 24 months as the ideal minimum interpregnancy interval (IPI) to minimize maternal and perinatal adverse outcomes. Some studies suggest that an interval longer than 59 months may affect these outcomes, but little is known about its influence on labor. The primary objective of this study was to compare the cesarean delivery rate between primiparous women with a long IPI and, on the one hand, primiparous women with an ideal minimum IPI of 18–24 months and, on the other hand, with nulliparous women.

Methods This retrospective cohort study of 17 years included nulliparas and primiparas who gave birth to live singleton fetuses in cephalic presentation after 22 weeks of gestation. Women with an IPI < 18 months or from 24 to 59 months were excluded, as were women with planned cesarean. We analyzed three groups: primiparous women with a long IPI defined as > 59 months, primiparous women with an ideal minimum IPI (18–24 months), and nulliparous women.

Results The study included 18,503 women: 1342 women in the "long IPI" group, 1388 in the "ideal minimum IPI" group, and 15,773 in the nulliparous women group. The cesarean delivery rate was significantly higher in the long compared to the ideal minimum IPI group [12.2% vs. 6.3%, respectively; aOR = 2.2 (95% CI 1.6–3.1)], but both groups had similar durations of labor, regardless of mode of delivery. Women in the long IPI group had significantly lower cesarean rates than nulliparous women [12.2% and 14.3%, respectively; aOR = 0.5 (95% CI 0.4–0.7)], and the nulliparous women had a significantly longer mean duration of labor.

Conclusions Primiparas with a long IPI, compared with ideal minimal IPI have a higher risk of cesarean delivery during labor. Compared with nulliparous women, primiparous women with a long IPI had a lower cesarean rate.

Keywords Interpregnancy interval · Mode of delivery · Cesarean · Duration of labor · Stage of labor

Abbreviations

IPI	Interpregnancy interval
CS	Cesarean section
WHO	World Health Organization
BMI	Body mass index
OR	Odd ratio

Introduction

Interpregnancy interval (IPI) is defined by the duration between the date of the last delivery and the date of the next conception [1]. Several authors have studied perinatal and maternal outcomes associated with different IPIs and showed that long IPI (> 59 months) and short intervals (< 18 months) are associated with adverse perinatal outcomes such as preterm birth, fetal growth restriction (FGR) and low birth weight, and neonatal admission to an intensive care unit [2–8]. IPI longer than 59 months is also associated with a higher risk of preeclampsia [1, 9]. Based on these results, in 2005, the World Health Organization (WHO) defined an ideal minimum IPI of 24 months, which appears to be associated with the best perinatal and maternal outcomes [1].

Little is known about labor outcomes, such as its duration and mode of delivery, according to IPI [10, 11]. Nonetheless some studies have shown that labor dystocia increases

✉ Uzma Ishaque
uz.ishaque@gmail.com

[1] Department of Gynecology and Obstetrics, Reims University Hospital, 45 Rue Cognacq Jay, Reims, France

[2] Department of Gynecology and Obstetrics, Robert Debré University Hospital, AP-HP, Paris, France

[3] Université de Paris, Epidemiology and Statistics Research Center/CRESS, INSERM, INRA, 75004 Paris, France

[4] École de sages-femmes Baudelocque, Université Paris Descartes, Assistance publique-Hôpitaux de Paris, 75014 Paris, France

proportionally with IPI [12], which would logically increase the risk of women with long IPI for cesarean delivery, given that such dystocia is the main cause of cesareans during labor [13, 14].

The literature shows that the duration of labor is longer in nulliparous than in parous women [15, 16]. But differences in this duration between primiparous women according to their IPI have never been compared. In clinical practice, practitioners consider that IPI affects labor; indeed, many of them consider that women with a long IPI should be treated as nulliparous women for the management of labor [12]. The objective of this study was to compare the cesarean delivery rate between primiparous women with a long IPI and primiparous women with an ideal minimum IPI of 18–24 months on the one hand and on the other hand, with nulliparous women.

Materials and methods

This retrospective single-center cohort study examined records during a 17-year period between January 1, 2000 and June 27, 2017, in a level 3 maternity unit, in Paris (France). The interval between two pregnancies was defined by the time between the date of the last delivery and the date of the conception of the pregnancy studied.

Women were informed as they registered to the hospital that their medical file's data could be used for medical research, after collecting their consent. This study followed rules set by our methodology reference MR-001 (law N°2016-41 of 26th January 2016). This observational study respects women's privacy and anonymity. The National Commission of data processing and liberties number 293683 approves the database.

Women were included if they had given birth to their first or second child, a live singleton in cephalic presentation after 22 weeks of gestation with cephalic presentation and had planned a vaginal delivery. The exclusion criteria were parity ≥ 2, that is, delivering at least their third child from their third pregnancy; a twin or higher order pregnancy, non-cephalic fetal presentation, medically indicated termination of pregnancy, or utero fetal death for the studied pregnancy, or planned cesarean delivery; and primiparous women with an IPI < 18 months or between 24 and 59 months were excluded to avoid sampling bias (Fig. 1).

Three groups were defined. The study group was the "long IPI" study group, comprising primiparous women who became pregnant > 59 months after their first delivery. They were compared with two different reference groups: the "ideal minimum IPI" group of the primiparous women conceiving between 18 and 24 months after their first delivery and the nulliparous group.

The data analyzed retrospectively, had been collected prospectively, at each follow-up consultation and at delivery by the healthcare professionals caring for the patient. The entire medical file was computerized and completed prospectively at each consultation, at delivery and after childbirth. These data were verified at an obstetric staff meeting the day after delivery. The same procedures governed collection of

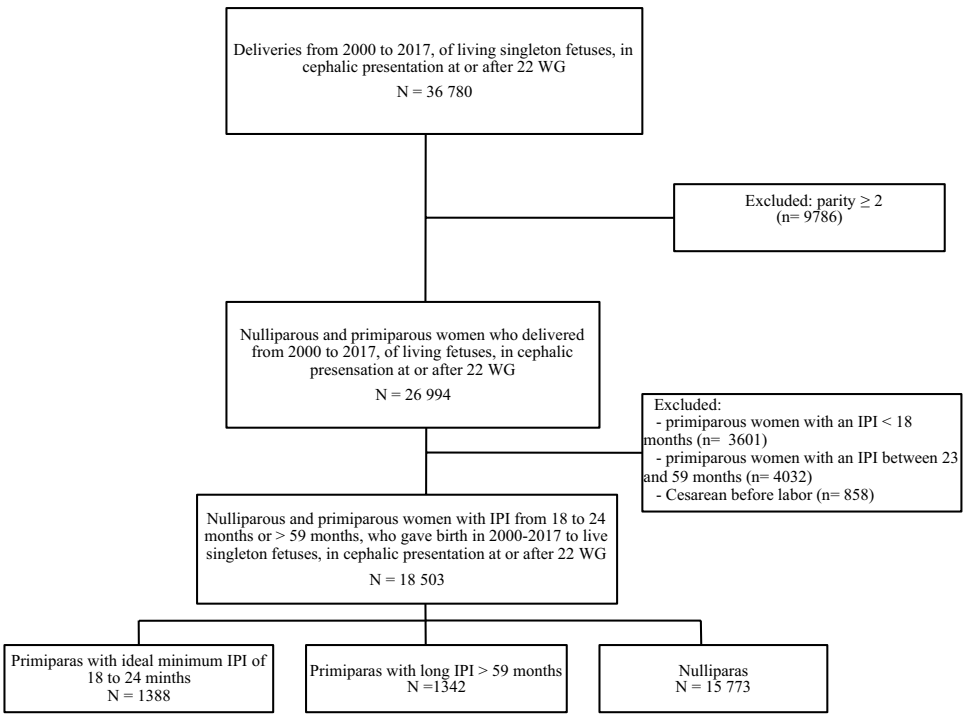

Fig. 1 Flow chart. *IPI* interpregnancy interval

women's demographic information and medical and obstetric history.

Partograms were also computerized and prospectively completed by the midwives and/or obstetricians during labor. Pelvic examinations were performed hourly once labor started. Pushing began when fetal presentation was engaged.

We studied the duration of the different stages of labor, dividing the first stage is into a passive first phase, from the admission for labor to 6 cm of cervical dilation, and the active phase from 6 cm to full dilation. The second stage of labor was defined as the duration between full dilatation and delivery. Each duration was calculated based on the exact date and time of each pelvic examination. When no pelvic examination was mentioned hourly, we considered that labor was progressing linearly between each mentioned pelvic examination.

The primary outcome was the rate of intrapartum cesarean, treated as a binary variable.

The secondary outcomes were the duration of labor (continuous variable) overall as well as the analysis of the durations of its specific phases (continuous variable: specific phases of the first stage and the second stage). Secondary endpoints were analyzed first in the total population, and then in the population of women with vaginal deliveries. We also studied labor characteristics such as: epidural use, use of oxytocin, amniotic fluid color, need of manual rotation, and maternal complications such as post-partum hemorrhage. Neonatal outcomes such as birth weight, fetal growth restriction, cord pH, respiratory help, and neonatal death were also considered.

We conducted two sensitivity analyses. First, we compared primiparous women with an IPI longer than 10 years to nulliparas, to assess whether the difference between the groups increased proportionally according to interval. Second, we included only women who had spontaneously started labor at term (> 37 weeks of gestation), to test results for a population at low obstetric and neonatal risks.

Group characteristics were compared by Chi-squared or Fisher tests for categorical variables and by Student's or Wilcoxon rank tests for quantitative variables.

The association between IPI and cesarean rate was studied with a simple univariate logistic regression analysis and is presented as estimated unadjusted odds ratios (ORs) and their 95% confidence intervals (CI). The independent association between IPI and cesarean delivery during labor was tested and quantified by a multivariate logistic regression, with cesarean delivery as the dependent variable. Results were adjusted for confounding variables defined after analysis of the literature: maternal age, preconception body mass index, previous cesarean, gestational diabetes, gestational hypertensive disorder, suspected fetal macrosomia, gestational age at delivery, and mode of entry into labor. The analyses were performed with STATA 13 software.

Results

Over the 17-year period, the study included 18,503 women: 1342 women were in the long IPI group, 1388 in the ideal minimum IPI group, and 15,773 in the group of nulliparas (Fig. 1). The women in the long IPI group were significantly older and more frequently overweight than those in the ideal minimum IPI group; they also had a more frequent history of diabetes and hypertension. Inversely, gestational diabetes and FGR were twice as frequent among women with the ideal minimum IPI as among those in the long IPI group. Compared to the nulliparas, women in the long IPI group were also significantly older and more frequently had a high BMI (overweight or obesity) and hypertension (Table 1).

Compared to the ideal IPI group, women in the long IPI group had higher rates of hypertensive pregnancy related pathologies. They also had more suspicion of foetal macrosomia. Compared to primipara, women in long IPI group had more frequently gestational diabetes (Table 2).

Preterm delivery (≤ 37 weeks of gestation) was more frequent among the women in the long IPI group than those in the ideal minimum IPI group and the spontaneous labor rate was lower. These two groups did not differ significantly for any of the other characteristics of labor studied. Comparison of the long IPI group and the nulliparas showed a significantly higher spontaneous labor rate in the former (Table 3).

The cesarean rate was significantly higher in the long IPI group compared with the ideal minimum IPI group (12.2% vs. 6.3%, respectively, $P < 0.001$, unadjusted OR = 2.1, 95% CI 1.6–2.7, adjusted OR = 2.2, 95% CI 1.6–3.1) (Tables 4, 6). Indication for cesarean in the long IPI group was more frequently a pathological cardiotocogram (CTG), compared to ideal minimum IPI group, where obstructed labor and pathological cardiotocograms were equally frequent. In primiparous women group, obstructed labor was the first indication for cesarean (Table 4). The duration of labor overall was similar in both groups as a whole, regardless of the mode of delivery (299 min, or nearly 5 h, on average, in the long IPI group compared to 288 min or 4.8 h in the ideal minimum IPI group, $P = 0.19$) (Table 3) and for vaginal deliveries only. There was no difference in the duration of the different phases of labor between the two groups (Appendix 1).

Compared with the nulliparous women, those in the long IPI group had a significantly lower cesarean rate (12.2% and 14.3%, respectively, $P = 0.03$, unadjusted OR = 0.8, 95% CI 0.7–0.9, aOR = 0.5, 95% CI 0.4–0.7) (Table 6). The mean duration of labor, regardless of mode of delivery, was significantly higher among the nulliparous women: 462 min (7.7 h) compared to 299 min (nearly 5 h) in the long IPI group ($P = 0.002$) (Table 3).

Table 1 Maternal characteristics

	Long IPI[a] *N* = 1342 *n* (%)	Ideal IPI[b] *N* = 1388 *n* (%)	*P*	Nulliparous women *N* = 15,773 *n* (%)	*P*
Age (years)					
Mean ± SD	33.8 ± 4.6	31.0 ± 4.6	<0.001	29.2 ± 5.5	< 0.001
< 30 years	289 (21.5)	572 (41.2)		8924 (56.6)	
[30–39]	923 (68.8)	783 (56.4)	< 0.001	6326 (40.1)	< 0.001
≥ 40 years	130 (9.7)	33 (2.4)		523 (3.3)	
Body mass index (kg/m^2)			0.003		< 0.001
< 18.5	123 (10.0)	141 (11.0)		1946 (13.3)	9648 (65.9)
[18.5–24.9]	708 (58.0)	820 (63.7)			
[25–29.9]	262 (21.5)	229 (17.8)		2167 (14.8)	
≥ 30	128 (10.5)	97 (7.5)		876 (6.0)	
Weight gain					
Mean ± SD	11.8 ± 6.6	11.6 ± 5.4	0.47	12.4 ± 5.9	0.002
< 9	220 (25.4)	241 (25.6)	0.04	2288 (20.9)	0.006
[9–11]	169 (19.5)	227 (24.2)		2398 (21.9)	
≥ 12	477 (55.1)	472 (50.2)		6258 (57.2)	
Medical history					
Hypertension	27 (2.0)	11 (0.8)	0.007	134 (0.9)	< 0.001
Diabetes	14 (1.0)	5 (0.4)	0.03	148 (0.9)	0.70
Myomectomy	9 (0.7)	4 (0.3)	0.15	85 (0.5)	0.53
Obstetric history					
Preterm birth	112 (8.4)	108 (7.8)	0.59	–	
Late miscarriage	11 (0.8)	9 (0.7)	0.6	–	
Medically indicated TOP	8 (0.6)	24 (1.7)	0.006	–	
Intrauterine fetal death	8 (0.6)	15 (1.1)	0.17	–	
Delivery after 42 WG	20 (1.5)	41 (3.0)	0.01	–	
Preeclampsia	51 (3.8)	50 (3.6)	0.78	–	
Gestational diabetes	19 (1.4)	48 (3.5)	0.001	–	
FGR	39 (2.9)	93 (6.7)	< 0.001	–	
Macrosomia	107 (8.0)	117 (8.4)	0.66	–	
Postpartum hemorrhage	22 (1.6)	14 (1.0)	0.15	–	
Previous cesarean	241 (18.0)	236 (17.0)	0.51	–	
Fetopelvic disproportion	72 (5.4)	76 (5.5)	0.90	–	

IPI interpregnancy interval; *SD* standard deviation; *TOP* termination of pregnancy; *WG* weeks of gestation; FGR Fetal growth restriction

[a]Long IPI: interpregnancy interval > 59 months

[b]Ideal IPI: interpregnancy interval between 18 and 24 months

Hypotrophy rates below the 10th and 5th percentiles were higher in the long IPI group compared to the ideal IPI group. However, no difference was found in severe hypotrophy below the 3rd percentile. For the umbilical cord pH, the pH rate < 7.10 was similar between the long and the ideal IPI groups (respectively 1.1% vs 1.1%, $p = 0.93$). Compared with primipara, women of long IPI group had significantly low risk of fetus below 10th, 5th or 3rd percentiles (Table 5).

The sensitivity analysis of primiparas group that gave birth more than 10 years after their first delivery included 251 women. The cesarean rate was significantly higher in this group with an IPI > 10 years than among the ideal minimum IPI group (16% vs. 6.3%, respectively, $P < 0.001$, aOR = 4.1, 95% CI 2.3–7.3) (Table 6, Appendix 2) and did not differ from that in the nullipara group (14.3% and 16%, respectively, $P = 0.46$, aOR = 0.9, 95% CI 0.5–1.5).

The sensitivity analysis of women who entered spontaneous labor at 37 weeks of gestation or later included 955 women in the long IPI group, 1067 in the ideal IPI group, and 9895 in the group of nulliparas. The long IPI group had a significantly higher cesarean rate than the ideal IPI group (11% vs. 5.6%, $P < 0.001$, aOR = 2.2, 95% CI 1.5–3.3) and a

Table 2 Characteristics of pregnancy

	Long IPI* *N* = 1342 *n* (%)	Ideal IPI** *N* = 1388 *n* (%)	*P*	Nulliparous women *N* = 15,773 *n* (%)	*P*
Aspirin	175 (13.0)	195 (14.0)	0.44	1374 (8.7)	< 0.001
Cervical cerclage	27 (2.0)	31 (2.2)	0.69	64 (0.4)	< 0.001
Gestational diabetes	89 (6.6)	75 (5.4)	0.18	621 (3.9)	< 0.001
Preeclampsia	47 (3.5)	24 (1.7)	0.004	544 (3.4)	0.92
Hospitalization before 37 WG	201 (15.0)	175 (12.6)	0.07	2237 (14.2)	0.70
Hospitalization for preterm labor	84 (6.3)	93 (6.7)	0.64	1054 (6.7)	0.8
Premature rupture of membrane	14 (1.0)	8 (0.6)	0.17	157 (1.0)	0.95
Intrauterine growth restriction	20 (1.5)	11 (0.8)	0.85	293 (1.9)	0.34
Antenatal corticotherapy	46 (3.4)	43 (3.1)	0.63	657 (4.2)	0.19
Placenta previa	40 (3.0)	49 (3.5)	0.42	439 (2.8)	0.63
Suspected macrosomia	153 (13.1)	125 (10.2)	0.03	1108 (8.0)	< 0.001

IPI interpregnancy interval; WG weeks of gestation

[a]*Long IPI* interpregnancy interval > 59 months

[b]*Ideal IPI* interpregnancy interval between 18 and 24 months

significantly lower rate than the nulliparas (11.0% vs. 14.5%, *P* = 0.003, aOR = 0.6, 95% CI 0.4–0.8) (Table 6, Appendix 3).

Discussion

This study found that the rate of cesarean delivery during labor was twice as high among women whose second pregnancy began more than 59 months, compared with 18–24 months, after their first delivery. This rate was still higher among those with an IPI > 10 years. Total duration of labor, on the other hand, did not differ among primiparas according to the interval between their first and second pregnancies. In contrast, the primiparas with a long IPI had a lower cesarean rate and a shorter duration of labor than nulliparas.

The data in the literature about cesarean rates and IPI are sparse, conflicting, have some methodological limitations, and are difficult to compare with ours. Two previous retrospective studies compared populations of multiparous women with an IPI > 6–7 years to women with a IPI lower than that [17, 18] and found no significant differences in cesarean rates between their two groups with higher and lower IPIs. Both studies had limitations, however, including a small number of patients and the use of a single cutoff to define the IPI, which can produce an overlap bias. More importantly, they took place in countries and/or times, where obstetrical practices were different from those in developed countries today. These results can therefore not be extrapolated to our population in a high-resource country in the 21st century. Only one study has reported that cesarean rates increase with IPI and it took place in a population of women with prior cesarean births [11].

Few data are available about differences in the duration of labor according to IPI. The findings of the studies mentioned above [17, 18] are consistent with ours on this question: they too found no difference between the two groups. Moreover, they described durations of labor quite similar to those we report here.

Our results thus, do not support the physiological regression hypothesis that suggests that after giving birth, mothers gradually lose their physiological capacities and become more similar to primiparous women as their IPI increases [12, 19, 20]. This hypothesis, however, has never been proved. The physiological functioning of the uterus can be measured by the need for uterotonic drugs, such as oxytocin, during labor. In our study, the women from the long IPI group did not receive a significantly higher dose of uterotonic drugs during labor than those from the ideal IPI group. Moreover, the lack of a significant difference in labor duration between the two groups also supports the conservation of uterine physiological capacity in primiparous women, even after a long IPI.

Our results have clinical implications and provide evidence for optimal obstetric management of prenatal care and labor in women having a second child after a long IPI. They clearly demonstrate that these women should not be confused with nulliparous women during labor, but that obstetricians should remain vigilant about their higher risks for cesarean delivery.

Our study has several strengths. The parous group was limited to primiparas, that is, women having a second child, to ensure that the groups are comparable, given that multiparity influences both cesarean rates and the duration of labor, which were the two primary outcome criteria for this study.

Furthermore, women with long IPI are usually older and have many possible pathologies, and therefore this group may have more planned cesarean, which was not the aim

Table 3 Characteristics of labor

	Long IPI[a] *N* = 1342 *n* (%)	Ideal IPI[b] *N* = 1388 *n* (%)	*P*	Nulliparous women *N* = 15,773 *n* (%)	*P*
Term (gestational week)					
Mean ± SD	39.4 ± 2	39.6 ± 1.6	0.01	39.4 ± 2.2	0.99
< 37	103 (7.7)	55 (4.0)	< 0.001	1258 (8.0)	0.16
[37–38]	267 (19.9)	274 (19.7)		2946 (18.7)	
[39–40]	738 (55)	850 (61.2)		8502 (53.9)	
41	207 (15.4)	183 (13.2)		2586 (16.4)	
≥ 42	27 (2.0)	26 (1.9)		481 (3.0)	
Spontaneous labor	1143 (85.2)	1252 (90.2)	< 0.001	11,951 (75.8)	< 0.001
Cervical dilatation at admission for labor					
Mean ± SD	3.6 ± 1.8	3.6 ± 1.7	0.94	3 ± 1.3	< 0.001
Median [IQI]	3 [2–4]	3 [2–4]	0.35	3 [2, 3]	< 0.001
Epidural	999 (74.4)	1109 (79.9)	0.001	13,944 (88.4)	< 0.001
Cervical dilation at epidural analgesia					
Mean ± SD	4.4 ± 2	4.5 ± 2	0.4	4 ± 2	< 0.001
Median [IQI]	4 [3–6]	4 [3–6]	0.5	4 [3–5]	< 0.001
Oxytocin	580 (43.2)	585 (42.2)	0.6	9343 (59.2)	< 0.001
Maximum dose of oxytocin					
Mean ± SD	39 ± 24	37 ± 23	0.18	42 ± 26	0.002
Median (IQI)	30 [20–50]	30 [20–50]	0.35	40 [20–60]	0.002
Amniotic fluid color			0.16		0.05
Clean	1049 (79)	1122 (81.5)		11,975 (76.5)	
Tinted	196 (14.8)	188 (13.7)		2440 (15.6)	
Meconial	83 (6.2)	66 (4.8)		1241 (7.9)	
Manual rotation	79 (5.9)	91 (6.6)	0.47	1510 (9.6)	< 0.001
Total duration of labor					
Mean	299	288	0.19	462	0.002
Median [IQI]	275 [133–427]	269 [151–402]	0.62	431 [285–591]	< 0.001

IPI interpregnancy interval; *SD* standard deviation; *IQI* interquartile interval

[a]*Long IPI*: interpregnancy interval > 59 months

[b]*Ideal IPI*: interpregnancy interval between 18 and 24 months

of this study. To take into account the limitation of our ability to assess causality between long IPI and delivery outcomes, we performed an adjustment for confounding variables defined after an analysis of the literature. For this, our database provided precise information on maternal and obstetrical characteristics. Thanks to these data and the many available variables, we tried to avoid this bias. Data were collected prospectively by the health professionals caring for the patients. This method enabled exhaustive collection of data. Furthermore, the quality of the information collected was checked daily in departmental staff meetings after delivery in the presence of those professionals. The external validity of our study is confirmed by the similarity of the characteristics of the women in this study and the data about their labor to those of the 2016 National Perinatal Survey [21]. In addition, the durations of labor in our study are similar to those found in another French study with similar population characteristics [22].

Our study also has some limitations. First, it is a single-center study. Nonetheless, such studies have an important compensatory advantage, for a single center can provide homogenous management of women during labor, unavailable in multicenter studies, because of the high variability in practices for labor management from one hospital to another (in use of oxytocin, time before cesarean for obstructed or arrested labor, etc.). Another limitation is that our study did not collect the causes of the long intervals between the two pregnancies and some of them (change of partner, medically assisted procreation, etc.) could be confounding factors in the occurrence of a cesarean section. Furthermore, because the mother's geographic origin was missing for 25% of the women in our study, we did not include it as an adjustment variable, although it is a

Table 4 Characteristics of delivery

	Long IPI[a] *N* = 1342 *n* (%)	Ideal IPI[b] *N* = 1388 *n* (%)	*P*	Nulliparous *N* = 15,773 *n* (%)	*P*
Mode of delivery			< 0.001		0.03
Cesarean	163 (12.2)	87 (6.3)		2252 (14.3)	
Vaginal	1179 (87.8)	1301 (93.7)		13,521 (85.7)	
Cesarean					
Indication for cesarean	102 (62.6)	44 (50.6)	0.011	939 (41.7)	< 0.001
Pathologic cardiotocogram	54 (33.1)	43 (49.4)		1265 (56.2)	
Obstructed labor	7 (4.3)	0 (0)		48 (2.1)	
Other indication					
Cervical dilation at cesarean (cm)					
Mean ± SD	5.0 ± 2.6	5.6 ± 2.8	0.12	5.6 ± 2.6	0.007
Vaginal delivery			0.008		< 0.001
Spontaneous	957 (81.2)	1108 (85.2)	0.77	7662 (56.7)	
Instrumental	222 (18.8)	193 (14.8)		5859 (43.3)	0.78
Type of instrument					
Forceps	158 (71.2)	143 (74.1)		4255 (72.6)	
Spatula	42 (18.9)	34 (17.6)		1102 (18.8)	
Vacuum	22 (9.9)	16 (8.3)		502 (8.6)	
Indication for instrumental extraction			0.26		0.02
Abnormal fetal heart rate	99 (44.6)	79 (41.4)		3277 (56.3)	
Lack of progression	123 (55.4)	110 (57.6)		2532 (43.6)	
Other	0 (0)	2 (1.0)		7 (0.1)	
Episiotomy	390 (33.3)	389 (30.0)		8770 (65.1)	
Third-stage perineal injury	2 (0.2)	3 (0.2)		31 (0.2)	
Delivery complication					
Postpartum hemorrhage	38 (2.8)	46 (3.3)	0.47	629 (4.0)	0.04
Management of PPH	33 (2.5)	41 (3.0)	0.43	556 (3.5)	0.04
Sulprostone	0 (0)	0 (0)	–	4 (0.03)	–
Bakri balloon	0 (0)	0 (0)	–	5 (0.03)	–
Embolization	0 (0)	0 (0)	–	3 (0.02)	–
Vascular ligation	0 (0)	1 (0.1)	–	20 (0.1)	–
Uterine compression suture	0 (0)	0 (0)	–	0 (0)	–
Hysterectomy	2 (0.8)	1 (0.4)	0.58	0 (0)	–
Uterus ruptured with prior cesarean					
Transfusion					
In delivery room	3 (0.2)	2 (0.1)	0.63	108 (0.7)	0.04
In postpartum room	5 (0.4)	7 (0.5)	0.6	128 (0.8)	0.08
Transfer to maternal intensive care unit	0 (0)	1 (0.1)	0.33	29 (0.2)	–
Maternal death	0 (0)	0 (0)	–	0 (0)	–

IPI interpregnancy interval; *PPH* postpartum hemorrhage

[a]*Long IPI*: interpregnancy interval > 59 months

[b]*Ideal IPI*: interpregnancy interval between 18 and 24 months

recognized risk factor for cesarean delivery [23]. The reasons of this increase of cesarean risk still remain unknown. The analysis of indications for cesarean found a majority of pathological cardiotocogram, among women in long IPI group. This data can be correlated to the increased risk of FGR in this group that can be a reason for increased pathological CTG.

This population of women with an IPI > 59 months is at an increased risk of cesarean delivery compared to women with an "ideal minimum IPI". We must be vigilant about this increase of cesarean section risk and be aware in such situations, but cesarean section indication during labor should remain an operation based on clinical and obstetrical observations only.

Table 5 Neonatal outcomes

	Long IPI[a] $N = 1342$ n (%)	Ideal IPI[b] $N = 1388$ n (%)	P	Nulliparous women $N = 15\,773$ n (%)	P
Weight at birth (g)					
Mean ± SD	3272 ± 536	3366 ± 512	< 0.001	3186 ± 574	< 0.001
< 2500	86 (6.4)	53 (3.8)		1342 (8.5)	
[2500–3799]	1059 (78.9)	1083 (78.0)	0.001	12 652 (80.2)	< 0.001
≥ 3800	197 (14.7)	252 (18.2)		1776 (11.3)	
Fetal growth restriction					
< 10th percentile	104 (7.8)	75 (5.4)	0.01	1866 (11.8)	< 0.001
< 5th percentile	60 (4.5)	40 (2.9)	0.03	1048 (6.6)	0.002
< 3rd percentile	33 (2.5)	31 (2.2)	0.7	721 (4.6)	< 0.001
Cord pH					
< 7.10	14 (1.1)	14 (1.1)	0.93	210 (1.4)	0.40
< 7.00	4 (0.3)	2 (0.2)	0.40	40 (0.3)	0.74
Respiratory help					
Mask ventilation	44 (3.3)	43 (3.1)	0.8	732 (4.6)	0.02
Nasal ventilation	11 (0.8)	10 (0.7)	0.8	106 (0.7)	0.53
CPPV	14 (1.0)	22 (1.6)	0.22	377 (2.4)	0.002
Intubation	25 (1.9)	17 (1.2)	0.18	401 (2.5)	0.13
Ventilation assistance	72 (5.4)	78 (5.6)	0.8	1295 (8.2)	< 0.001
Neonatal death in delivery room	2 (0.2)	0 (0)	0.15	17 (0.1)	0.66

IPI interpregnancy interval; *CPPV* continuous positive pressure ventilation

[a]Long IPI: interpregnancy interval > 59 months

[b]Ideal IPI: interpregnancy interval between 18 and 24 months

Table 6 Risk of cesarean section for woman with long interpregnancy interval

Population reference group (n/N)[a]	Unadjusted OR (95% CI)	Adjusted[b] OR (95% CI)
Overall population (163/1342)		
Ideal minimal IPI group (87/1388)	2.1 (1.6–2.7)	2.2 (1.6–3.1)
Nulliparous (2252/15773)	0.8 (0.7–0.9)	0.5 (0.4–0.7)
Subgroup analysis of primiparas IPI > 10 years (40/251)		
Ideal minimum IPI group (87/1388)	2.8 (1.9–4.2)	4.1 (2.3–7.3)
Nulliparous (2252/15773)	1.1 (0.8–1.6)	0.9 (0.5–1.5)
Subgroup analysis of women who entered spontaneous labor ≥ 37 WG (105/955)		
Ideal minimum IPI group (60/1067)	2.2 (1.6–3.0)	2.2 (1.5–3.3)
Nulliparous (1431/9895)	1.1 (0.9–1.3)	0.6 (0.4–0.8)

[a]n = number of cesarean/N = total sample size

[b]Adjustment for maternal age, preconception body mass index, previous cesarean, gestational diabetes, gestational hypertensive disorder, suspected fetal macrosomia, gestational age at delivery, and mode of entry into labor

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

Appendix 1: duration of different stages of labor in women with vaginal deliveries

Duration (min)	Long IPI[a] $N=1179$	Ideal IPI[b] $N=1301$	P	Nulliparous women $N=13,521$	P
Total duration of labor	$N=1168$	$N=1296$		$N=13,506$	
Mean (±SD)	289 (±201)	281 (±180)	0.28	452 (±207)	0.007
Median [IQI]	269 [125–416]	261 [147–390]	0.79	422 [283–571]	<0.001
Before 6 cm	$N=1168$	$N=1296$		$N=13,501$	
Mean (±SD)	141 (±132)	137 (±119)	0.36	206 (±139)	<0.001
Median [IQI]	109 [31–218]	110 [39–210]	0.90	195 [95–292]	<0.001
6–10 cm	$N=1168$	$N=1296$		$N=13,504$	
Mean (±SD)	98 (±90)	97 (±83)	0.77	147 (±109)	<0.001
Median [IQI]	69 [34–134]	75 [37–134]	0.48	120 [67–199]	<0.001
Complete dilation	$N=1169$	$N=1295$		$N=13,490$	
Mean (±SD)	30 (±47)	29 (±45)	0.71	55 (±57)	<0.001
Median [IQI]	0 [0–55]	0 [0–48]	0.61	40 [0–110]	<0.001

IPI interpregnancy interval; *SD* standard deviation; *IQI* interquartile interval

[a]*Long IPI*: interpregnancy interval > 59 months

[b]*Ideal IPI*: interpregnancy interval between 18 and 24 months

Appendix 2: mode of delivery and duration of labor in a subgroup analysis defining long IPI as equal to or higher than 10 years

	Long IPI[a] $N=251$ *n* (%)	Ideal IPI[b] $N=1388$ *n* (%)	P	Primiparous women $N=15,773$ *n* (%)	P
Mode of delivery			<0.001		0.46
Cesarean	40 (16.0)	87 (6.3)		2252 (14.3)	
Vaginal delivery	211 (84.0)	1301 (93.7)		13,521 (85.7)	
Total duration of labor for women with vaginal delivery (min)					
Mean	303	281	0.11	452	<0.001
Median [IQI]	271 [135–435]	261 [147–390]	0.40	422 [283–571]	<0.001

IPI interpregnancy interval; *IQI* interquartile interval

[a]*Long IPI*: interpregnancy interval > 59 months

[b]*Ideal IPI*: interpregnancy interval between 18 and 24 months

Appendix 3: mode of delivery and duration of labor in a subgroup analysis of women with spontaneous labor at term (> 37 WG)

	Long IPI* $N=955$ n (%)	Ideal IPI** $N=1067$ n (%)	P	Nulliparous women $N=9895$ n (%)	P
Mode of delivery			< 0.001		0.003
Cesarean	105 (11.0)	60 (5.6)		1431 (14.5)	
Vaginal	850 (89.0)	1007 (94.4)		8464 (85.5)	
Total duration of labor in vaginal deliveries (min)					
Mean (± SD)	268	261	0.44	440	< 0.001
Median [IQI]	250 [114–382]	244 [133–366]	0.92	429 [288–579]	< 0.001

IPI interpregnancy interval; *SD* standard deviation; *IQI* interquartile interval

* Long IPI: interpregnancy interval > 59 months

** Ideal IPI: interpregnancy interval between 18 and 24 months

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