Clinical and Experimental Obstetrics & Gynecology

Clin. Exp. Obstet. Gynecol. **2022**; 49(5): 102
https://doi.org/10.31083/j.ceog4905102

Original Research

Labor induction: change of indications and outcomes over time and future trends — a retrospective analysis

Aida Omerović[1,†], Sandra Pajek[1,†], Veronika Anzeljc[2], Faris Mujezinović[1,2,*]

[1]Department of Perinatology, Faculty of Medicine University of Maribor, 2000 Maribor, Slovenia
[2]Department of Perinatology, University Medical Centre Maribor, 2000 Maribor, Slovenia
*Correspondence: faris.mujezinovic@ukc-mb.si (Faris Mujezinović)
[†]These authors contributed equally.

Academic Editor: Paolo Ivo Cavoretto
Submitted: 7 October 2021 Revised: 1 November 2021 Accepted: 4 November 2021 Published: 26 April 2022

Abstract

Background: The purpose of this study was to evaluate the results of induction of labor over time in order to identify future trends. **Methods**: Data were collected from a national database for University Medical Center Maribor on the pregnant women demographics, the indications for labor induction, the process of induction and delivery, and the outcomes of delivery for periods 2011–14 and 2015–18. **Results**: In the second period (2015–18), the rate of labor induction increased (14.7% vs. 19.0%, $p < 0.00001$), pregnant women were older (29.7 years vs. 30.0 years, $p = 0.0018$), were more frequently monitored in tertiary hospitals during pregnancy (40.6% vs. 80.7%, $p < 0.00001$), had hypertension in pregnancy (5.4% vs. 2.7%, $p = 0.0002$), and oligohydramnios (9.6% vs. 6.9% , $p = 0.007$). During labor, amniotomies (60.3% vs. 53.7%, $p = 0.0004$), umbilical cord prolapses (1.2% vs. 0.1%, $p = 0.0003$), meconium amniotic fluids (12.7% vs. 8.8%, $p = 0.0008$), pathological CTG tracings (15.2% vs. 8.4%, $p < 0.00001$) were less frequent. There were less episiotomies (37.4% vs. 29.1%, $p < 0.00001$), vacuum extractions (4.2% vs. 2.8%, $p = 0.049$), while the rate of caesarean sections remained constant (15.0% vs. 16.6%, $p = 0.23$). **Conclusions**: There is a tendency toward increased induction of labor (IOL) rates, probably related to higher average age of women, but with better delivery outcomes. Our findings reflect local practice and cannot be generalized.

Keywords: postterm pregnancy; induction of labor; indications; outcomes; trends of induction

1. Introduction

With incidence rates from 12% to 36%, induction of labor (IOL) is one of the most common obstetric treatments [1]. It was introduced in clinical practice in the 1780s by Thomas Denman in London, when there was a concern that pregnancy could jeopardize fetal or mother's health [2]. Many changes have occurred in medical practice from that time, influencing decisions to induce labor, indications and methods for induction, risk perception of stillbirth in the final weeks of pregnancy, and health-related policies and recommendations of professional societies regarding IOL [3]. There is a tendency toward deferring the decision to have children later in life, as well as an increase in average body mass index (BMI) [4].

Initially, the usual technique of IOL was oxytocin, and the most common indication for induction of labor was postterm pregnancy [5]. Later, the indications for IOL were expanded to include diagnoses such as diabetes mellitus in pregnant women and a reduction in the quantity of amniotic fluid [6]. Recently, overview of the most influential guidelines for IOL identified 12 indications for IOL (placenta abruption, chorioamnionitis, gestational hypertension, preeclampsia/eclampsia, postterm pregnancy, premature rupture of membranes, maternal medical conditions, fetal compromise, fetal death, logistic reasons at term (e.g., distance from the hospital), uncomplicated twin pregnancy $\geq$38 week and intrauterine death in a prior pregnancy) and 9 contraindications (vasa previa or complete placenta previa, transverse fetal lie, umbilical cord prolapse, previous classical cesarean delivery, active genital herpes infection, previous myomectomy entering the endometrial cavity, pelvic structural deformities, invasive cervical carcinoma and previous uterine rupture) [7].

There were additional changes in the IOL's techniques and medicines. Prostaglandins in different forms were initially brought into the practice, followed by mechanical methods for induction (for example Foley catheter) [8]. IOL also raised concerns about possible complications of IOL, the medicalization of childbirth, and a debate about proper IOL protocols. However, recent studies, have shown that induction of labor is a safe approach that might potentially find a place in prophylactic usage for prevention of stillbirths beyond the 39th week of pregnancy [9]. Surprisingly, rates of IOL are not consistent between nations, as the prevalence of IOL varies greatly [1].

The purpose of this study was to evaluate the results of induction of labor at the University Medical Center Maribor between the years 2011–14 and 2015–18 in order to identify future trends.

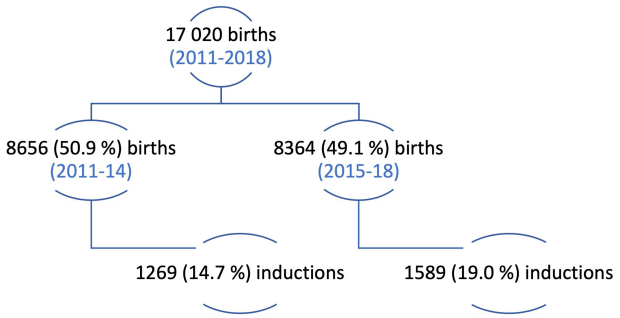

Fig. 1. Flowchart from total number of deliveries to the number and percentages of inductions in both observed periods (2011–14 and 2015–18). *p*-value for percentage difference between two observed periods is less than 0.00001.

2. Materials and methods

In this retrospective single-institution analysis, we gathered data on pregnant women who had induction of labor at the Department of Perinatology at the University Medical Center Maribor between 2011 and 2018. We examined data from two time periods — January 2011 to December 2014 (2011–14 Group) and January 2015 to December 2018 (2015–18 Group) — and looked at the consequences of their delivery. Data were gathered from the Slovenian National Perinatal Information System (NPIS), which is required by law to record all deliveries in Slovenia after the 22nd week of pregnancy with fetuses weighing more than 500 g. We focused on pregnant women who underwent induction of labor at term and excluded those with an induction of labor before 37+0 weeks of pregnancy.

Each pregnant woman was also informed of the procedure and signed the consent. Pregnant women were admitted to the maternity hospital in the morning on the day of induction, where the procedure of labor induction was performed after cardiotocography (CTG), which was used to assess the fetal basal heart rate, frequency variability and the presence of periodic changes — accelerations and decelerations. The following drugs were used to induce labor: Prepidil gel, Prostin 2 g and Prostin 1 g.

We searched for the data describing the demographic characteristics of mother (age of the mother, number of successful previous births, mode of conception, maternal diseases, use of nicotine and alcohol, physical activity, marital status and education), events during labor and delivery (labor onset, type of membrane rupture, duration of labor, appearance of amniotic fluid, use and dosages of oxytocin), complications before and after birth of the baby, and the mode of delivery. Neonatal data such as birth weight, birth length and APGAR score in 1, 5 and 10 minutes were also acquired.

There were no changes in clinic management or internal guidelines between the observed time periods.

This study was approved by the Institutional Review Board of UMC Maribor (Reg. No. UKC-MB-KME 50/20). All patients signed a written informed consent form to allow the use of their medical records retrospectively for research purposes. Statistical analysis was performed using the SPSS software version 27.0 for Mac OS (IBM Corp., Armonk, NY, USA). For comparison of categorical variables, we used the chi-squared test, and for continuous variables we used the Mann-Whitney U-test. The population characteristics were expressed as continuous or categorical variables and calculated as frequencies or averages and standard deviations (SD), respectively. Statistically significant differences were identified when $p < 0.05$.

Our study's sample size could detect a 4% difference between groups with 80% power (1-beta) and a 5% significance level, indicating a clinically relevant difference [10]. The risk of bias in our study's outcomes could not be entirely eliminated. The biggest danger of bias, in our judgment, was present at the time of gathering information on the pregnancy and entering it into the database. This danger, in our judgment, was mitigated by mandatory training in data collection in the national database, as well as a common and detailed structure of forms for data entry on a nationwide basis [11].

3. Results

From January 2011 to December 2018, the Department of Perinatology at the University Clinical Center Maribor (UKC Maribor) in Maribor, Slovenia, registered 17020 births. In the first period (2011–14) there were 8656 (50.9%) births and in the second period (2015–18) there were 8364 (49.1%) births. The monitored eight-year period included 2858 (16.8%) inductions of labor with lower proportion of inductions in the first period (2011–14) (1269 (14.7%)) in comparison to the second observed period (2015–18) (1589 (19.0%)) (Fig. 1).

Women in the 2011–14 group were in average slightly younger (29.7 years, SD (5.2 years)) then women in the 2015–18 group (30.3 years SD (5.0 years)) ($p < 0.00001$). Majority of induction of labor was performed in primiparous women in both periods (2011–14 group: 61.1%, 2015–18 group: 54.5%). However, these differences were not statistically significant.

In overall period, diabetes mellitus before pregnancy was present in 20 (0.7%) women, but much less in 2011–14 group (4 women (0.3%)) then in 2015–18 group (16 women (1.0%)), $p = 0.03$. Smoking was much more prevalent in 2011–14 group (145 women (11.4%)) then in 2015–18 group (98 women (6.2%)), $p < 0.00001$. In general, more women in 2011–14 group had various accompanying diseases (388 women (30.6%)) then in 2015–18 group (217 women (13.7%)), $p < 0.00001$. More details regarding the demographics of pregnant women could be found in Table 1.

Table 1. Comparison of characteristics of pregnant women with induction of labor between the periods 2011–14 and 2015–18 at the University Medical Center Maribor.

	2011–14 N = 1269		2015–18 N = 1589		2011–18 N = 2858		*p* value
Age of the mother Average (SD)	29.7	(5.2)	30.0	(5.0)	29.9	(5.2)	0.0018*
Primiparous women	775	(61.1)	927	(58.3)	1702	(59.6)	0.14
Twins in family N (%)	120	(9.5)	164	(10.3)	284	(9.9)	0.44
Congenital anomalies N (%)	25	(2.0)	32	(2.0)	57	(2.0)	0.93
Hypertension in family N (%)	338	(26.6)	469	(29.5)	807	(28.2)	0.09
Diabetes mellitus in family N (%)	352	(27.7)	489	(30.8)	841	(29.4)	0.08
Smoking N (%)	145	(11.4)	98	(6.2)	243	(8.5)	<0.00001*
Diseases before pregnancy N (%)	388	(30.6)	217	(13.7)	605	(21.2)	<0.00001*
Previous caesarean section N (%)	11	(0.9)	9	(0.6)	20	(0.7)	0.34
Pre-pregnancy diabetes mellitus N (%)	4	(0.3)	16	(1.0)	20	(0.7)	0.03*
Hypertension before pregnancy N (%)	18	(1.4)	16	(1.0)	34	(1.2)	0.30
Spontaneous abortion N (%)	237	(18.7)	286	(18.0)	523	(18.3)	0.64
Previous stillbirth N (%)	14	(1.1)	10	(0.6)	24	(0.8)	0.17
Twins	21	(1.7)	39	(2.4)	60	(2.1)	0.14

N—Absolute number; SD—Standard deviation; %—group share;

*Values of *p* less than 0.05 represent a statistically significant value.

School for parents was visited more frequently in 2011–14 group (1049 women (82.7%)) than in 2015–18 group (1176 (74.0%)), $p < 0.00001$. Screening tests in pregnancy such as nuchal translucency, combined test or uterine artery doppler measurements were performed less frequently in 2011–14 group (1011 women (79.7%)) than in 2015–18 group (1319 women (83.0%)), $p = 0.02$. More women had amniocentesis in 2011–14 group (103 women (8.1%)) than in 2015–18 group (73 women (4.6%)), $p = 0.00001$. However, frequency of chorionic villus sampling (CVS) stayed the same in both groups (11 women (0.9%) vs. 11 women (0.7%), $p = 0.60$). Percentage of pregnancy monitoring in the tertiary hospital was not as high in 2011–14 group (515 women (40.6%)) as in 2015–18 group (1282 women (80.7%)), $p < 0.00001$. Conversely, hospitalisation rate during pregnancy was higher in 2011–14 group (388 women (30.6%)) than in 2015–18 group (307 women (19.3%)), $p < 0.00001$. Rate of hypertension diseases in pregnancy has decreased over time 69 (5.4%) vs. 43 (2.7%) women in 2011–14 group and 2015–18 group, respectively ($p = 0.0002$). Oligohydramnios was more frequently diagnosed in 2011–14 group (122 women (9.6%)) than in 2015–18 group (109 women (6.9%)), $p = 0.007$. More details about pregnancies of women who had labor induction in the period 2011–18 can be found in Table 2.

Artificial bladder perforation (amniotomy) as a method for IOL declined from 765 (60.3%) in the first period to 853 (53.7%) in the second period ($p = 0.0004$). Meconium amniotic fluid occurred considerably less frequently in the second period (161 (12.7%) vs. 140 (8.8%), $p = 0.0008$). Oxytocin use increased from 382 (30.1%) in 2011–14 to 802 (50.5%) in 2015–18 ($p < 0.00001$). Pathological cardiotocographic tracings were seen in 193 (15.2%) pregnant women during the first period and less commonly during the second period (133 pregnant women, 8.4%), $p < 0.00001$. Consequently, fetal scalp blood sampling was less used during the second period (142 pregnant women (11.2%) vs. 114 pregnant women (7.2%), $p = 0.0002$).

During the second period, vacuum extraction was less common (53 pregnant women (4.2%) vs. 45 pregnant women (2.8%), $p = 0.049$). The rate of caesarean sections remained constant (190 pregnant women (15.0%) vs. 264 (16.6%), $p = 0.23$). Episiotomy was performed in 474 women (37.4%) in the first period, and in 462 women (29.1%) in the second period, $p < 0.00001$. In the first period, rupture of the perineum of the second-degree occurred in 73 pregnant women (5.8%), while in the second period this rate was lower (53 pregnant women (3.3%), $p = 0.0018$). The incidence of third-degree perineal laceration thus increased from 0.2% (2 pregnant women) in the first period to 0.8% (12 women) in the second period, $p = 0.02$. There was a significant decline of frequency of umbilical cord prolapses in the second period (15 pregnant women (1.2%) vs. 2 women (0.1%), $p = 0.0003$). More details about course of labor can be found in Table 3. Fig. 2 depicts the parameters that changed statistically significantly across two observation periods.

In the second period (2015–18), infants were delivered sooner on average (39.3 weeks (1.5 week) vs. 39.0 weeks (1.8 weeks), $p = 0.0001$), weighed less (3312.3 g (580.5 g) vs. 3257.5 g (605.1 g), $p = 0.01$), and were in better clinical condition (Apgar score in 5 min: 8.95 (0.74) vs. 9.02 (0.68), $p = 0.08$ (Table 4).

4. Discussion

In terms of IOL indications, women's features, pregnancy peculiarities, labor and delivery outcomes, our study revealed several important differences between two periods.

Table 2. Comparison of pregnancy events in pregnant women with induction of labor between the periods 2011–14 and 2015–18 at the University Medical Center Maribor.

	2011–14 N = 1269		2015–18 N = 1589		2011–18 N = 2858		*p* value
School for parents N (%)	1049	(82.7)	1176	(74.0)	2225	(77.9)	<0.00001*
Screening tests in pregnancy N (%)	1011	(79.7)	1319	(83.0)	2330	(81.5)	0.02*
Amniocentesis N (%)	103	(8.1)	73	(4.6)	176	(6.2)	0.0001*
CVS N (%)	11	(0.9)	11	(0.7)	22	(0.8)	0.60
Pregnancy surveillance in tertiary center N (%)	515	(40.6)	1282	(80.7)	1797	(62.9)	<0.00001*
Hospitalisation during pregnancy N (%)	388	(30.6)	307	(19.3)	695	(24.3)	<0.00001*
Hypertension in pregnancy N (%)	69	(5.4)	43	(2.7)	112	(3.9)	0.0002*
Gestational diabetes mellitus N (%)	323	(25.5)	410	(25.8)	733	(25.6)	0.83
IUGR N (%)	185	(14.6)	231	(14.5)	416	(14.6)	0.98
Polyhydramnios N (%)	38	(3.0)	62	(3.9)	100	(3.5)	0.19
Oligohydramnios N (%)	122	(9.6)	109	(6.9)	231	(8.1)	0.007*
External cephalic version N (%)	6	(0.5)	14	(0.9)	20	(0.7)	0.19
Corticosteroids for lung maturation during pregnancy N (%)	21	(1.7)	26	(1.6)	47	(1.6)	0.97

*Values of *p* less than 0.05 represent a statistically significant value;

IUGR—Intrauterine growth restriction; CVS—Chorionic villus sampling; N—Absolute number; %—group share.

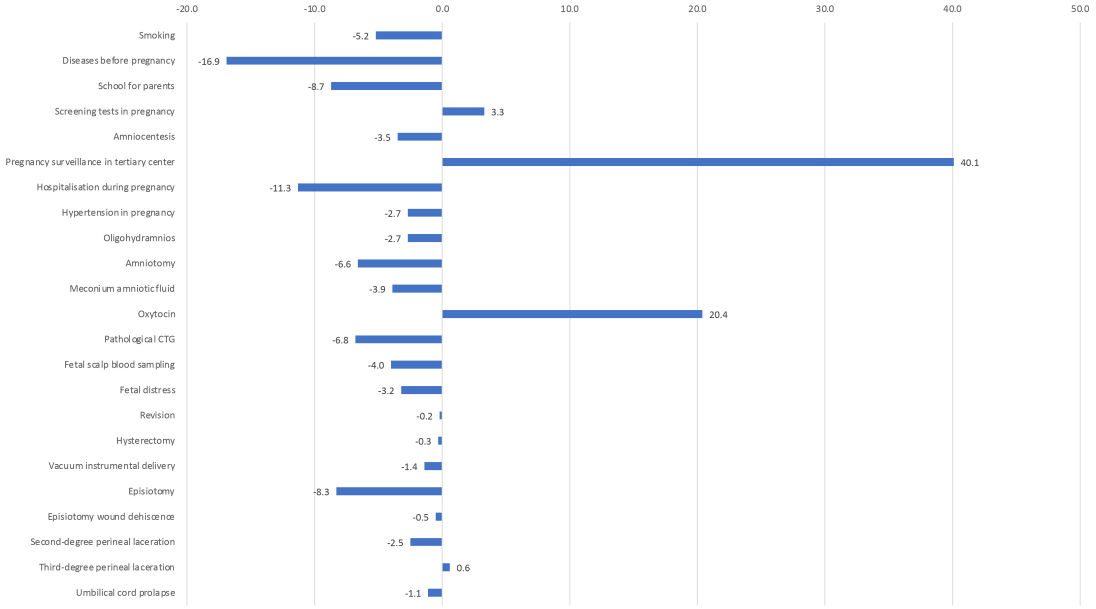

Fig. 2. Depicts the parameters that changed statistically significantly across two observation periods.

There were 292 (3.4%) fewer births in the second period similar to the overall trend in Slovenia [12]. However, the decline in the number of births in Slovenia as a whole was larger than in our department. The delay of choices on the birth of the first child and the decline in the number of women of reproductive age (15–49 years) as a result of birth rates could be the two most important factors for the decrease in the number of births in Slovenia during the previous decade [13]. Pallikadavath *et al.* [13,14] identified similar reasons in Western world for this trend.

The average age of mothers at birth increased from 29.7 years to 30.0 years in the second period. This tendency was even more pronounced at the national level, where pregnant women were on average 0.7 years older than women in labor at UKC Maribor over the same time period [15]. This is also consistent with the growing average age of women giving birth that has been seen in Western society in recent decades [16]. However, the observed trend of growing maternal age in Slovenia has begun to decrease in comparison to the last forty years, with the average age of mothers at birth increasing by only one year in the previous decade [12,15,16].

Between 2011 and 2018, the prevalence of labor induction in our department was 16.8%, close to the national average of 17.0% but lower than that of other developed nations (25%) [17,18]. However, the rate of IOL in Europe varies greatly by area or nation, ranging from 6.8% in Lithuania to 33.0% in Wallonia (Belgium) [19]. How-

Table 3. Comparison of the frequency of events during childbirth in pregnant women with induction of labor between the periods 2011–14 and 2015–18 at the University Medical Center Maribor.

	2011–14		2015–18		2011–18		*p* value
	N = 1269		N = 1589		N = 2858		
Amniotomy N (%)	765	(60.3)	853	(53.7)	1618	(56.6)	0.0004*
Meconium amniotic fluid N (%)	161	(12.7)	140	(8.8)	301	(10.5)	0.0008*
Oxytocin N (%)	382	(30.1)	802	(50.5)	1184	(41.4)	<0.0001*
Pathological CTG N (%)	193	(15.2)	133	(8.4)	326	(11.4)	<0.0001*
Fetal scalp blood sampling N (%)	142	(11.2)	114	(7.2)	256	(9.0)	0.0002*
Fetal distress N (%)	107	(8.4)	83	(5.2)	190	(6.6)	0.0006*
Shoulder distocia N (%)	3	(0.2)	1	(0.1)	4	(0.1)	0.21
Labor arrest N (%)	85	(6.7)	94	(5.9)	179	(6.3)	0.39
Caesarean section N (%)	190	(15.0)	264	(16.6)	454	(15.9)	0.23
Laparotomy wound dehiscence N (%)	1	(0.1)	0	(0.0)	1	(0.0)	0.26
Thromboembolic complications N (%)	0	(0.0)	0	(0.0)	0	(0.0)	-
Wound infection N (%)	2	(0.2)	6	(0.4)	8	(0.3)	0.27
Revision N (%)	3	(0.2)	0	(0.0)	3	(0.1)	0.05*
Hysterectomy N (%)	4	(0.3)	0	(0.0)	4	(0.1)	0.02*
Amniotic fluid embolism N (%)	1	(0.1)	0	(0.0)	1	(0.0)	0.26
Postpartum hemorrhage N (%)	17	(1.3)	12	(0.8)	29	(1.0)	0.12
Atony N (%)	5	(0.4)	5	(0.3)	10	(0.3)	0.72
Vacuum instrumental delivery N (%)	53	(4.2)	45	(2.8)	98	(3.4)	0.049*
Episiotomy N (%)	474	(37.4)	462	(29.1)	936	(32.8)	<0.0001*
Episiotomy wound dehiscence N (%)	10	(0.8)	5	(0.3)	15	(0.5)	0.08*
Uterus rupture N (%)	2	(0.2)	0	(0.0)	2	(0.007)	0.44
First-degree perineal laceration N (%)	307	(24.2)	389	(24.5)	696	(24.4)	0.85
Second-degree perineal laceration N (%)	73	(5.8)	53	(3.3)	126	(4.4)	0.0018*
Third-degree perineal laceration N (%)	2	(0.2)	12	(0.8)	14	(0.5)	0.02*
Forth-degree perineal laceration N (%)	1	(0.1)	2	(0.1)	3	(0.1)	0.70
Perineal laceration — all N (%)	383	(30.2)	456	(28.7)	839	(29.4)	0.39
Birth path laceration N (%)	442	(34.8)	517	(32.5)	959	(33.6)	0.20
Manual removal of placenta N (%)	20	(1.6)	15	(0.9)	35	(1.2)	0.13
Hysterectomy N (%)	1	(0.1)	0	(0.0)	1	(0.0)	0.26
Abrasion N (%)	12	(0.9)	9	(0.6)	21	(0.7)	0.24
Umbilical cord prolapse N (%)	15	(1.2)	2	(0.1)	17	(0.6)	0.0003*

N—Absolute number; %—group share; CTG—Cardiotocography;

*Values of *p* less than 0.05 represent a statistically significant value.

Table 4. Comparison of data on newborns of women in labor after induction between periods 2011–14 and 2015–18 in the University Medical Center Maribor.

	2011–14		2015–18		2011–18		*p* value
	N = 1269		N = 1589		N = 2858		
Birth weight below 1800 g N (%)	10	(0.8)	15	(1.2)	25	(0.8)	0.67
Birth weight (g) Average (SD)	3312.3	(580.5)	3257.5	(605.1)	3281.8	(594.8)	0.013*
Birth length (cm) Average (SD)	49.8	(2.5)	49.6	(2.8)	49.7	(2.6)	0.04*
Gestational age (weeks) Average (SD)	39.3	(1.5)	39.0	(1.8)	39.2	(1.7)	0.0001*
APGAR at 1 minute Average (SD)	8.42	(1.14)	8.45	(1.08)	8.44	(1.11)	0.46
APGAR at 5 minutes Average (SD)	8.95	(0.74)	9.02	(0.68)	8.99	(0.70)	0.008*
APGAR at 10 minutes Average (SD)	9.18	(0.60)	9.28	(0.75)	9.22	(0.66)	0.0001*

N—Absolute number; SD—standard deviation; %—share in the group;

*Values of *p* less than 0.05 represent a statistically significant value.

ever, as compared to the rest of the world (9.6%), Slovenia had a higher IOL rate. According to the WHO, African countries have the lowest rate of introduction (Nigeria 1.4%), whereas Asian and Latin American countries have the greatest (Sri Lanka 35.5%) [18].

Simultaneously with the decrease in the number of newborns at the University Medical Center Maribor, there was a rise in the rate of IOL in the later period (14.7% vs. 19.0%, $p < 0.00001$), similar to the whole Slovenia (2013 16.3% and 2017 19.0%) [19]. This increase in IOL rates was even more pronounced at NHS hospitals in the United Kingdom, where IOL rates climbed from 20.4% to 32.6% between 2007 and 2018 [20]. In Australia, every third pregnant woman was induced, with the proportion of induced births increasing from 21.3 % to 30.9% between 2012 and 2017 [21]. A rise in the number of induced births is considered to be related to an increase in the incidence of pregnancy complications. The rise in the number of problematic pregnancies might be linked to an increase in the age of women in labor and changes in their health state, both of which are harmed by the popularity of the Western lifestyle [22].

Prenatal diabetes increased from 0.3% to 1.0% ($p = 0.03$) over the studied periods. Increased weight, reduced physical activity, and increased stress on one hand, and changes in diagnostic criteria on the other, might be the cause of this global trend [23,24]. Coton *et al*. [25] discovered a rise in prenatal diabetes among women in labor in the United Kingdom, where the frequency was 2.34 per 1000 births in 2015 and 10.62 per 1000 pregnancies in 2012. A considerable increase in the prevalence of type 2 diabetes contributed considerably to the increase in the number of women with prenatal diabetes. Women with prenatal diabetes were older and had a higher mean BMI than healthy pregnant women. The implications of an increasing number of diabetic women are mirrored in an increasing proportion of unhealthy pregnancies, which can increase the IOL rate even more. The primary aims of inducing labor in a diabetic pregnant woman are to prevent stillbirth and fetal overgrowth in the uterus, as well as associated problems such as increased perinatal mortality, shoulder dystocia, delivery trauma, and the necessity for caesarean section [24].

Women smoked less in the later period (2015–18) (11.4% vs. 6.2%, $p < 0.00001$). The drop in the proportion reflects the decrease in the incidence of smoking among pregnant women in general. In Slovenia, 11.0% of pregnant women smoked in 2010, and this figure decreased to 9.5% in 2015, still higher than the European average (5–8%) [25].

In the later period (2015–18), more women had screening tests (79.7% vs. 83.0%, $p = 0.02$). Because of the concern of problems associated to the invasive procedure itself, increased availability of combination test and cf-DNA testing in the first trimester of pregnancy also impacted a substantial reduction in the number of amniocentesis (8.1% vs. 4.6%, $p = 0.0001$) [26]. Surprisingly, the CVS rate remained constant during the study period (0.9% vs. 0.7%, $p = 0.60$). Primary maternal education and a history of more than two losses were revealed to be independent significant predictors of decreased amniocentesis by Sadecki *et al*. [27]. Women with individualized risk ratings for trisomy 21 more than 1:100 opted out of invasive prenatal diagnostics much less frequently than the rest participants in their research [27].

More women were referred to tertiary care during pregnancy in the later period (40.6% to 80.7%, ($p < 0.00001$). This trend could be the consequence of an increase of gestational diabetes in pregnancy. Due to changes in the diagnostic criteria, based on data from the international study The Hyperglycemia and Adverse Pregnancy Outcomes (HAPO), we can expect an increase in the incidence of gestational diabetes from 6% to 18% of all pregnancies [28]. Other possible reason for the increase in tertiary care referrals was the increase of availability of clinics for high-risk pregnancy, making the referrals much easier. Increased quality management out of hospital could be the reason for decreased number of hospitalisations (30.6% vs. 19.3%, $p < 0.0001$).

Surprisingly, the proportion of induced women who were diagnosed with hypertension in pregnancy decreased from 5.4% to 2.7% between 2011–14 and 2015–18. This trend could be consequence of larger introduction of uterine doppler screening for hypertensive diseases in the first trimester according to the Fetal Medicine Foundation criteria and prophylactic use of aspirin [29].

In 2011–14, oligohydramnios was the fourth most common reason for beginning delivery; however, in 2015–18, it was the sixth most prevalent reason (9.6% vs. 6.9%, $p = 0.007$). The reasons may lay in more strict diagnostic criteria for oligohydramnios in the second period [30]. According to Zilberman *et al.* [31], non-reassuring monitors necessitating prompt delivery and a poorer composite neonatal outcome were more likely in severe oligohydramnios than in mild or moderate oligohydramnios.

The diagnosis of postterm pregnancy as an indication for IOL declined between 2011–14 and 2015–18. Prolonged pregnancy accounted for 3.28% of all indicators in the first period studied, but only 1.85% in the second period. To reduce the risk of complications associated with postterm pregnancy, the 2008 NICE guidelines advocate inducing labor between 41 and 42 weeks of gestation in women with uncomplicated pregnancies [32]. This approach might explain the decline in meconium amniotic fluid rates (12.7% to 8.8%, $p = 0.0008$), which is already reported in the literature [33]. The same can be assumed for the decrease in the rate of abnormal CTGs (15.2% vs. 8.4%, $p = 0.0001$), the rate of fetal scalp blood sampling (11.2% vs. 7.2%, $p = 0.0002$), and the rate of fetal distress (8.4% vs. 5.2%, $p = 0.0006$). In Slovenia, the attitude to induction of labor for women with postterm pregnancies is moderate, not very cautious or forceful [34].

Percentage of artificial bladder perforation or amniotomy as a method of induction of labor between 2011–2014 and 2015–2018 declined from 60.3% to 53.7% (p = 0.0004). The explanation may be traced back to a more cautious approach to pregnancies in which cervical dilation had already occurred, allowing for spontaneous labor. According to the 2008 NICE recommendations, single amniotomies or amniotomies combined with oxytocin are not advised as the primary way of inducing labor, except in rare clinical circumstances when the use of vaginal PGE2 is contraindicated [32]. A decrease in the incidence of amniotomies as an induction method might potentially explain the larger decline in the frequency of umbilical cord prolapse (1.2% vs. 0.1%, p = 0,0003). Wong at al, on the other hand, emphasized that umbilical cord prolapse can occur with either ruptured or intact membranes. As a result, they proposed a new vocabulary for describing umbilical cord prolapse: cord prolapse, cord presentation, and compound cord presentation, which should be characterized based on the positional connection between the chord, the fetal presenting part, and the cervix [35].

In contrast to the amniotomy trend, oxytocin for labor stimulation was administered to 30.1% of all women who had labor induction between 2011 and 2014, and this rose to 50.5% between 2015 and 2018. However, according to WHO guidelines, oxytocin should be used to induce labor only when prostaglandins are not available or are contraindicated as a technique of IOL [36]. This is in line with NICE recommendations, which say that oxytocin should not be used as the only way of inducing labor.

We also discovered a declining tendency for superficial perineum lacerations (5.8% vs. 3.3%, p = 0.0018) and episiotomy (37.4% vs. 29.1%, $p < 0.00001$). Even in the preceding decade, a conservative tendency toward episiotomies was observed on a nationwide basis (from 51.0% to 36.1% in 2004 and 2010 year, respectively) [19]. Many studies have revealed that episiotomies do not prevent perineum lacerations [37]. There was a modest rise in the rate of 3rd and 4th degree lacerations. We believe that this was due to greater attention to the problem rather than an increase in the frequency of this event [38].

There was a tendency for fewer vacuum instrumental deliveries (4.2% vs. 2.8%, p = 0.049). Slovenia has a vacuum rate of about 5% for all pregnancies, which is significantly lower than in other nations, given that forceps are rarely utilized as a mean of instrumental delivery [39]. This decrease may indicate that a cautious approach to instrumental delivery may be beneficial.

Despite the fact that inductions were performed on average earlier, the clinical circumstances of the newborns were better, with clinically insignificant differences in weight. According to the findings of Allen *et al.* [40], a rise in post-term induction of labor with time was related with a substantial increase in severe newborn morbidity, particularly among children delivered to multiparous women.

Our research has several limitations. When opposed to prospective investigations, its retrospective nature provides a lower degree of evidence. The inclusion of all pregnant women with IOL at our department during the study period reduced selection bias. Retrospective studies are prone to confounding and can only assess correlation, not causation. Our data represents a single institution's experience, and our conclusions reflect local practice and cannot be generalized.

5. Conclusions

There is a tendency toward increased IOL rates, which may be related to older average age of pregnant women and potential pregnancy problems. Because of the new recommendations for postterm pregnancies, it is predicted that this trend will continue in the future. On the other hand, the rise in induction rate, is extremely unlikely to be related to an unfavorable course and outcome of labor and deliveries.

Author contributions

FM designed the research study. AO and SP performed the research and analyzed the data equally. AO, SP and FM wrote the manuscript. FM and VA reviewed the script. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was part of a larger study approved by the Institutional Review Board of UMC Maribor (Reg. No. UKC-MB-KME 50/20). All patients signed a written informed consent form to allow the use of their medical records retrospectively for research purposes.

Acknowledgment

We would like to acknowledge Saša Nikolić for her help in providing the data from a national registry and preparing them in a suitable format.

Funding

This research received no external funding.

Conflict of interest

The authors declare no conflict of interest.

References

[1] Seijmonsbergen-Schermers AE, van den Akker T, Rydahl E, Beeckman K, Bogaerts A, Binfa L, *et al*. Variations in use of childbirth interventions in 13 high-income countries: A multinational cross-sectional study. PLoS Medicine. 2020; 17: e1003103.

[2] Drife JO. The history of labour induction: how did we get here?

Best Practice & Research Clinical Obstetrics & Gynaecology. 2021; 77: 3–14.
[3] Middleton P, Shepherd E, Morris J, Crowther CA, Gomersall JC. Induction of labour at or beyond 37 weeks' gestation. Cochrane Database of Systematic Reviews. 2020: CD004945.
[4] Kerbage Y, Senat MV, Drumez E, Subtil D, Vayssiere C, Deruelle P. Risk factors for failed induction of labor among pregnant women with Class III obesity. Acta Obstetricia Et Gynecologica Scandinavica. 2020; 99: 637–643.
[5] Alfirevic Z, Kelly AJ, Dowswell T. Intravenous oxytocin alone for cervical ripening and induction of labour. Cochrane Database of Systematic Reviews. 2009; 2009: CD003246.
[6] Kawakita T, Grantz KL, Landy HJ, Huang CC, Kominiarek MA. Induction of Labor in Women with Oligohydramnios: Misoprostol Compared with Prostaglandin E2. American Journal of Perinatology. 2017; 34: 204–210.
[7] Tsakiridis I, Mamopoulos A, Athanasiadis A, Dagklis T. Induction of Labor: an Overview of Guidelines. Obstetrical & Gynecological Survey. 2020; 75: 61–72.
[8] Sandberg EM, Schepers EM, Sitter RLV, Huisman CMA, Wijngaarden WJV. Foley catheter for induction of labour filled with 30 mL or 60 mL: a randomized controlled trial. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2017; 211: 150–155.
[9] Souter V, Painter I, Sitcov K, Caughey AB. Maternal and newborn outcomes with elective induction of labor at term. American Journal of Obstetrics and Gynecology. 2019; 220: 273.e1–273.e11.
[10] Sealed Envelope Ltd. Power calculator for binary outcome superiority trial. 2012. Available at: https://www.sealedenvelope.com/power/binary-superiority/ (Accessed: 26 October 2021).
[11] Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, *et al*. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011; 343: d5928.
[12] Perinatal information system. National Institute of Public Health. 2020. Available at: https://www.nijz.si/sl/podatki/perinatalni-informacijski-sistem (Accessed: 20 August 2020).
[13] Ljubljana: National Institute of Public Health. Health Statistical Yearbook of Slovenia 2018. 2020. Available at: https://www.nijz.si/sl/publikacije/zdravstveni-statisticni-letopis-2018 (Accessed: 12 July 2021).
[14] Pallikadavath S, Rajan SI, Wilson C. Low fertility in developing countries: causes and implications. Journal of Biosocial Science. 2017; 49: S1–S3.
[15] Rudolf A, Mihevc Ponikvar B. Births and births in Slovenia 2016–2018. Ljubljana: National Institute of Public Health. 2020. Available at: https://www.nijz.si/sites/www.nijz.si/files/publikacije-datoteke/porodi_in_rojstva_v_sloveniji_2007-2018.pdf (Accessed: 12 July 2021).
[16] Mills M, Rindfuss RR, McDonald P, te Velde E. Why do people postpone parenthood? Reasons and social policy incentives. Human Reproduction Update. 2011; 17: 848–860.
[17] Bezjak K. Induction of labour and birth outcomes - data analysis for Slovenia: diploma work. Ljubljana: University of Ljubljana. 2019. Available at: https://repozitorij.uni-lj.si/IzpisGradiva.php?id=112843&lang=eng (Accessed: 28 December 2021).
[18] World Health Organization. WHO recommendations: Induction of labour at or beyond term. 2015. Available at: https://apps.who.int/iris/bitstream/handle/10665/277233/9789241550413-eng.pdf?ua=1 (Accessed: 7 July 2021).
[19] The health and care of pregnant women and babies in Europe in 2010. European Perinatal Health Report 2010. 2013. Available at: https://www.europeristat.com/index.php/reports/european-perinatal-health-report-2010.html (Accessed: 12 July 2021).
[20] Leeds: NHS Digital. NHS Maternity Statistics, England 2017-18. 2018. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-maternity-statistics/2017-18 (Accessed: 12 July 2021).
[21] Artuso H, Davis DL. Trends and characteristics of women undergoing induction of labour in a tertiary hospital setting: a cross-sectional study. Women and Birth. 2021. (in press)
[22] European Perinatal Health Report. Core indicators of the health and care of pregnant women and babies in Europe in 2015. 2015. Available at: https://www.europeristat.com/index.php/reports/european-perinatal-health-report-2015.html (Accessed: 12 July 2021).
[23] Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004; 27: 1047–1053.
[24] Berger H, Melamed N. Timing of delivery in women with diabetes in pregnancy. Obstetric Medicine. 2014; 7: 8–16.
[25] Coton SJ, Nazareth I, Petersen I. A cohort study of trends in the prevalence of pregestational diabetes in pregnancy recorded in UK general practice between 1995 and 2012. BMJ Open. 2016; 6: e009494.
[26] Miltoft CB, Rode L, Ekelund CK, Sundberg K, Kjaergaard S, Zingenberg H, *et al*. Contingent first-trimester screening for aneuploidies with cell-free DNA in a Danish clinical setting. Ultrasound in Obstetrics & Gynecology. 2018; 51: 470–479.
[27] Sadlecki P, Grabiec M, Walentowicz P, Walentowicz-Sadlecka M. Why do patients decline amniocentesis? Analysis of factors influencing the decision to refuse invasive prenatal testing. BMC Pregnancy and Childbirth. 2018; 18: 174.
[28] Mussa J, Meltzer S, Bond R, Garfield N, Dasgupta K. Trends in National Canadian Guideline Recommendations for the Screening and Diagnosis of Gestational Diabetes Mellitus over the Years: A Scoping Review. International Journal of Environmental Research and Public Health. 2021; 18: 1454.
[29] Rolnik DL, Nicolaides KH, Poon LC. Prevention of preeclampsia with aspirin. American Journal of Obstetrics and Gynecology. 2020. (in press)
[30] Moise KJ. Toward consistent terminology: assessment and reporting of amniotic fluid volume. Seminars in Perinatology. 2014; 37: 370–374.
[31] Zilberman Sharon N, Pekar-Zlotin M, Kugler N, Accart Z, Nimrodi M, Melcer Y, Cuckle H, Maymon R. Oligohydramnios: how severe is severe? The Journal of Maternal-fetal & Neonatal Medicine. 2021; 1: 1–7.
[32] NICE. National Collaborating Centre for Women's and Children's Health. Induction of labour: NICE Clinical Guideline. 2nd Ed. 2008. Available at: https://www.nice.org.uk/guidance/cg70/evidence/full-guideline-pdf-241871149 (Accessed: 12 July 2021).
[33] Yoder BA, Kirsch EA, Barth WH, Gordon MC. Changing obstetric practices associated with decreasing incidence of meconium aspiration syndrome. Obstetrics and Gynecology. 2002; 99: 731–739.
[34] Obreza K, Verdenik I, Mivšek AP. Analysis of post-term pregnancy management in Slovenia in 2012. Obzornik Zdravstvene Nege. 2017; 51: 219–225.
[35] Wong L, Kwan AHW, Lau SL, Sin WTA, Leung TY. Umbilical cord prolapse: revisiting its definition and management. American Journal of Obstetrics and Gynecology. 2021; 225: 357–366.
[36] World Health Organization. WHO recommendations: Induction of labour at or beyond term. 2015. Available at: https://apps.who.int/iris/bitstream/handle/10665/277233/9789241550413-eng.pdf?ua=1 (Accessed: 12 July 2021).
[37] Clesse C, Cottenet J, Lighezzolo-Alnot J, Goueslard K, Scheffler M, Sagot P, *et al*. Episiotomy practices in France: epidemiology and risk factors in non-operative vaginal deliveries. Scientific Reports. 2020; 10: 20208.

[38] Sioutis D, Thakar R, Sultan AH. Overdiagnosis and rising rate of obstetric anal sphincter injuries (OASIS): time for reappraisal. Ultrasound in Obstetrics & Gynecology. 2017; 50: 642–647.
[39] Goordyal D, Anderson J, Alazmani A, Culmer P. An engineering perspective of vacuum assisted delivery devices in obstetrics: a review. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine. 2021; 235: 3–16.
[40] Allen VM, Stewart A, O'Connell CM, Baskett TF, Vincer M, Allen AC. The Influence of Changing Post-Term Induction of Labour Patterns on Severe Neonatal Morbidity. Journal of Obstetrics and Gynaecology Canada. 2012; 34: 330–340.