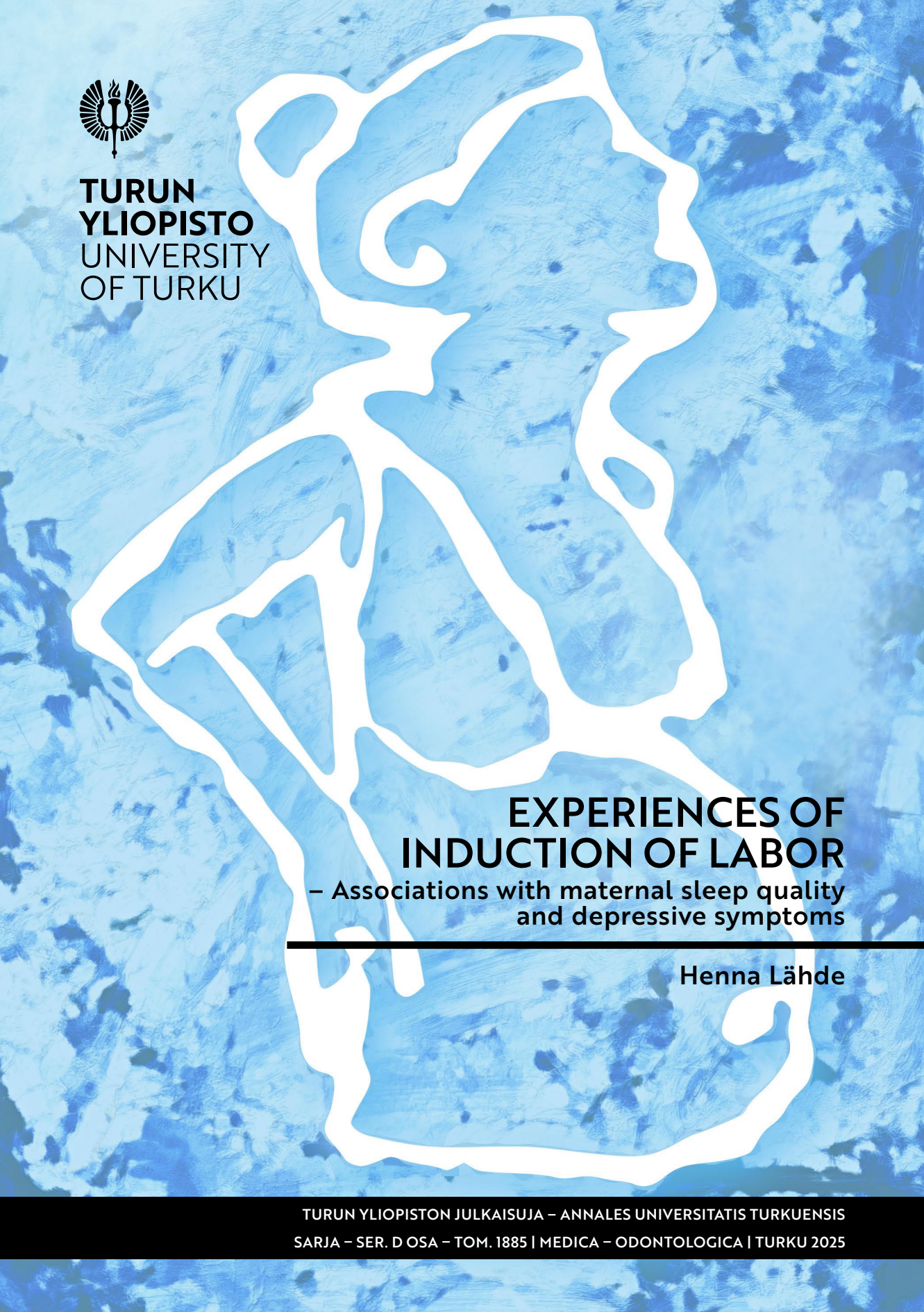

TURUN YLIOPISTO
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EXPERIENCES OF INDUCTION OF LABOR

– Associations with maternal sleep quality and depressive symptoms

Henna Lähde

TURUN YLIOPISTON JULKAISUJA – ANNALES UNIVERSITATIS TURKUENSIS
SARJA – SER. D OSA – TOM. 1885 | MEDICA – ODONTOLOGICA | TURKU 2025

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University of Turku

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The originality of this publication has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

Cover Image: Henna Lähde and Heikki Halkosaari

ISBN 978-952-02-0201-9 (PRINT)
ISBN 978-952-02-0202-6 (PDF)
ISSN 0355-9483 (Print)
ISSN 2343-3213 (Online)
Painosalama, Turku, Finland 2025

To my family

UNIVERSITY OF TURKU
Faculty of Medicine
Institute of Clinical Medicine, Department of Obstetrics and Gynecology
HENNA LÄHDE: Experiences of Induction of Labor – Associations with Maternal Sleep Quality and depressive Symptoms
Doctoral Dissertation, 165 pp.
Doctoral Programme in Clinical Research
June 2025

ABSTRACT

The experience of labor (EOL) has immediate and long-lasting implications for the well-being of the mother, the infant, and the entire family. Induction of labor (IOL) rates are rising and approximately one third of the labors are induced. However, women with IOL have higher risk of a negative EOL than women with spontaneous onset of labor (SOL). In addition, during pregnancy, maternal sleep quality typically deteriorates, and depressive symptoms become frequent, so both symptoms may interfere with the EOL.

This thesis addresses associations between maternal sleep quality and depressive symptoms during pregnancy, general experiences of labor and experiences of IOL. The importance of the IOL setting (outpatient [OP] or inpatient [IP]) was evaluated. Two different study cohorts were studied, the FinnBrain Birth Cohort Study (Studies I and II and the Clinical Hospital Cohort Study (Studies III and IV). The FinnBrain Birth Cohort Study was a longitudinal follow-up study of low-risk full-term pregnancies. The Study I, which included 1778 women (IOL group n=331, SOL group n=1447), aimed to evaluate whether sleep quality is associated with the likelihood of ending with IOL. The Study II, which included 2405 women (IOL group n=419, SOL group n=1876), aimed to evaluate whether sleep quality and depressive symptoms during pregnancy are associated with the EOL. The Clinical Hospital Cohort Study was a randomized controlled trial (RCT) that included 117 women with full-term non-complicated pregnancies scheduled for IOL, which was carried out with a catheter. Experiences during and after IOL were assessed using Visual Analogue Scale (VAS) questionnaires. The aim in Study III was to evaluate the experiences of catheter IOL in OP and IP settings. The aim in Study IV was to evaluate the experiences of IOL and its associations with maternal sleep quality and depressive symptoms.

While deterioration in sleep quality was noticeable in pregnant women, it was unconnected to the likelihood to ending with IOL. Compared to women with SOL, those with IOL reported a poorer EOL. Furthermore, sleep disturbances and depressive symptoms *per se* were connected with a poorer EOL. Women with sleep disturbances were more likely to report more negative experiences during the catheter IOL. And additionally, although catheter IOL was well accepted in both settings, women in the OP setting were less satisfied and more anxious than those in the IP setting.

In conclusion, IOL is associated with a poorer EOL. The results of this thesis also highlight the association between maternal sleep disturbances and depressive symptoms during pregnancy and a poorer EOL, with symptomatic women reporting a more negative EOL. Therefore, the preferences and experiences of the women themselves should lead decisions regarding IOL.

KEYWORDS: acceptance, childbirth experience, depression, depressive symptoms, experience of labor, induction of labor, inpatient, insomnia women, pregnant, outpatient, satisfaction, sleep disturbances, sleepiness, sleep quality

TURUN YLIOPISTO
Lääketieteellinen tiedekunta
Kliininen laitos, Synnytys- ja naistentautioppi
HENNA LÄHDE: Äidin unen laadun ja masennusoireiden yhteys synnytyksen käynnistämiseen ja käynnistyskokemukseen
Väitöskirja, 165 s.
Turun kliininen tohtoriohjelma
Kesäkuu 2025

TIIVISTELMÄ

Synnytyskokemuksella on vaikutuksia äidin, vastasyntyneen ja koko perheen hyvinvointiin. Synnytyksen käynnistykset ovat lisääntyneet ja nykyään noin joka kolmas synnytys käynnistetään. Synnytyksen käynnistys on kuitenkin yhdistetty huonompaan synnytyskokemukseen verrattaessa itsestään käynnistyneisiin synnytyksiin. Raskauden aikana äidin unen laatu huononee ja masennusoireet yleistyvät ja myös näillä oireilla voi olla vaikutusta synnytyskokemukseen.

Tässä väitöskirjassa selvitettiin äidin koetun unen laadun ja masennusoireiden yhteyttä toisaalta synnytyskokemukseen yleensä ja toisaalta synnytyksen käynnistys-kokemukseen. Lisäksi selvitettiin käynnistyksen toteutuspaikan (koti vs. sairaala) merkitystä. Väitöskirja koostui kahdesta kohortista, FinnBrain syntymäkohortista ja Kliinisestä sairaalakohortista. FinnBrain-tutkimus oli pitkittäinen seurantatutkimus naisilla, joilla oli täysiaikainen raskaus. I osatyöhön osallistui 1778 naista (käynnistys-ryhmä n=331 ja itsestään käynnistyneiden ryhmä n=1447). Työssä selvitettiin, onko unenlaadulla yhteys siihen, että synnytys päätyy käynnistykseen. II osatyöhön osallistui 2405 naista (käynnistysryhmä n=419 ja itsestään käynnistyneiden ryhmä n=1 876). Tutkimuksen tarkoituksena oli selvittää, onko unenlaadulla ja masennusoireilla yhteys synnytyskokemukseen. Kliiniseen sairaalakohorttitutkimukseen (osatyöt III ja IV) värvättiin 117 tervettä täysiaikaisesti raskaana olevaa naista, jotka tulivat sairaalaan suunniteltuun synnytyksen käynnistykseen. Käynnistys toteutettiin katetrilla. Naiset arvottiin kahteen ryhmään: joko kotona tai sairaalassa toteutettavaan käynnistykseen. Synnytyksen käynnistyskokemusta selvitettiin käynnistyksen aikana ja synnytyksen jälkeen kyselykaavakkeilla. Osatyössä III verrattiin kotona toteutettavaa synnytyksen käynnistyskokemusta sairaalassa toteutettuun. Osatyössä IV selvitettiin äidin unen laadun ja masennusoireiden yhteyttä katetrikäynnistyskokemukseen.

Verrattuna itsestään käynnistyneeseen synnytykseen, synnytyskokemus oli huonom-pi, jos synnytys oli käynnistetty. Myös äidin uniongelmat ja masennusoireet olivat yhteydessä huonompaan synnytyskokemukseen. Lisäksi uniongelmat olivat yhteydessä huonompaan katetrikäynnistyskokemukseen. Vaikka käynnistyskokemus oli hyvä, niin kotona olleet naiset olivat hieman tyytymättömämpiä ja ahdistuneempia käynnistyksen aikana kuin ne naiset, joiden käynnistys toteutettiin sairaalassa.

Yhteenvetona voidaan todeta, että synnytyksen käynnistäminen on yhteydessä huonompaan synnytyskokemukseen. Myös uni- ja masennusoireista kärsivät naiset ilmoittavat synnytyskokemuksensa olevan huonompi. Äidin toiveisiin ja kokemuksiin tulisikin kiinnittää huomiota synnytyksen käynnistystä suunniteltaessa.

AVAINSANAT: nainen, masennus, masennusoireet, polikliininen synnytyksen käynnistäminen, raskaus, synnytys, synnytyskokemus, synnytyksen käynnistäminen, tyytyväisyys, uneliaisuus, unenlaatu, unettomuus, unihäiriöt, väsymys.

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Abbreviations

ACOG	American College of Obstetricians and Gynecologists
AOR	Adjusted odds ratio
BMI	Body mass index
BNSQ	Basic Nordic Sleep Questionnaire
CEQ	Childbirth Experience Questionnaire
CI	Confidence interval
CS	Cesarean section
CTG	Cardiotocography
EOL	Experience of labor
EPDS	Edinburgh Postnatal Depression Scale
FHR	Fetal heart rate
FMBR	Finnish Medical Birth Register
GBS	Group B Streptococcus (Streptococcus agalactiae)
GW	Gestational week
HR	Hazard ratio
IP	Inpatient
IOL	Induction of labor
LADSI	Labour and Delivery Satisfaction Index
MCR	Mechanical cervical ripening
NICE	National Institute for Health and Care Excellence
NICU	Neonatal intensive care unit
NO	Nitric oxide
OP	Outpatient
OR	Odds ratio
PG	Prostaglandin
PGE	Prostaglandin E
RCT	Randomized controlled trial
PROM	Premature rupture of membranes
PSQI	Pittsburgh Sleep Quality Index
PTSD	Posttraumatic stress disorder
RR	Risk ratio

SDB	Sleep disordered breathing
SOL	Spontaneous onset of labor
VAS	Visual Analogue Scale
WHO	World Health Organization

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Lähde H, Karlsson H, Karlsson L, Perasto L, Varis V, Rinne K, Paavonen EJ, Polo-Kantola P. Sleep disturbances in late pregnancy: associations with induction of labor. *Archives of Gynecology and Obstetrics.* 2024;310:2045–2053.

II Lähde H, Karlsson H, Karlsson L, Perasto L, Ilvonen R, Rinne K, Paavonen EJ, Polo-Kantola P. Experience of labor in women with induced and spontaneous labor: associations with sleep disturbances and depressive symptoms. (*Manuscript*)

III Haavisto H, Polo-Kantola P, Anttila E, Kolari T, Ojala E, Rinne K. Experiences of induction of labor with a catheter – a prospective randomized controlled trial comparing the outpatient and inpatient setting. *Acta Obstetricia et Gynecologica Scandinavica.* 2021;100:410–417.

IV Haavisto H, Rinne K, Kolari T, Anttila E, Ojala E, Polo-Kantola P. Depressive symptoms and sleep disturbances in late pregnancy: associations with experience of induction of labor with a catheter. *European Journal of Obstetrics & Gynecology and Reproductive Biology.* 2023;283:25–31.

1 Introduction

Induction of labor (IOL) is a medical procedure used to initiate labor before it begins spontaneously. IOL rates are rising and in developed countries, approximately 30 % of labors are induced.[1,2] IOL is typically recommended for medical reasons, such as post-term pregnancy and premature rupture of membranes (PROM), pregnancy complications, like preeclampsia and gestational diabetes, and other maternal and fetal health concerns.[2,3,4] In some cases IOL is elective, meaning that it is performed without a distinct medical reason but may be requested by women because of, for example maternal tiredness or family reasons.[5,6] IOL is usually performed in an inpatient (IP) setting in hospital using mechanical method, such as a catheter, or with medical method, such as prostaglandin or oxytocin. However, IOL is increasingly performed in outpatient (OP) setting using prostaglandin[7] or catheter, the latter being more commonly used in Finland.[8,9]

Childbirth is a unique moment in a woman's life and can range from being a transformative life experience to a severely traumatizing event. Thus, the experience of labor (EOL) is a complex combination of physical, psychological, emotional and social elements that are accompanied by various obstetrical factors.[10,11] The EOL has been reported to be more negative in women with IOL than in those with spontaneous onset of labor (SOL).[12] IOL may negatively contribute to the EOL depending on the method used and the duration of labor.[13] The EOL, as well as the experiences of IOL, can vary widely from person to person, and it often depends on the mother's medical history, the support of caregivers,[14,15] labor pain control during childbirth[16] and the numerous obstetrical and psychosocial factors.[11,17,18,19,20,21]

Importantly, sleep disturbances[22,23] and depressive symptoms[24] are common during pregnancy. Sleep quality deteriorates as pregnancy proceeds.[22,24] Furthermore, similar to the general population, pregnant women with depressive symptoms suffer from sleep disturbances and vice versa.[22,24] Sleep disturbances and depressive symptoms may deteriorate the EOL. Maternal sleep disturbances relate to higher level of anxiety[25], stress[26], and fear of childbirth[27] and these interaction may further deteriorate the EOL. Previously, depressive symptoms during pregnancy have shown to relate to negative EOL, mainly via sense of losing control during labor.[28] There is still no clear evidence of how sleep disturbances or depressive

symptoms affect the EOL. Studies have shown associations between depression and a more negative EOL, but only one previous study has evaluated both, sleep and depressive symptoms, and it showed that satisfaction with IOL was independent of sleep quality or depression.[17]

2 Review of the literature

2.1 Induction of labor

The average length of human gestation is 40 weeks or 280 days. A pregnancy that has lasted 37+0─38+6 gestation weeks (gws) is considered early-term and one that has lasted 39+0─40+6 is sonsidered full-term.[29] A late-term pregnancy is determined as between gws 41+0 and 41+6, and a post-term pregnancy begins at gw 42+0. Postpartum time is usually defined as the first 6 months after delivery. According the World Health Organization (WHO), IOL is defined as the 'initiation of labor by artificial means prior to the spontaneous onset at a viable gestational age, with the aim of achieving vaginal delivery in a pregnant woman'.[3] IOL should be performed only due to a clear medical indication and when the expected benefits outweigh the potential harms.

According to the American College of Obstetricians and Gynecologists (ACOG) Practice guideline (2024)[30] the first stage of labor is defined as the 'interval between the onset of labor and complete or 10 cm cervical dilation'. The first stage is further divided into two phases: latent and active. The latent phase of labor is characterized by gradual and relatively slower cervical dilation, which starts with the perception of regular uterine contractions and ends when rapid cervical change initiates.This phase of rapid cervical change is termed the active phase of labor and continues until complete cervical dilation. The second stage of labor commences at 10 cm cervical dilation and ends with the delivery of the neonate. The third stage of labor is the period between the delivery of the neonate and delivery of the placenta.

The rate of IOL is increasing.[31] Worldwide, approximately every fourth labor is induced[3,31,32,33] but in developed countries, such as Finland, approximately every third labor is induced.[1] The rates of IOL in Finland between 1990 and 2020 are presented in **Figure 1**. The IOL rates in five university hospitals in 2010, 2015 and 2022 are shown in **Figure 2.**

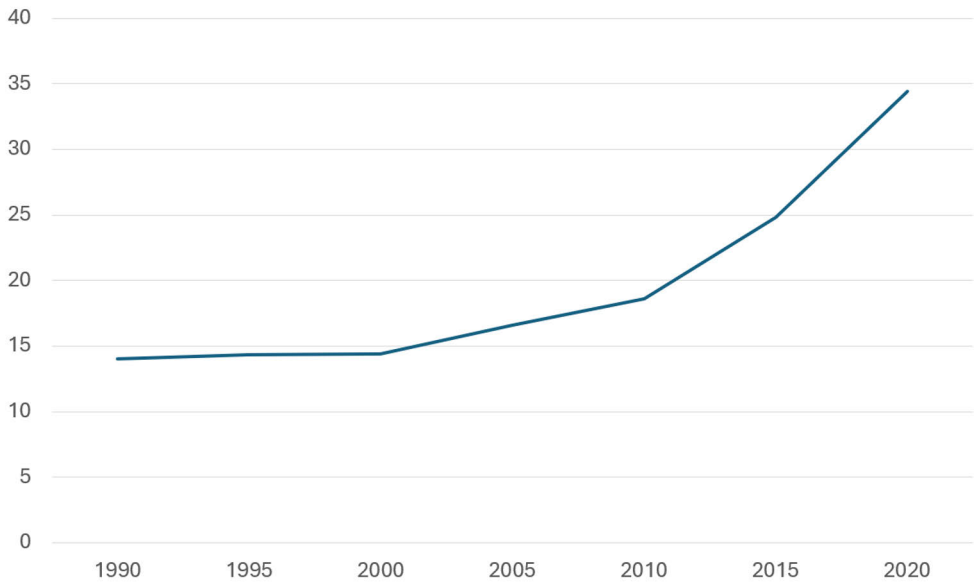

Figure 1. Labor induction rates (%) in Finland during 1990 – 2020 (with permission from Heidi Kruit, statistics from Hauhio N, Heino A, Gissler M. Perinatal statistics: parturients, deliveries and wewborns 2022. Official statistics of Finland, Perinatal statistics. The Finnish Institute for Health and Welfare (THL); 2023.[34] https://thl.fi/tilastot-ja-data/tilastot-aiheittain/seksuaali-ja-lisaantymisterveys/synnyttajat-synnytykset-ja-vastasyntyneet/perinataalitilasto-synnyttajat-synnytykset-ja-vastasyntyneet)

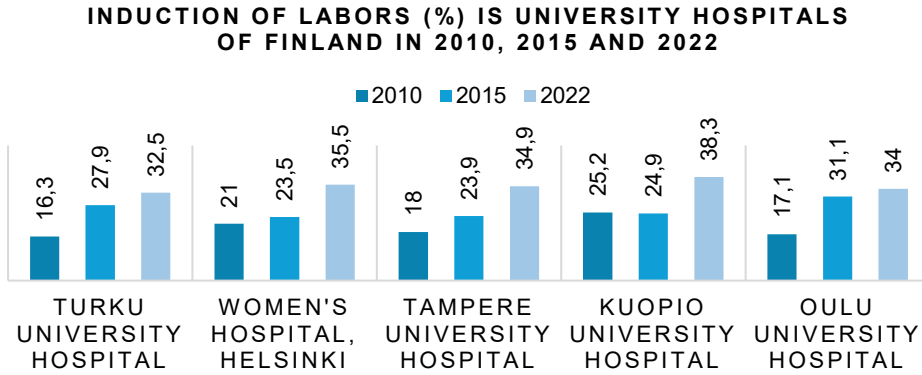

Figure 2. Induction of labor rates in the five University Hospitals in Finland (with permission from The Finnish Institute for Health and Welfare, THL). Helsinki University Hospital includes counts only from Women's hospital statistics.

The rise in induction rates is partly explained by increased maternal age and obesity[31,35] and by knowledge about IOL timing in complicated pregnancies.[36] Other important factors include women's desire for IOL,[5,6] maternal tiredness[5,6,37] and

social reasons[38]. The rise in statistics in IOL rates is likely also due to improved reporting practices and registries during the last decade. The changes in maternal characteristics in large Finnish register study are shown in **Figure 3.**

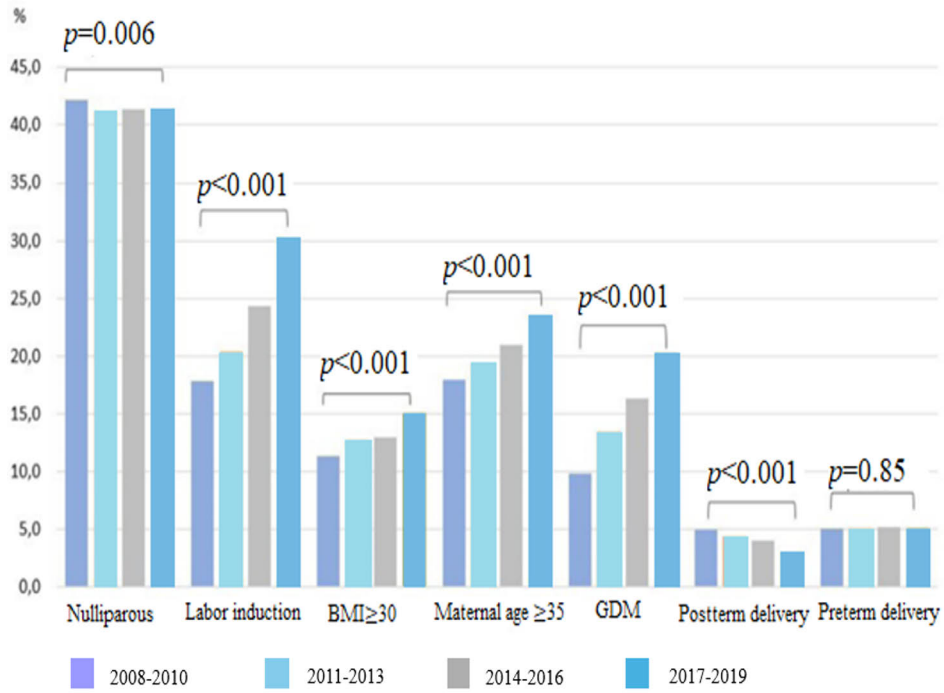

Figure 3. Changes in maternal characteristics from the Medical Birth Register study of 663 024 live births in Finland from 2008 to 2019. BMI, body mass index; GDM, gestational diabetes mellitus. *Kruit H, Gissler M, Heinonen S, et al. Breaking the myth: the association between the increasing incidence of labour induction and the rate of caesarean delivery in Finland - a nationwide Medical Birth Register study. BMJ Open 2022;12:e060161.*[1] (with permission from Springer Nature)

2.1.1 Indications and timing of labor induction

Several clinical guidelines and recommendations have been published on indications for IOL, such as WHO recommendations, the ACOG Practice Bulletin, and the National Institute for Health and Care Excellence (United Kingdom, NICE) guidelines.[4,39,40]

In Finland, IOL is currently not advised or widely practiced until 41+5 gw in low-risk pregnancies. Whether pregnancy should be only under surveillance or labor induced in women with full-term or at 41+0 gws or longer is a hot topic in the research field, when trying to judge the right timing for the IOL.[41,42,43,44,45] These studies compare healthy full-term IOL to expectant management while considering

labor outcomes. The most significant impact on induction practice is likely to arise from the ARRIVE study published at the end of 2018.[43] This well-designed and properly powered multicentre randomized controlled trial (RCT) compared 3062 low-risk primiparous IOLs (without a medical or obstetric indication for IOL) at 39 gw to 3044 women in the expectant routine management group. It provided valid and generalisable evidence that, compared to expectant management, IOL at 39 gws was associated with lower cesarean section (CS) rates (18.6 % compared with 22.2%) without compromising perinatal or maternal outcomes. Thus, there has been substantial interest among IOL studies regarding the rate of CS and contradictory results have been found.[18,41,46,47] In Finland, the increased frequency of IOL in recent years has not been shown to be associated with an increased rate of CS.[1,18]

The indications for IOL according to the guidelines are presented in **Table 1**. The most common indications for IOL are post-term pregnancy and term PROM, constituting 50–60% of all inductions.[48,49,50] In addition, common reasons for IOL include pregestational diabetes mellitus or gestational diabetes, hypertensive disorders of pregnancy, intrahepatic cholestasis of pregnancy, and fetal growth disturbances.[31] Still, the principal indication is post-term pregnancy, since this may be associated with a significant increased risks of perinatal mortality of the fetus.[4,31,42,51] However, the indications for some cases of IOL remain unexplained[31] and warrant further investigation. The timing of the IOL depends on many pregnancy factors, with some recommendations shown in **Table 2**.

Table 1. Induction of labor indications according to guidelines of WHO, ACOG and NICE.

WHO	ACOG	NICE
Post-term pregnancy	Post-term pregnancy	Post-term pregnancy
PROM	PROM	PROM
	Intrauterine fetal death	Intrauterine fetal death
	Preeclampsia	Maternal request
	Chorioamnionitis	
	Gestational hypertension	
	Maternal disease[a]	
	Fetal compromise[b]	
	Twin pregnancy ≥ 38 weeks	
	Logistic reasons[c]	

References[3,38,40,49,51,52,53,54,55,56,57,58]

[a]Diabetes mellitus, hypertension, renal disease, and chronic pulmonary disease.

[b]Severe fetal growth restriction, immunization, and oligohydramnios.

[c]Fear of rapid labor, psychosocial reasons, and distance from hospital

WHO, the World Health Organization; AGOC, The American College of Obstetricians and Gynecologists; NICE, National institute for Health and Care Excellence; PROM, premature rupture of membranes

Table 2. Induction of labor timing summarized from the recommendations ACOG and NICE.

Indication	Timing of IOL	
	ACOG gestation week	NICE gestation week
Post-term pregnancy	41–42	41–42
PROM	Expectant management[b] or waiting 24 hours[c]/immeadiate	Immediate[a]
Pregestational diabetes	39–40[d]	37+0−38+6
Medically treated gestational diabetes Non-medically treated gestational diabetes	39+0−39+6[d] 39+0−40+6	39+0−40+6[d]
Chronic hypertension	≥37+0−39+0 medicated ≥37+6−39+6 non-medicated	≥37+0 medicated
Gestational hypertension	37+0	37+0
Mild preeclampsia	37+0	37+0
Severe preeclampsia	latest 34+0	latest 34+0
Intrahepatic cholestasis of pregnancy	36+0−39+6	
Maternal age ≥ 40	39+0−39+6	
Dichorionic twin	37-0−38-0	37-0−38-0
Monochorionic-diamniotic twins	36+0−37+0	36+0−37+0

References:[40,51,52,53,54,55,56,57,58]

[a]34+0–37+0: If Streptococcus agalactia (GBS) test positive

[b]34+0–37+0: GBS prophylaxis if needed

[c] ≥37+0 and GBS test negative

[d] If no complications

AGOC, The American College of Obstetricians and Gynecologists; NICE, National institute for Health and Care Excellence; PROM, premature rupture of membranes

The contraindications for IOL are similar to those of vaginal delivery and include a transverse fetal lie, intolerable fetal distress, placenta previa, vasa previa, umbilical cord prolapse, maternal human immunodeficiency virus (HIV) infection with a high viral load, active primary genital herpes infection, pelvic deformity, uterine rupture, and history of a classical CS. Elective CS is also commonly recommended instead of vaginal birth after two previous consecutive CS.[59]

2.1.1.1 Elective induction of labor for non-medical reasons

The ARRIVE trial demonstrated that elective IOL for primiparous women decreased the risk for CS while not increasing neonatal morbidity.[43] A subsequent single-centre retrospective cohort demonstrated similar benefits, with elective IOL not only lowering the frequency of CS but also decreasing perinatal morbidity.[45] Maternal tiredness is a relevant indication for elective IOL. According to a study by Dögl et

al. (2018)[5], approximately one-third of elective IOLs were performed because of the mother's request, and the indication in every fifth of these IOLs were maternal fatigue and tiredness. A report on maternal perspectives to elective IOL according to the ARRIVE trial revealed that almost half of the women would have been interested in elective IOL at 39 gws, even in the absence of medical indications.[60] However, a Swedish study by Nilver et al. (2021))[61] found that there were no differences in experiences of labor between the IOL and expectant management groups, when the IOL group was induced at 41-0−41+2 and the expectant management group was induced at least 42+0−42+1.

2.1.1.2 Failure of induction of labor

During the first stage of labor the cervix begins to soften, thin (efface), and dilate (usually up to 3–4 cm). ACOG recommends that cervical dilation of 6 cm be considered the start of the active phase of labor.[30] Failed IOL should be the preferred terminology when there is no progression in the latent phase. Failure to progress the first stage of labor is the one most common indication for CS during the labor.[62] Furthermore, it is the most common indication both when labor is started spontaneously or when labor is induced.[62] One Finnish study from Järvelin et al. (1993)[63] found that the most common reason for CS was dysfunctional or/and arrested labor, which occurred 1.5 times more in the elective IOL group than in spontaneous labor group and 2.9 times more than in the IOL group with medical reasons for IOL. In Seyb et al. (1991)[64], arrested labor or otherwise said "labor dystocia" occurred in 6% of the cases of spontaneous labors and in 13-14% in elective or medical IOLs. Failure to progress in the first stage (<4cm cervix dilation) occurred in only 1.6% of the inductions. Also, primiparity and higher body mass index (BMI) increase the risk of CS during IOL, but the information of the incidence of failure of IOLs is limited.[65,66] ACOF recommends that if the maternal and fetal status remain reassuring, CS can be avoided for failed IOL in the latent phase during the first stage of labor recommending that oxytocin be administered for at least 12–18 hours after membrane rupture before deeming the induction to be unsuccessful.[30]

2.1.2 Methods of induction of labor

There are many strategies for IOL, including pharmacologic and mechanical methods. The choice of different methods is dependent on the state of the pregnancy (non-complicated/complicated), the state of the cervix (unripe/ripe) and the preference of the woman herself. The degree of cervical ripeness is usually described by the Bishop score[67] (**Table 3**).

Table 3. Determining the Bishop score (1-10). Bishop score of less than l6 indicates an unripe cervix, and a score a 6 or above is used as a marker for a ripened cervix.

Variable		Score	
	0	1	2
Dilatation cm	0	1–2	3–4
Effacement	<3/0–30%	1–3/40–50%	<1/60–70%
Consistency	Firm	Medium	Soft
Position	Posterior	Mid	Anterior
Station in relation to the interspinous level	-3 or above	-2	-1–0

For cervical ripening both prostaglandins (PGs) and catheters (single or double balloon) are potent and safe.[68] Cervical ripening consists of a series of biochemical processes involving various inflammatory mediators (PGs, interleukins, insulin-like growth factor binding protein-1, matrix metalloproteinases) and hormonal factors, such as estrogen and progesterone.[69,70,71,72] However, the exact mechanism is not completely understood. One possible explanation is that the stroma of the cervix is made up of collagen bundles, with glycosaminoglycans and proteoglycans interspersed between the collagen fibers.[73] During ripening, these components decrease in density. Remodeling of collagen fibers, decreased collagen fiber strength, and diminished strength of the extracellular matrix contribute to cervical softening and swelling.[73,74,75] Mechanical methods are used to dilate the cervix but may also increase PGs and/or oxytocin release by causing localized inflammation.[68] Instead, PG preparations act to promote both cervical remodeling and uterine activity.[76]

Intravenous oxytocin infusion and amniotomy are recommended when the cervix is favorable, otherwise cervical ripening is necessary to increase the likelihood of successful induction.[77] Several methods of cervical ripening are commonly used because the currently available data do not justify to recommend one method over any other.[78,79,80] Although IOL is typically performed in hospital, for women at low risk, cervical ripening can also be carried out in outpatient (OP) settings.[81] Commonly used IOL methods and protocols in Finland are shown in **Table 4** and **Figure 4**.

Table 4. Methods for the induction of labor in Finland based on Varha Obstetrical guidance.

Bishop < 6
Catheter (single or double balloon)
Use for 24 hours if intact membranes
Outpatient induction of labor is an option
If broke membranes: Use for 8 hours, with antibiotics (use of antibiotics variates between hospitals depending on *Group B streptococcus* status)
Prostaglandin analogues:
Misoprostol (25 μg or 50 μg, every 2–4 hours)
Use is not recommended in case of a previous uterus scar (cesarean section)
Dinoprostone tape (for 24hour)
Catheter and prostaglandin together
Laminaria tents (Dilapan-S)
Bishop > 6
Amniotomy
Oxytocin (recommended separately for women who have a previous cesarean section)
Prostaglandin and/or catheter if needed (especially with primiparas)

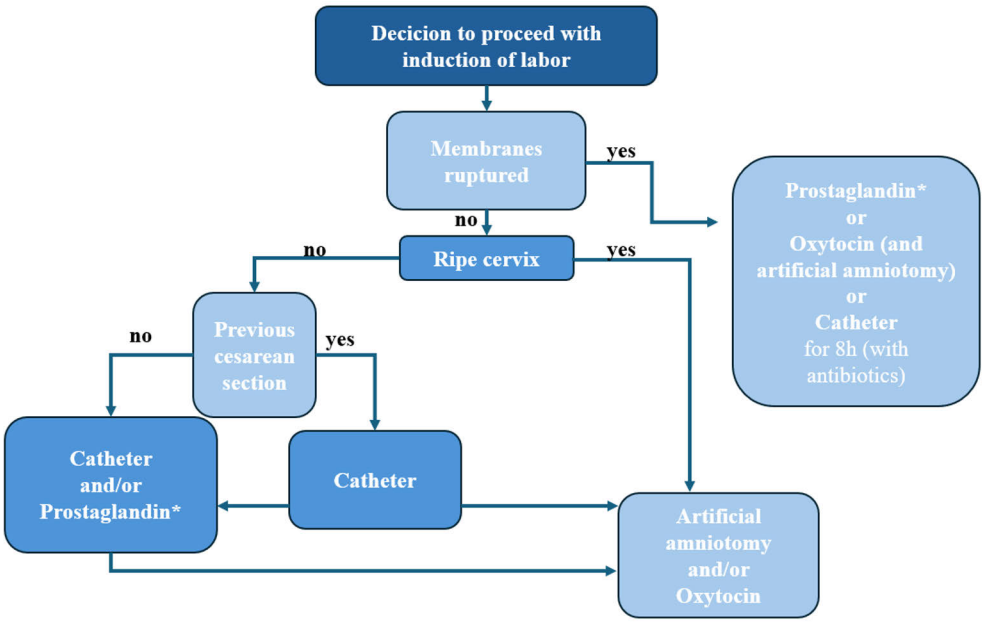

Figure 4. The induction of labor protocol. *Misoprostol 25 μg/2hour or 50 μg/4hour or dinoprostone tape. Special caution and discretion should be exercised when using prostaglandins in patients who have had a previous uterine procedure.

2.1.2.1 Induction of labor with a catheter

The origin of balloon dilatation in medicine dates back to the 1700s, when balloons were used in urological conditions, such as dilatation of the urethra using both animal-based materials and vulcanized rubber.[82] Still, single balloon catheter (the foley catheters) are used widely in urology. In 1855, Braun was the first to demonstrate that a rubber balloon catheter could be used to dilate the cervix during the labor process.[82] In the same year, Mattei used a water-filled balloon made from sheep bladder for women in labor, his report is considered the forebearer of the single balloon catheter for pre-induction cervical ripening.[83] The first report using the single balloon catheter for preinduction cervical ripening was authored by Embrey and Mollison[84] in 1967.

Mechanical cervical ripening (MCR) with catheter is an IOL method recommended by the WHO (2011), because it is quite risk-free and effective.[68,85,86] Both single and double balloon catheters are available. The mechanism of catheter-induced cervical ripening consists of direct mechanical stretching of the cervix and lower uterine segment, and stimulation of endogenous prostaglandin release following separation of the chorionic membrane and decidua.[87,88] Another potential mechanism that enhances cervical softening is the stimulation of inflammatory cytokine secretion, such as interleukins and matrix metalloproteinases.[89] However, cervical ripening is a complex, quite unexplained process, and the final conclusion about the action remain unsolved.[49]

A single balloon catheter is inserted through the cervical canal into the space between the amniotic membrane and the lower uterine segment digitally or by direct visualization during a speculum examination. Double balloon catheters include a stylet for insertion, which facilitates insertion through cervical canal. However, single balloon catheters are cheaper, which may have an effect on the choice of catheter. After ensuring that the tip of the catheter is positioned above the internal opening of the cervix, the balloon is inflated with 30−80 ml of saline and retracted to rest on the internal cervical os **(Figure 5)**. In addition to the uterine balloon, a double balloon catheter includes a cervicovaginal balloon, which is inflated with a maximum of 80 ml saline after inflation of the uterine balloon (**Figure 6**). With a single balloon catheter, traction is typically applied by taping the catheter's tube onto the inner thigh, while in double balloon catheter the lower balloon creates cervical compression and traction is not required. In Finland, catheter can be used for 24 hours. Following favorable expulsion of the catheter, the cervix is dilated to 3−4 cm. After expulsion, early amniotomy is recommended. If amniotomy has been performed within 1 hour of catheter expulsion, delivery can be achieved sooner.[90] In the case of an unripe cervix after expulsion of the catheter, a new catheter can be inserted or IOL can be continued through the application of PGs. If the membranes

are broken, the catheter can be used for 8 hours with protection of intravenous antibiotics.

Two RCTs reported that single balloon catheter is associated with less pain, and delivery can be achieved faster with single balloon catheter than with double balloon catheters.[91,92] However, a recent review article summed up that single and double balloon catheters are similarly effective when the outcome is achieved vaginal birth, and also when comparing adverse maternal and perinatal outcomes.[93] Furthermore, for low-risk pregnancies, MCR is secure even for use in OP settings.[94,95,96] A study using a Foley (single balloon catheter) for cervical ripening showed that even with ripened cervix, catheter IOL rarely caused progression to spontaneous labor without amniotomy and oxytocin augmentation.[97]

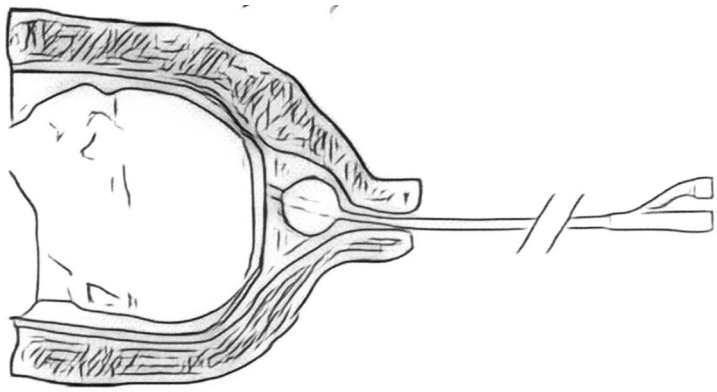

Figure 5. A single balloon catheter is inserted through the cervical canal into the space between the amniotic membrane and the lower uterine segment, and the balloon is inflated with saline.

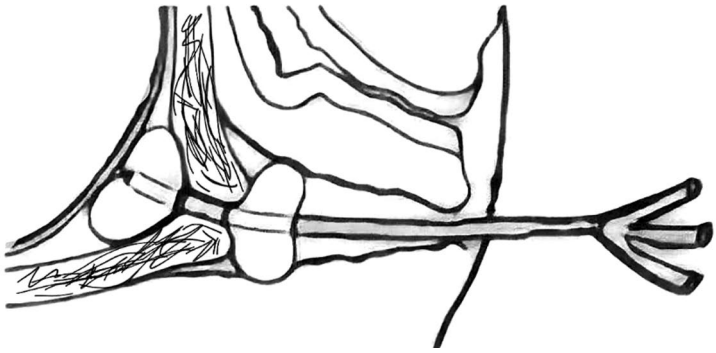

Figure 6. Application of a double balloon catheter.

2.1.2.2 Induction of labor with prostaglandins

PGs are formed from arachidonic acid, which is liberated from membrane phospholipids via phospholipases A2 and C. Although there are several types of natural PGs, prostaglandin E (PGE) and prostaglandin F (PGF) play a central role in human parturition through mechanisms that include cervical ripening and myometrial contractions and, thus, are essential in IOL.[76] Misoprostol (prostaglandin E1 [PGE1]), is a methyl ester analogue of PGE1 that was originally developed to treat gastric ulcers[98], and is now also used for termination of pregnancy, postpartum hemorrhage and IOL. Another widely used PGE is dinoprostone (prostaglandin E2 [PGE2]), which can be used vaginally as a gel or a tape. Together with misoprostol these are the two main PG formulations currently used for cervical ripening and IOL. Uterine contractions occur when PGs bind to smooth muscle cells in the decidua. These contractions cause the degradation of collagen in the connective tissue of the cervical stroma, leading to cervical ripening.[76]

For IOL, misoprostol became more widely used in 1990s. The benefits of misoprostol include effectiveness, low costs and easy administration. For IOL, misoprostol can be administered orally, vaginally, rectally, or sublingually. Misoprostol tablets are normally used in 25 μg and 50 μg doses in obstetrics. Vaginally administered 25 to 50 μg tablets of misoprostol every 2 to 4 hours are the most frequently used dosages[99,100]. Still, based on the results of a meta-analysis, the optimal dose of misoprostol remains indefined.[101]

With PGE there is a risk of tachysystole and uterine hyperstimulation during cervical ripening and these side-effects occur in around 4% of the IOLs independent of the used dose or administration route.[102,103,104] Uterine hyperstimulation can be defined as single contractions lasting 2 minutes or more, or five or more contractions during a 10-minute period. Uterine hyperstimulation with fetal heart rate (FHR) changes (known as uterine hyperstimulation syndrome) includes uterine tachysystole/hypertonus with FHR changes such as persistent decelerations, tachycardia or decreased short-term variability shown in cardiotocography (CTG). However, the risk of hyperstimulation is dependent on the dose and administration route of misoprostol, with high doses and vaginal administration associated with a higher risk of hyperstimulation. With lower (20−25 μg) oral doses the risk is for hyperstimulation and CS is lower than with larger oral amounts and is also similar to that detected with the use of dinoprostone.[105] Moreover, there have been several reports of uterine rupture in patients receiving misoprostol while attempting a trial of labor after CS,[106,107] therefore, it is recommended that PG analogues be avoided after CS. The use of misoprostol vaginal insert appears to lead to shorter induction-to-delivery interval, a lower rate of oxytocin augmentation, and an increased rate of uterine hyperstimulation, compared to the use of dinoprostone insert.[108,109,110] Common side effects, including fever, chills, and diarrhea, are more common

symptoms with the use of higher misoprostol doses, such as those used for induced abortions, but are rare with the doses used for IOL.

2.1.2.3 Comparison of catheter and prostaglandins for induction of labor

The systematic review by Jozwiak et al. (2012)[68], which included 71 trials with 9722 women with IOL showed that IOLs with catheter have equivalent clinical effectiveness and lower rates of hyperstimulation with FHR changes than PGs. Furthermore, no differences in CS rates or vaginal delivery within 24 hours of induction were found. However, in a review and meta-analysis by Eikelder et al. (2016)[104], single balloon catheter was associated with better safety outcomes, less hyperstimulation, fewer vaginal instrumental deliveries and fewer CS because of FHR abnormality compared to misprostol. A systematic review and meta-analysis by McMaster et al. (2015)[111] that included 26 RCTs found no increased risk of infections with Foley catheter IOL. In addition, a 2018 systematic review and meta-analysis comparing Foley catheter to dinoprostone insertion for cervical ripening showed no difference in induction to delivery intervals and CS rates.[112]

A 2018 systematic review on complications from insertion to expulsion of a catheter during IOL showed adverse event rates of 0.0–0.26% with 'pain/discomfort' being the most common.[94] Lim et al. (2018)[113] and Blanc-Petitjean et al. (2021)[13] found that pain score in IOL with catheters were lower than with PGEs. Nevertheless, in both studies, the IOL groups expressed similarly good satisfaction scores.

2.1.2.4 Combined use of catheter and prostaglandin in induction of labor

Several trials, and systematic reviews with direct and indirect pairwise meta-analyses, have compared the effectiveness of single and double balloon catheters to PGs alone or the use of catheter concomitantly with PGs.[91,114,115,116] A randomized trial published by Levine et al. (2016)[116] evaluated the effectiveness of the simultaneous use of single balloon catheters with misoprostol compared to the use of catheter or misoprostol alone. Combination methods achieved a faster median time to delivery than single-agent methods (misoprostol–Foley: 13.1 hours, misoprostol: 17.6 hours, Foley: 17.7 hours). When censored for CS and adjusting for parity, those who received misoprostol–Foley were almost twice as likely to deliver faster than women who received misoprostol alone (hazard ratio [HR]=1.92, 95% CI 1.42–2.59) or Foley alone (HR=1.87, 95% CI 1.39–2.52).[116] In Finland, a recent study by Kruit et al. (2025)[117] with primiparas found similar results (misoprostol–catheter: 21.7 hours, misoprostol: 37.0 hours, catheter: 31.7 hours). Moreover, in a

meta-analysis of 15 RCTs by Ornat et al. (2020)[115], misoprostol (oral or vaginal) together with single or double balloon catheter was associated with a shorter induction to delivery time interval than misoprostol alone, while there were no differences in the occurrence of tachysystole, chorioamnionitis, CS rate, birthweight, and Apgar scores at 5min. On the contrary, according to a 2020 network meta-analysis, the time to vaginal delivery with a combined Foley catheter and PGs was not shorter compared to than with a Foley catheter alone.[118]

2.1.2.5 Oxytocin, amniotomy and other options for the induction of labor

Labor contractions can be initiated by amniotomy and titrated oxytocin infusion in the hospital. Worldwide, oxytocin is the most widely used pharmacologic agent for IOL.[77] It was first identified by Sir Henry Dale, who extracted this molecule from the posterior pituitary of oxen in 1906. The new substance was given the name oxytocin, which in Greek means 'quick birth'. Oxytocin is known to be involved in various reproductive processes in the human body, including modulation of uterine contractions during labor, milk ejection reflex during breastfeeding, and functioning as a neurotransmitter involved in maternal behavior.[119] In the 1950s, a synthetic version of oxytocin was developed by de Vigneaud and colleagues that allowed for dose titration and control of uterotonic effects.

Oxytocin is a 9-amino acid cyclic neurohypophysial peptide. The effectiveness of exogenous oxytocin initiating and maintaining labor requires the presence and receptivity of oxytocin receptors in the myometrium and decidua.[120] In late pregnancy, myometrial sensitivity to oxytocin is augmented because the density of oxytocin receptors in the myometrium increases. Exogenously administered oxytocin has both an onset of action and half-life of a couple of minutes.[121] The uterine responses to oxytocin are dose dependent and vary between patients based on individual oxytocin receptor expression and post-receptor metabolism.[122] Complications and side effects from using oxytocin include anaphylactic reactions, postpartum hemorrhage, cardiac arrhythmias, nausea, vomiting, subarachnoid hemorrhage, hypertensive episodes, tachysystole and uterine rupture.[121]

A network meta-analysis comparing IOL methods (34 active treatment types) found that intravenous oxytocin combined with amniotomy led to the best probability (83%) of vaginal delivery being achieved within 24 hours.[123] Amniotomy stimulates oxytocin release from the pituitary gland followed by the release of PGs locally.[124] After contraindications to amniotomy (active herpes or HIV, placenta previa, vasa previa, or cord presentation) are excluded and fetal presentation and station are confirmed, the accessible membranes are ruptured with the use of a metal or plastic hook. Adverse effects included prolapse of the umbilical cord, chorioamnionitis, prolonged intervals to delivery, and maternal discomfort.

Amniotomy has been used alone or as an adjunct for cervical ripening and labor induction in patients with a favorable cervices. The use and timing of amniotomy after the expulsion of catheter has been debated. However, a recent randomized trial found that amniotomy within one hour of Foley catheter expulsion resulted in delivery 2.3 times faster than expectant management.[125] Based on the results from of a 2016 network meta-analysis, compared with other agents, the combination of amniotomy with intravenous oxytocin reduced the risk of not achieving vaginal delivery within 24 hours.[123]

Other mechanical methods for dilating the cervix include laminaria and synthetic hygroscopic cervical dilators. Dilapan-S® (Dilapan TM, Medicem, Czech Republic) is the most commonly used hygroscopic dilators. Laminaria and hygroscopic dilators have been used typically before gynecologic procedures that require entrance into the uterine cavity, but the effectiveness of the procedure to achieve IOL is questionable.[126] Nitric oxide (NO), a free radical with an ultrashort half-life synthesized from L-arginine by the enzyme NO synthase, is endogenously synthesized in the cervix and placenta during pregnancy.[127] The use of isosorbide mononitrate as an alternative agent for cervical ripening is based on its uterine relaxant properties.[127] Other used NO donors include isosorbide, nitroglycerin, and sodium nitroprusside. A Cochrane analysis by Ghosh et al. (2016)[128] evaluated intravaginally administered NO donors (isosorbide mononitrate, isosorbide, nitroglycerin, and sodium nitroprusside) for third-trimester IOL compared to placebo, vaginal PGE2, intracervical PGE2, vaginal misoprostol, and intracervical Foley catheter, but found no superiority concerning IOL; rather there were more side effects, including nausea, headache, and emesis.[128] In addition, membrane sweeping may result in endogenous PGs release following separation of the chorionic membrane and decidua.[129] There have also been studies about acupuncture and nipple stimulation for IOL with a favorable cervix.[80,130]

2.1.3 Setting of induction of labor

The concept of OP IOL, where cervical preparation and/or early labor occurs predominantly outside of hospital, typically at home, is an attractive alternative to IP management both economically and for patient satisfaction. The Foley catheter was first proposed for OP cervical ripening in 2001.[86] Since then, many RCTs have compared OP and IP cervical ripening and labor induction.[131,132,133,134] Upon expulsion of the catheter at home, randomized trial protocols suggest either immediate return or a scheduled return the following morning return to the hospital if there is a non-urgent event, such as ruptured membranes, bleeding, pain or decreased fetus movements, in the interim.[8,135,136]

A 2020 systematic review and meta-analysis comparing an OP setting to an IP setting with catheter-induced labor showed that OP priming is safe, Bishop scores were more improved after an OP setting than an IP setting, and that on OP setting shortened the hospital stay.[137] When compared to placebo or no treatment, OP induction using a variety of methods (vaginal and intracervical PGE2, vaginal and oral misoprostol, isosorbide mononitrate, mifepristone, estrogens, and acupuncture) appeared feasible. There was no evidence that agents used for IOL in an OP setting had an impact on maternal or neonatal health and significant adverse events were rare.[138] A study with of 111 women randomized to OP and IP Foley catheter groups showed no difference in clinical efficacy.[86] An OP versus IP study with oral misoprostol showed that time from hospital admission to delivery in the OP group was shorter than in the IP group (12.8 vs 20.6 h), as was also the total hospital stay (2 vs 3 days); however, the rates of vaginal birth were similar in the OP and IP groups.[139] A meta-analysis by Dong et al. (2020)[140] reviewed nine independent RCTs of OP versus IP cervical priming using catheters, vaginal PGs or a combination (IP PGs vs. OP catheters). The trials were conducted in Australia, Europe and North America. There were 2615 cases of low-risk IOLs (1320 OP vs 1295 IP). Although the meta-analysis was still underpowered for safety regarding rarer fetal morbidity and mortality measures (e.g. fetal death or hypoxic ischemic encephalopathy), the analysis nevertheless reported equivalence in safety measures such as chorioamnionitis, postpartum hemorrhage, mode of delivery, and admissions to the neonatal intensive care unit (NICU). Interestingly, a sub-analysis of the randomized trials between OP and IP catheters IOLs demonstrated a lower CS rate with OP management.

2.2 Experience of labor

Women's EOL is a central element for judging the quality of care in a maternity ward.[141] Between 5% and 20% of women report a negative EOL.[142,143,144,145] A positive EOL is highly important, since it increases maternal self-esteem and, self-efficacy, and improves acceptance for the maternal role.[146,147] A negative EOL, instead, may have both short- and long-term consequences, such as impairment in mother-child bonding, an increase in (postpartum) depression, problems in couple relationship and in relationships in general, fear of childbirth and requesting a CS in subsequent pregnancies.[27,148,149,150,151,152,153,154] A negative EOL has also been associated with having fewer offspring, longer intervals between the births of children and even subsequent intentional infertility.[148] Several other factors have also been associated with negative EOL, including lower quality of life, lower self-rated health, persistent memory of pain, and the development of posttraumatic stress disorder (PTSD) or its symptoms.[155,156,157,158,159] The consequences of a negative EOL are shown in **Table 5**.

Table 5. Consequences of negative experiences of labor.

Postpartum depression [151]
Posttraumatic stress (disorder) [158]
Persistent memory of pain [156]
Lower self-rated health [159]
Lower quality of life [157]
Problems in a couple relationship [154]
Subsequent intentional infertility and longer interval to the second baby [148]
Impairment in mother-child bonding[154]
Fear of childbirth[27]
Requesting a cesarean section in subsequent pregnancies[150]

2.2.1 Measurements of experience of labor

EOL is typically assessed using personal interviews or structured questionnaires. Free word interviews need to be transcribed, but structured questionnaires are often easier to convert into numerical scores.[160] There may be several flaws in collecting EOL data. One critical factor is the timing of the measurement. On the one hand evaluating the EOL just after delivery, for instance in the delivery room or postpartum ward, would probably ensure greater participation, but mothers may be too tired or the final EOL could be distorted because the actual event is too fresh. On the other hand, if the EOL is evaluated longer after delivery, the mother may be too occupied with their offspring and this delay often causes a loss of respondents, since the mother has already been discharged from the hospital. One study presented that primary EOL screening within a week of childbirth is good; however EOL screening some months afterwards when screening PTSD and its symptoms can provide even better timing.[161] Moreover, considering the high proportion of women with immigrant-background among the childbirth population, issues related to language skills must also be taken into account. Also, multidimensional and comprehensive measures require more effort from respondents, therefore, the participation of socioeconomic minorities or vulnerable individuals, such as women with mental problems, may be lacking.[162]

2.2.1.1 Visual analogue scale

A visual analogue scale (VAS) is a horizontal line with verbal anchors at the extremes of the scale. Usually, it is performed with a line wideness of 0–100 mm, on which the subject can place a tick, but sometimes it is presented with the numbers 0–10, with the subject picking the number. While the wording changes according to the context, VASs have been used to measure pain, anxiety, stress, mood, fear,

safeness and other subjective experiences.[92,136,152,163,164,165,166] The VAS is a simple measure for the EOL, but may not fully capture the holistic nature of labor. However, the reliability of the VAS as an overall labor satisfaction measure has been comprehensively demonstrated.[16,18,91,145,167,168,169,170,171,172] Usually it forms part of questionnaires items, such as with a 4-point Likert scale, which is a rating scale used to measure opinions, attitudes and, motivations, among others, often also in EOL studies.[17,43,136,173,174] A Likert scale uses a range of answer options from one extreme attitude to another, sometimes including a moderate or neutral option. Four- to seven-point scales are the most popular. The VAS lines and Likert-type question are shown in **Figure 7**.

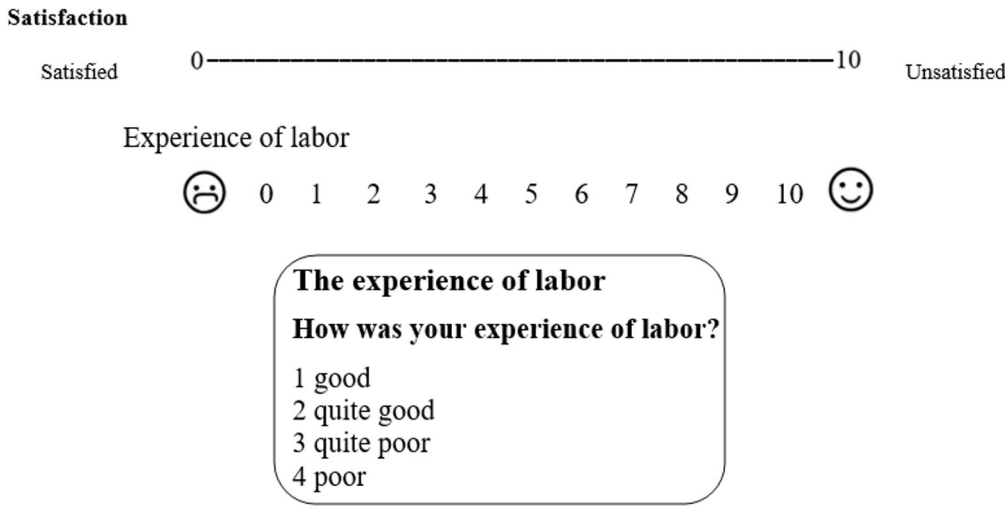

Figure 7. Visual analogue scale lines and Likert-type question about experience of labor.

2.2.1.2 Other methods

The list of questionnaires used to measure the EOL is wide.[11,160,161,175] For example, the Childbirth Experience Questionnaire (CEQ) was developed and validated in Sweden and then translated and culturally adapted to several other languages.[176] Identified areas of the EOL include intrapartum sense of security, experience of labor pain, support from a partner, midwifery care and support, memories of the childbirth and the experience of one's own performance. A revised version CEQ2, which was used for example by Nilver et al. (2021)[61] consists of 22 questions considering four different subscales of the childbirth experience: own capacity, perceived safety, professional support, and participation. Responses to the items of the CEQ are given

on a four-point Likert Scale. Three of the items (perceived pain, control and sense of security) are rated on a VAS (1–100).[152,177]

Moreover, the Labour and Delivery Satisfaction Index (LADSI) is a validated 38-item questionnaire measuring 'technical' and 'caring' components of satisfaction.[178,179] In addition, the Wijma Delivery Expectancy/Experience Questionnaire[180] was developed and validated to estimate fear of delivery and the experience of birth.

2.2.1.3 Risk factors for a negative experience of labor

Single status, inconvenient timing of pregnancy, experienced violence in history, lack of support from partner, and neonate admission to NICU are known risk factors for negative EOL.[143,144] The association between age and EOL is contradictory.[143,144,181] BMI's association with EOL has also been studied, with some evidence supporting that higher BMI may worsen the experience.[145] However, these associations have been shown to vanish in adjusted models.[145] Also primiparity has been identified as a risk factors for a more negative EOL.[171] Furthermore, pregnancy complications may have an effect on maternal wellbeing[182] and thus, easily also on EOL. The EOL is known to be worse in women with operative vaginal delivery and CS, especially if performed as an emergency[17,18,143,145,183,184] and in women with prolonged hospitalization.[171] Although pain during delivery typically worsen the EOL, studies have also shown that given epidural can make the EOL worse (measured using LADSI and the Wijma Delivery Expectancy/Experience Questionnaire or five-point scale).[179,185] In Sweden, epidural anesthesia was associated with less positive EOL when it was administered during labor despite not being the woman's preference. Additionally, it was more commonly given to women who reported a fear of childbirth or a preference for a CS.[185] Also, in Norway, low-risk women with no expressed preference for level of birth care were more satisfied if allocated to the midwifery unit compared to the obstetric unit, and EOL was better if they did not get epidural.[179]

Women who experience IOL have a higher risk of a negative EOL than women with SOL.[12,16,18,145,155,181,186,187] For instance, in a recent study from Finland that included 22 393 women with IOL and 72 658 women with SOL, IOL was associated with a more negative EOL (ORs varying from 1.43 to 1.77).[181] Furthermore, operative deliveries were perceived even more negatively when they were preceded by IOL.[181] Of note is, that women with IOL have more adverse delivery outcomes, such as longer duration of labor,[188] and an increased rates of operative vaginal deliveries[189] and postpartum hemorrhage,[145] both of which potentially may worsen the EOL.[181] Furthermore, qualitative studies have shown that a negative experience of IOL is associated with a lack of preparation and information about the benefits

and risks of IOL and its course, the intensity of pain, the duration of the induction and labor and a poorer medical outcome.[16,17,18,19,20,21]

Also, fear of childbirth[142,190] and antenatal depression have been shown to be associated with an adverse EOL, such as a higher experience of pain.[28,83,191] Likewise, previous studies have proposed an association between maternal sleep disturbances and negative EOL, such as more pain and discomfort during labor.[192]

2.2.1.4 Protective factors for a better experience of labor

Generally, the experiences of patients in hospitals are best when the medical outcomes of an intervention are both good and uncomplicated.[193] Receiving support during labor is a well-known protective factor for a better EOL.[14,15,175] Other important factors for better EOL are being in partnership[144,181], a sense of being able to take part in decision making regarding delivery type[20,117] and personalized care[195]. Moreover, emotional strength and higher self-esteem, a positive attitude towards labor and learned coping strategies are known to be associated with better a EOL.[196,197] Present data have also demonstrated better perinatal outcomes with elective IOL at term, regardless of the cervical status[44,198,199], which may lead to a better EOL. In the ARRIVE trial comparing IOL with expectant management among 6000 low-risk primiparous women at 39 gws, IOL resulted in a better global experience and less pain.[43]

A Finnish study by Joensuu et al. (2022)[18], which included 105 847 women in labor (46 % primiparas and 54 % multiparas) evaluated factors related to the EOL with VAS. The EOL was worse in primiparas. When analysing the parity groups separately, the effects of maternal confounding variables such as maternal age of ≤30 years, BMI before pregnancy of ≤ 30 and a lack of fear of childbirth were positive on EOL. Furthermore, the primiparas delivering during office hours (08:00–15:59) reported a better EOL than primiparas with evening (16:00– 23:59) or night (00:00–07:59) deliveries. On the contrary, multiparas reported a more positive EOL if they delivered at night compared to those who delivered in the evening.[18] Datta et al. (2012)[200] suggested that the use of a dedicated IOL ward could reduce delays during induction and increase maternal satisfaction. Associations between different factors and EOL are shown in **Table 6**.

Ramlee et al. (2023)[17], who conducted a study with 769 women to identify independent predictors for maternal satisfaction with their EOL, found 10 factors of better maternal satisfaction: maternal high school education (adjusted odds ratio, aOR= 2.90), no previous CS (aOR= 2.59), maternal involvement (aOR= 4.35), information provided (aOR= 4.50), time allowed for women to make their decision regarding IOL (aOR= 5.58), amniotomy (aOR= 2.69), induction to delivery interval (per hour reduction) (aOR= 1.04), mode of delivery (vaginal vs CS, aOR= 6.24), no

postpartum hemorrhage (aOR= 1.86), and no neonatal admission to NICU (aOR=2.63).

Table 6. Associations with experience of labor among studies.

Negative	Positive
Inconvenient timing of pregnancy[143]	Support received during labor[14,15,175]
Single relationship status[144]	
Experienced violence in history[143]	Sense of being able to take a part in decision making regarding the delivery type[17,194]
A negative previous birth experience[155]	Personalized care[195]
Lack of support[144]	Emotional strength and learned coping strategies[196,197]
Antenatal depression[28, 83,155,191]	Elective induction[43]
Lack of information during labor process[19,20,175]	Multiparity[181]
Induction on labor[12,16 ,145,155,181,186,187]	Spontaneous labor[12,16 ,145,155,181,186,187]
Setting and method of induction of labor[131,201,202,203]	Lower rate of obstetrical interventions[175]
Labor pain[16]	Delivery during office hours[18]
Long duration of induction or labor[188]	Labor in the midwifery unit compared to the obstetric unit[179]
Epidural anesthesia provided[179,185]	
Operative vaginal delivery[17,181,143,145,183,184]	
Emergency cesarean section[17,181,143,145,183,184]	
Labor complications such as postpartum hemorrhage or infection[181]	
Neonate admission to NICU after labor[143]	
Prolonged hospitalization[171]	

NICU, Neonatal intensive care unit

2.2.2 Experience of induction of labor

The maternal EOL should be listed in the set of core outcomes when assessing studies dealing with IOL.[204] However, a review of the literature showed that only around 5% of trials of IOL reported maternal experience of IOL.[100] Quantitative research on maternal experience of IOL is limited mainly to satisfaction measures. However, the results suggest that IOL is a challenging experience for women, which can be understood in terms of the gap between women's needs and the reality of their IOL experience concerning information and decision-making, support, and the environment. A feeling of lack of control in IOL booking and the IOL process,

feeling part of a production line system, feeling unsupported and uncomfortable in their surroundings undermined women's experiences of labor.[19]

Women who undergo IOL typically report lower satisfaction with their care during labor[12,16,18,145,155,186,187] and higher depressive symptoms in postpartum compared to women with SOL.[205,206] A cohort of 18 396 Finnish women[145] showed that those who underwent IOL were less satisfied with their labor experience than women with SOL (**Figure 8**). A poor EOL was also associated with primiparity, CS, operative vaginal delivery, postpartum hemorrhage, and maternal infections. Longer duration of labor is risk factor for more negative EOL.[188] The latent phase of labor is significantly longer in induced labor compared with spontaneous labor while the active phase of labor is similar between the two groups.[207] Thus, several factors have an impact on EOLs in induced labors. Previous studies evaluating EOL with IOL are described in **Table 7**.

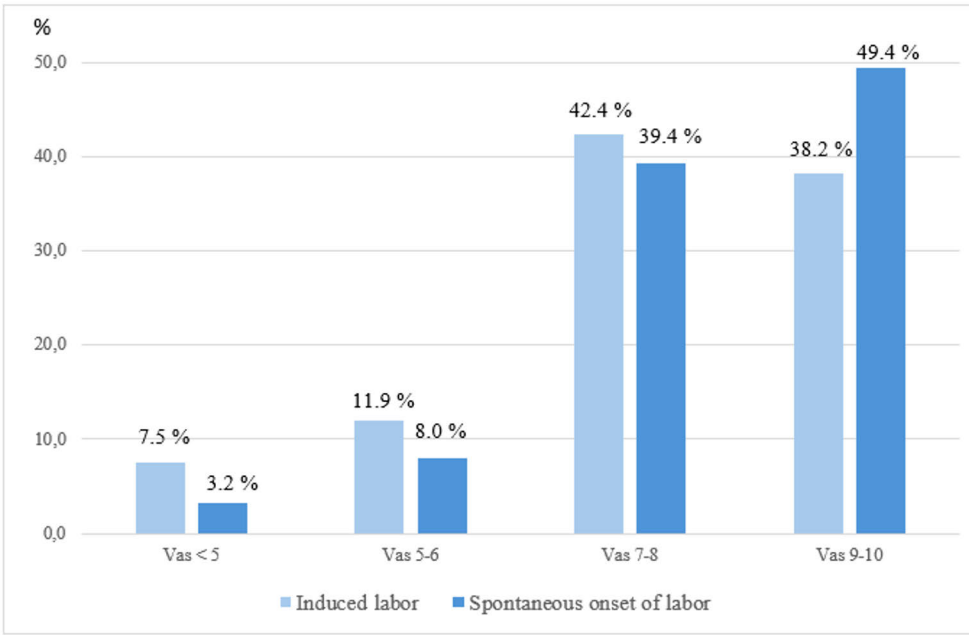

Figure 8. The distribution of experience of labor in Visual analogue scale scores in induced and spontaneous onset of labor (n=18 396). A higher proportion of women with induced labor were more dissatisfied for their experience of labor. *Adler K, Rahkonen L, Kruit H. Maternal childbirth experience in induced and spontaneous labour measured in a visual analog scale and the factors influencing it; a two-year cohort study. BMC Pregnancy Childbirth. 2020;20:415.* Preprinted with permission from Springer Nature.

2.2.2.1 Association between the experience of induction of labor and the method of induction

The method of IOL has been shown to have an impact on the experience of IOL. In a French study with 1 453 women, the experience of IOL was worse in women who needed cervical ripening (regardless of the method) than in women induced with oxytocin infusion.[201] Other studies have evaluated associations between IOL methods and experiences of IOL, usually by asking about experiences of pain and discomfort and the acceptability of the method.[13,202] Druenne et al. (2022)[208] assessed the maternal pain experience when performing IOL by vaginal PGE2, oral misoprostol, or the double balloon catheter. They found no difference in stress or in overall experience of IOL irrespective of the method used (using a numerical scale of 0-10; 7.03 in the vaginal PGE2 group, 7.14 in the oral misoprostol group, and 6.52 in the double balloon group).

In general, women with OP catheter induction have reported better satisfaction than those with PGE induction in an IP setting due to feeling more relaxed, having better sense of coping the discomfort, and having less pain.[131] However, in an IP setting, women with PGE IOL had been shown to have less fear.[202] Studies comparing catheter and PG induction show contradictory results regarding pain and discomfort.[113] Henry et al. (2013)[131] showed, that women with OP IOL using catheters felt twice as much discomfort at the commencement of cervical preparation, but half as much discomfort at the cervical preparation phase than women with IP IOL using PGEs. Furthermore, OPs slept better at home.[131] In a study with 300 women induced with intravaginal controlled-release PGE2, Biem et al. (2003)[209] found that more women in the OP group (56%) reported a high rate of satisfaction during the initial 12 hours of induction than those in the IP group (39%). Ratings of pain and anxiety during the first 12 hours of induction were similar.[209]

From the largest randomized trial of OP cervical priming to date, Turnbull et al. (2013)[203] approached eligible women taking part in a multicenter RCT of IOL with PGE2 gel, 407 women in the OP group and 414 women in the IP group. The questionnaire was assessed during enrollment and seven weeks after delivery. No statistically significant or clinically relevant differences were found in the questionnaires during enrollment, but small statistically significant differences were found in the postpartum questionnaire with those in the OP group feeling that they had more social support, self-efficacy and feelings about readiness, control, safeness and being better informed, as well as less stress. In two studies, women with slow release dinoprostone pessary or a nitric oxide donor used in cervical ripening in an OP setting preferred being at home, finding it more relaxing, familiar and private than hospital, although some reported increased anxiety.[210,211] The above data suggest that women with low-risk pregnancies largely prefer OP cervical priming.

Few studies have examined the experience of IOL separately from the overall labor experience, both in OP and IP settings.[136,212] Wilkinson et al's (2015) study[136] evaluated the experience of the IOL with a double balloon catheter between OP and IP settings. They enrolled 48 women (33 OPs and 15 IPs), who assessed comfortability and pain immediately after insertion of the catheter and safety and satisfaction with their care four weeks postpartum; no differences between the groups were found. Wang et al. (2021)[212] were the first to evaluate satisfaction in parous women with a single balloon catheter in the OP (n=54) and IP (n=64) groups and showed that both groups were equally satisfied and reported high satisfaction scores. Furthermore, women in both groups would have chosen the same type of care for their next pregnancy. Kruit et al. (2016)[8] showed that 85 % of 112 women with catheter IOL were satisfied with the OP setting. The studies evaluating experiences in IOL are described in **Table 7**.

Table 7. Experience of induction of labor (IOL) in previous studies.

Study	Method	Questionnaires	Results
Outpatient (OP) vs inpatient (IP) setting			
Turnbull et al. (2013)[203], OP n=407, IP n=414	PGE2 gel	Hospital Anxiety and Depression Scale the anxiety component of the Multiple Affect Adjective Check-List, and a 100 mm linear analog anxiety scale. Postpartum questionnaire, with a 7-point Likert scale (larger number more feeling)	Immediate questionnaires results: similar results in anxiety, depression, or infant feeding. Postpartum result: Social support (IP 3.19 vs OP 4.17), self-efficacy (IP 3.60 vs OP 3.77), readiness (IP 3.00 vs OP 3.18), stress (IP 3.16 vs OP 3.37), control (IP 3.5 vs OP 3.63), information (IP 3.63 vs OP 3.80), safety (IP 3.55 vs OP 3.72). All the mean differences were -0.16 to -0.25.
Henry et al. (2013)[131], OP n=50, IP n=51	OPs with single balloon catheter, IPs with vaginal PGE2 gel	5-point Likert scale questions	OP felt less pain (26% Vs 58%, *p*= 0.003), were more relaxed (100 % vs 65%, *p*=0.001), were able to rest more (100% vs 61%, *p*=0.001), had more sleep (5.8 Vs 3.4 h, *p*<0.001).
Wilkinson et al. (2015)[213], OP n=33, IP n=15	Double balloon catheter	5-point Likert scale questions, labor pain with Visual analogue scale (VAS) (0-100mm)	OP felt less isolated (9 % vs 30%), less emotionally alone (9% vs 36 %), had less no good night rest (68% vs 91%), were equally satisfied in both groups (91%). Pain VAS OP 25 vs IP 3.

Study	Method	Questionnaires	Results
Kruit et al. (2016)[8], only OP n=112	Single balloon catheter only in OP setting	5-point Likert scale question on the experience of induction	96/112 reported being satisfied with OP induction.
Wang et al. (2021)[212], OP n=65, IP n=64	Single balloon catheter	VAS 0-100 mm (labor pain), Six Simple Questions and Labor and Delivery Index	Equally satisfied, pain VAS: 50-70.
Hægeland et al. (2023)[214] OP n=12, IP n=4	Oral PGE1	Interviews at home	To feel secure at home, women needed sufficient information, close follow-up while at home, and an easy- to-administer induction method. OP induction gave women the opportunity of constant support from the partner and increased freedom of movement and self- expression. Some expressed relief over being randomized to IP labor induction, because of easy access to health providers, fetal monitoring, and not risking giving birth before arrival to the hospital. The women stressed the importance of being given a choice.
Inpatient setting			
Shechter-Maor et al. (2015)[202]	PGE2, n=26 and double balloon catheter, n=26	Questions Scaled 1–5 (larger number, more feeling)	Equally satisfied (PGE2 3.33 vs catheter 3.41, *P*=0.860), fear (PGE2 2.33 vs catheter 3.76, *P*=0.002), uncomfortable insertion PGE2 2.33 vs catheter 3.59 *p*=0.004).
Lim et al. (2018)[113]	Catheter, n= 31 and vaginal PGE2, n=52	Pain score 0–10, satisfaction 0–5	Less pain during IOL (catheter 4.5 vs PGE 5.6, *p*=0.044) and equal satisfaction (Catheter 3.4 vs PGE 3.2, *p*=0.465).
Blanc-Petitjean et al. (2021)[13]	Vaginal PGE2 pessary (n=614) or gel (n=190), vaginal PGE1(n=55), catheter(n=40)	Labor satisfaction 1–5 scale, labor pain 0–10 scale, other experiences 1–7 scales.	Catheter was less painful (aRR 1.78, 95% CI 1.20–2.65), there wasequal satisfaction between groups.
Dupont et al. (2020)[201]	n=3042, 1453 responses	Dissatisfaction at two months post-delivery with a 5-point Likert scale.	Primiparity associations to more negative experience: failed to include discussion of IOL (OR: 2.68, 95% CI 1.37- 5.23), lack of involvement in the decision-making process (OR: 1.92, 95% CI 1.23; 3.02) All: vaginal discomfort (OR: 1.98, 95% CI 1.16- 3.37 and OR: 4.23, 95% CI 2.04- 8.77). IOL performed using cervical

Study	Method	Questionnaires	Results
			ripening method was associated more often with dissatisfaction compared to using oxytocin. (p<0.01).
Druenne et al. (2022)[208]	oral PGE1 n=82, vaginal PGE2 n=35, double balloon catheter n=58	Numerical scale from 0 to 10	Overall pain between groups was similar (p=0.253). Pain at insertion: greater with catheter than with PGE2 (3.67 vs 5.75 p = 0.001). Pain in the 2 h prior to the delivery room greater with PGE2 and PGE1 compared to the catheter (7.91 and 7.4 vs 5.47 respectively, p <0.001). Women with catheter would more often have preferred to be induced by another method compared to those induced by PGEs (p= 0.004). No significant difference in stress and overall experience of induction depending on the method.
IOL vs spontaneous onset of labor (SOL)			
Nuutila et al. (1999)[186] IOL n=135, SOL n=135	IOL n=44 with amniotomy and 91 vaginal prostaglandin gel, followed by amniotomy. SOL n=135	Yes/no-answers and VAS (0–6 scale) questions	IOLs reported fear of pain less often (45%) than the SOL group (57%) (p=0.03). The labor experience corresponded with the patients' expectations better in the SOL than in the IOL group (p=0.03). IOL was a positive experience in 90% of women who underwent immediate amniotomy and in 69% of those who received prostaglandin ripening first.
Henderson et al. (2013)[12], 5333 women, 896 of whom were induced	<37 weeks:261, 38–41 weeks:3827, ≥42 weeks: 493	Open text responses	IOL: Primiparas were less satisfied with their care
Unsal et al (2018)[205]	All n=1010, women informed: amniotomy n=312, oxytocin infusion n=312	Perception of birth scale (1-5 scale) about delivery and labor experience, EPDS (6 to 8 weeks postpartum)	Amniotomy and oxytocin infusion negatively affected the mothers' EPDS scores (both p<0.001)
Joensuu et al. (2021)[18]	IOL n=22 393 SOL n=72 658	VAS (1-10 scale) for the childbirth experience	Measures made in primiparous and multiparous groups. The effect of IOL in the experience of labor was negative (β_P=-0.34, p<0.001; β_M=-0.25, p<0.001)

2.3 Sleep during pregnancy

Normal sleep duration in young adults ranges from approximately 7 to 9 hours.[215] Pregnancy can bring various changes in maternal sleep patterns. Sleep disturbances are common, and symptoms vary at different stages of pregnancy.[22,24,83] Previous research evaluating sleep quality in late pregnancy is quite unanimous that sleep disturbances are frequent.[22,24,216,217,218] Usually, the need of sleep rises from the time before pregnancy.[217] In pregnant women, sleep is commonly disrupted as a result of multiple factors that vary along the pregnancy, such as hormonal and anatomical alterations, increased urinary frequency and physical discomfort.[24] Digestion slows down, which may lead to constipation and gastroesophageal reflux.[219] Urination increases because of the growing uterus and also because of increased overnight sodium excretion causing awakening.[219] Other reasons for awakenings in early pregnancy include nausea, backaches, leg cramps, and the bed partner and children in the family.[220] The female sex hormones, estrogen and progesterone, increase during pregnancy with different effects on sleep and respiratory physiology. The early increase of progesterone during the first trimester enhances slow-wave sleep activity and acts as respiratory drive stimulant due to the induction of gamma-amino butyric acid receptors.[221,222] High estrogen levels during pregnancy increase blood circulation, inducting hyperemia, edema and mucus secretion, all of which may narrow upper airways and thus increase their resistance.

2.3.1 Measurement of sleep quality

Several questionnaires (like Basic Nordic Sleep questionnaire, BNSQ [shown in the Appendix]; the Pittsburgh Sleep Quality Index, PSQI; the Insomnia Severity Index, ISI), and the Bergen Insomnia Scale [BIS] have been used to rate subjective sleep disturbances.[22,24,216,223,224,225] In addition to questionnaires, objective methods, such as actigraphy and polysomnography have been used to gain more detailed objective information about the sleep architecture during pregnancy.[226]

Sleep architecture can be measured in a laboratory setting or at home with specific sensors and technics.[227,228] Polysomnography measures have identified a number of features characteristic of poor quality sleep in pregnancy, including reduced sleep efficiency. However, subjective sleep and objective sleep do not always concur. In clinical practice the subjective perception of poor night sleep is feasible and thus, more important.[229]

2.3.2 Sleep quality throughout pregnancy

Sleep disturbances peak at the end of pregnancy.[24,230] At the beginning of pregnancy, increased fatigue and sleepiness are often the primary sleep complaints,[231] while in

late pregnancy, insomnia symptoms, such as difficulty to fall asleep and nocturnal awakenings increase.[22,216,217] In addition, sleep disordered breathing (SDB), including both snoring and obstructive sleep apnea become more common during pregnancy, mainly because of weight gain and edema.[232,233] Restless leg syndrome is also a very well-known condition during pregnancy,[234] also causing sleep disturbances.

Sleep quality is worst during the third trimester.[231,235] In two Finnish studies using the BNSQ, a pilot study with 78 women[24] and in a follow-up study with 1858 women,[22] 15% and 30% women, respectively, reported poor general sleep quality during late pregnancy. Further, according to a meta-analysis including 42 studies and using the PSQI questionnaire for sleep quality evaluation, the prevalence of poor sleep was 45% in the perinatal period.[236] In a study with 2427 pregnant women, 76% experienced poor sleep quality evaluated by PSQI across all months of pregnancy. A meta-analysis of sleep quality across pregnancy found that the prevalence of disturbed sleep (PSQI scores ≥ 5) increased from the second to the third trimester.[235] According to a Finnish study with 325 women, 30% of mothers prenatally (in the third trimester) and 20% postnatally (three months after delivery) suffered from restless sleep. A recent Finnish study with 1858 women by Aukia et al. (2020)[22] evaluated insomnia symptoms during pregnancy. All insomnia symptom types (difficulties to fall asleep, number of nocturnal awakenings per week and per night, and too early morning awakenings) increased from early pregnancy to late pregnancy and from mid- pregnancy to late pregnancy. In addition, nocturnal awakenings per night increased from early pregnancy to mid- pregnancy. In the third trimester of pregnancy, approximately 98% of women experienced nocturnal awakenings.[217] Furthermore, the majority of pregnant women reported taking daytime naps.[216]

Compared to pre-pregnancy, the reported average sleep duration increase during the first trimester,[217] but decreases marginally as pregnancy proceeds[22,217]. Furthermore, the number of short sleepers (< 6 hours/night) increases in late pregnancy.[237,238] In particular, multiparity, higher age and higher BMI, as well as depressive symptoms are associated with shorter sleep duration.[216,237] Maternal older age is also associated with poor sleep quality during pregnancy.[235]

Insomnia is prevalent during pregnancy and depending on the trimester, with 25–40% of women reporting insomnia symptoms.[235] Insomnia is defined as initiative insomnia, when a person has difficulty to fall asleep or maintaining insomnia, which includes nocturnal awakenings and too early morning awakening without the ability to fall asleep again. All of these insomnia types lead to non-restorative sleep. There are inherent challenges in determining clinical levels of insomnia in pregnant women, particularly with regard to meeting the 3-month duration criterion of symptoms due to the symptom changes occurring across a relatively short period of time.

Sleepiness is a common first-trimester complaint that may even precede the realization of pregnancy.[239] It is typically classified as morning sleepiness, daytime sleepiness, and daytime napping. Around 37% of women report new onset excessive daytime sleepiness during the first trimester. Furthermore, primiparous women are more likely to report excessive sleepiness than multiparas.[240] One study found a persistently high sleepiness throughout pregnancy,[216] while another study showed that sleepiness was the most frequent in early pregnancy but, subsequently diminished later.[239] Studies have proposed a U-shape occurrence of sleepiness which is lowest in mid-pregnancy.[22,239]

2.3.2.1 Sleep disturbances, pregnancy and labor outcomes

Sleep disturbances have been shown to be associated with pregnancy complications.[242,243] For example, women with short and long sleep duration, and with SDB, have been found to be at a higher risk for preeclampsia and gestational diabetes[242] and gestational hypertension,[244] complications that often lead to IOL. In addition, women of advanced age are at a higher risk of adverse obstetrical outcomes[245] and sleep disturbances,[246] which may also increase the risk of having IOL.

Sleep disturbances have also been shown to be related to labor. Women with sleep disturbances experience more pain during delivery, have longer duration of labor,[188,247] and deliver at a lower gestational age.[248] Short sleep duration, usually referred to as sleep under 7 hours per night,[249] increases the risk of preterm birth[250] and CS.[188] Furthermore, SDB has also been shown to be associated with an increased risk of preterm birth and CS.[243]

Although sleep disturbances during pregnancy have been shown to be associated with pregnancy and delivery complications, little is known about their direct associations with IOL. One of the mediators between sleep disturbances and IOL could be cytokines; lighter sleep and less slow wave (deep) sleep are associated with greater inflammatory biomarkers in late pregnancy.[251] There is a trend for overexpression of anti-inflammatory T helper 2 lymphocyte produced cytokines in early pregnancy and a shift towards a T helper 1 lymphocyte produced cytokines produced proinflammatory cytokine profile when pregnancy proceeds towards labor.[252] In addition, poor general sleep quality in late pregnancy has been shown to be related to increased proinflammatory interleukin-6 concentration, including in T helper 1 lymphocyte produced cytokines.[252] In conclusion, sleep deprivation and poor general sleep quality have been shown to increase pro-inflammatory cytokine levels, and thus, it can be argued that sleep deprivation is a stressor,[252,253] that may lead to IOL. However, according to a single previous study of 35 pregnant women,

no differences were found in sleep duration or nightly wake-up times between women with IOL and SOL.[218]

2.3.2.2 Association between sleep quality and experience of labor

Maternal sleep disturbances relate to higher level of anxiety,[25] stress,[26] and fear of childbirth.[27] Poor sleep quality has been shown to be associated with depressive symptoms during pregnancy[24,254,255] and postpartum.[255] This interaction may further deteriorate the EOL. Nevertheless, in Ramlee et al. (2023) study[17] maternal satisfaction with IOL was independent of sleep quality. However, one can hypothesize that maternal sleep worsens considerably, especially in latent phase of labor with plausible painful contractions, and women feel tiredness[256], leading to early hospital admission due to symptoms of sleep disturbances and pain, which may also affect the EOL in negative way.[257]

However, no previous studies have evaluated the connection between sleep disturbances and the EOL in general. Beebe and Lee (2007)[226] showed that women who had sleep deprivation over the 5 days of pregnancy before labor reported increased pain and discomfort during labor. Sleep disturbances have been connected with various pregnancy and delivery complications, which may indirectly lead to worse EOL. Lee et al. (2004)[188] showed that short sleep (i.e. sleeping under 6 hours) was a risk factor for CS. This association was also shown in a study including only women with IOL.[258] In addition, short sleep has been shown to be associated with gestational diabetes,[259] which increases the risk of IOL, and thus possibly also induce a negative EOL.

2.4 Depression symptoms during pregnancy

Depressive disorders are characterized by an enduring low mood, loss of energy, markedly decreased interest in activities, several somatic and cognitive symptoms, insomnia symptoms and recurrent thoughts concerning death.[260] Similar to sleep disturbances, depressive symptoms are frequent during pregnancy,[254] and depressive disorders also increase when pregnancy proceeds.[261] More research exists about perinatal depression, not only antenatal depression, and a meta-estimate for the prevalence of maternal depression during pregnancy and postpartum (i.e. perinatally) is approximately 11–15%.[262,263] Moreover, women with a history of depression may be more susceptible to experiencing depressive symptoms during pregnancy.[28,254] Women in low- and middle- income countries have a higher prevalence of perinatal depression than women in high-income countries.[262] Prevalence estimates of maternal perinatal depression vary depending on the assessment method used, the sample characteristics and the study location.

Postpartum depressive symptoms are similar to depressive symptoms during pregnancy, but symptoms can develop into hostile attitudes towards the infant.[264] Diagnosis can be set up if symptoms have lasted at least two weeks.[265] The rapid fall in placental hormones, especially in estrogen, after delivery has been implicated in the experience of postpartum emotional distress. Typically, so-called 'baby blues' are confined to the first week postpartum, but more serious forms of maternal depression, so-called postpartum depression typically have an onset at about 2–4 weeks after delivery and during the first postnatal year.[266] This more serious form occurs in about 10% of new mothers and has been attributed to a prior history of mental health problems.[228] Postpartum psychosis is the most serious form of postpartum depression, with an occurrence of 1–2/1000 pregnancies.[266]

2.4.1 Measurements of depressive symptoms

Depressive symptoms can be evaluated by using several questionnaires. The most commonly used questionnaire during pregnancy and postpartum is the Edinburgh Postnatal Depression Scale (EPDS) (shown in the Appendix.).[260] The EPDS questionnaire includes 10 items using a self-reported 4-point Likert scale type. Cut-off level of ≥ 10 can be considered to indicate increased depression symptoms,[266] and ≥ 13 as serious depression.[267] The Beck Depression Inventory (BDI)[268] is also widely used to diagnose depression, also during pregnancy. [261,269,270,271]

2.4.2 Depression symptoms and pregnancy and labor outcomes

Depressive symptoms during pregnancy have many effects on maternal health via mood disorders after childbirth[272,273] and thus indirectly also on the fetus.[274,275] Perinatal stress and depression may also be associated with preterm birth and low birth weight.[276,277,278] Further, depressive symptoms during pregnancy increase the risk of postpartum depression.[272,277]

2.4.3 Sleep disturbances and comorbidity with depression

Poor sleep is a proposed contributor to the increased vulnerability to depression during the perinatal period.[270,279] The unique physiological changes and psychological adjustments during pregnancy typically lead to an increased risk for sleep disruption, poor sleep quality and insomnia, which can contribute to an increased risk of depression, and conversely, depressive symptoms and depression can lead to disturbed sleep.[24,254,255] Sleep quality during pregnancy is associated with

postpartum depression.[23,280,281] However, in one study, the effect of sleep quality on postpartum depression existed only in pregnant women over 30 years.[281]

Indeed, the existence of sleep disturbances is part of the diagnostic criteria for depression. In particular, it has been suggested that insomnia symptoms directly contribute to high rates of depressive symptoms.[282] For example, poor sleep quality during pregnancy is associated with antenatal stress and perinatal depression.[281,279,283] Although it has been suggested that the relationship between insomnia and depression is bidirectional,[284] recent trajectory analyses of insomnia and depressive symptoms have suggested that poor prenatal sleep precedes postpartum depressive symptoms.[285,286]

Okun et al. (2011)[287] suggested that sleep disturbances are associated with depressive symptoms in both the second and third trimesters. However, the FinnBrain Birth Cohort Study showed an association between sleep disturbances and depressive symptoms in the third trimester, but not in the second trimester.[24] Moreover, Yu et al. (2017)[288] reported that the association between sleep and mental status is strongest in the second trimester compared to the first and third trimesters. Nevertheless, disturbed sleep in early pregnancy has also been associated with depressive symptoms in late pregnancy.[270] Furthermore, depressive symptoms in early pregnancy seem to be related to an increase in sleep disturbances throughout pregnancy.[22]

2.4.4 Depressive symptoms and experience of labor

Depressive symptoms during pregnancy have been shown to relate to a negative EOL, mainly through a sense of losing control during labor.[28] Also, physiological and psychological stress may may negatively affect labor and consequently the EOL.[289] In addition, the EOL can be influenced negatively by fear of childbirth,[290] which is more common in women with depressive symptoms.[291] However, Ramlee et al. (2023)[17], found no connection between satisfaction with IOL and depression.

3 Aims

This thesis explored maternal experiences of IOL, with particular interest in its associations with maternal sleep quality and depressive symptoms during pregnancy. The specific aims are as follows:

1. To evaluate whether maternal sleep quality in late pregnancy is associated with the likelihood that the pregnancy will end with IOL.
2. To assess whether maternal sleep quality and depressive symptoms during pregnancy are associated with the EOL and whether this possible association interferes with IOL.
3. To evaluate the importance of the induction setting for the experience of IOL.
4. To assess whether maternal sleep quality and depressive symptoms in late pregnancy are associated with the experience of IOL.

4 Material and methods

The material in this present thesis consists of two cohorts:

1. The FinnBrain Birth Cohort Study (Studies I and II), a longitudinal follow-up study conducted during pregnancy.
2. The Clinical Hospital Cohort Study (Studies III and IV), a prospective RCT that compared IOL in OP and IP settings.

4.1 Participants, data collection and study design

4.1.1 FinnBrain Birth Cohort Study

The FinnBrain Birth Cohort Study (www.finnbrain.fi)[292] is a large general population-based cohort survey for which women were recruited from the Turku University Hospital and the Åland Central Hospital districts between 2011 and 2015. The study is a transgenerational prospective observational study investigating the effects of prenatal and early life stress exposure on child health and brain development. This cohort profile covered the prenatal and early postnatal periods of the study. Trained research nurses recruited families from maternity welfare clinics after their first pregnancy ultrasound visits. For the entire FinnBrain Birth Cohort Study, women with sufficient knowledge of Finnish or Swedish and normal ultrasound results were invited to participate. Altogether 3808 women were enrolled in the study.

A flow chart of the FinnBrain sub-studies included in this thesis is presented in **Figure 9**. The FinnBrain cohort involved 3808 women, of whom 3661 delivered. Those who delivered in ≥ 38+0 gw and had healthy, low-risk pregnancies without severe pregnancy complications, breech presentation fetus, multifetal pregnancy, early spontaneous rupture of membranes, or planned CS were included.

In the FinnBrain Birth Cohort Study, the study questionnaires were assessed four times: in early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and after delivery (0–6 days postpartum). The early, mid-, and late pregnancy questionnaires were sent via either post or email, and if no

response was received within two weeks, a reminder was sent twice via text message two and three weeks after the original questionnaire. Two groups were formed: (1) the IOL group and (2) the spontaneous onset of labor (SOL) group.

In the Study I, women who answered the BNSQ after delivery (n=1778) were included. Of these, 1497 women answered within seven days and five women later (day 8 [n=1], day 9 [n=1], day 12 [n=1], day 16 [n=1], day 30 [n=1]), while in 276 questionnaires, the date of the reply was missing. In the Study II, women who answered the BNSQ in at any of the four study points (the restricted time limits described above) and the questionnaire including the EOL question after delivery were included, thus, the questionnaires of 2405 women were eligible for analysis.

4.1.1.1 Basic maternal, delivery and newborn characteristics

Background information, including age (years), pre-pregnancy BMI (kg/m^2), parity (primiparous/multiparous) and smoking (yes/no) was taken from the baseline questionnaire assessed around gw 14. The delivery and newborn information were taken from the Finnish Medical Birth Register (FMBR). Reasons for IOL, the primary method for IOL (prostaglandin, catheter, artificial rupture of membranes or oxytocin), failure of induction, the mode of delivery (vaginal/vacuum extraction/emergency CS [elective excluded from the study]) and the length of the delivery (min), as well as the newborn variables including birthweight (grams), Apgar scores (at 1, 5 and 15 minutes) and the pH of the umbilical artery and vein at birth**.**

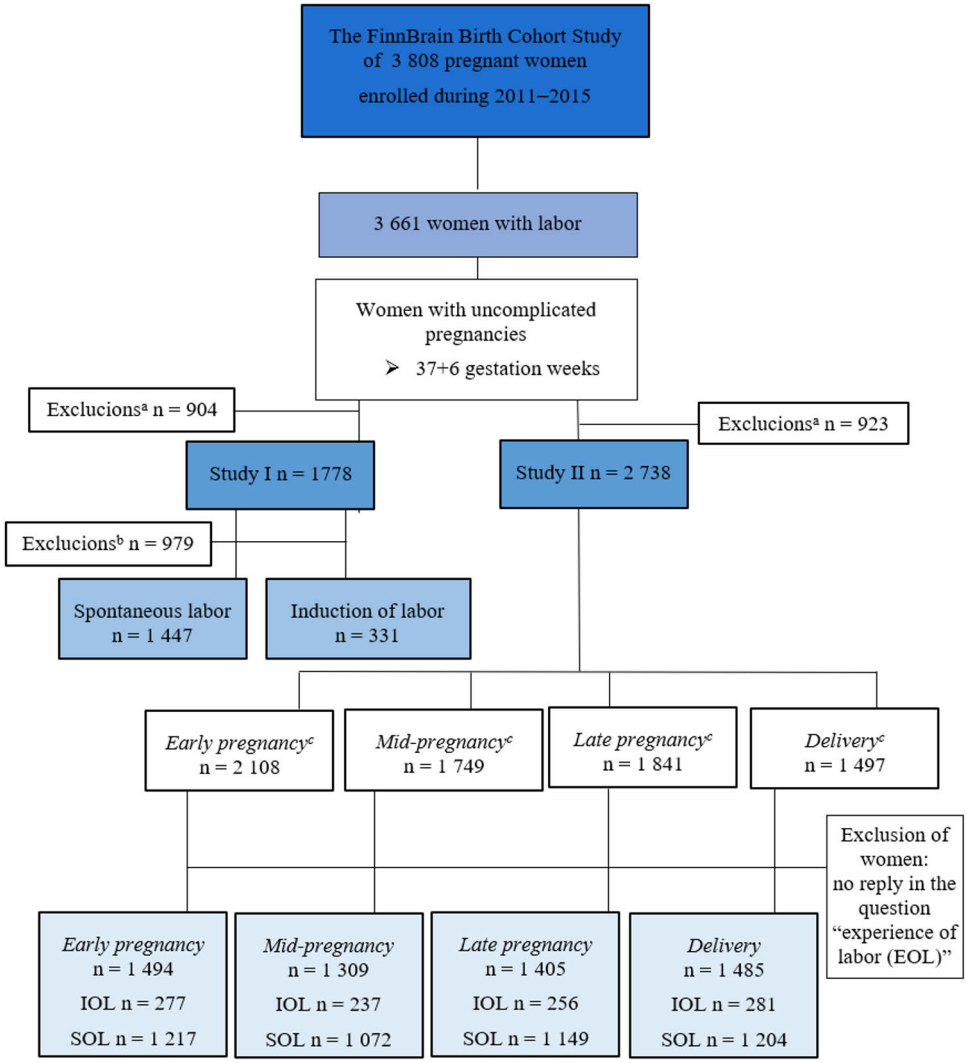

Figure 9. Flow chart of the FinnBrain Birth Cohort Study (Studies I and II). [a]Exclusion criteria: pregnancies under 38 gestation weeks, diabetes mellitus, gestational diabetes mellitus with pharmacotherapy, hypertension/preeclampsia, cholestasis of pregnancy, multiple pregnancy, breech presentation fetus, planned cesarean section. [b]Exclusion of women with no sleep data (the Basiq Nordic Sleep Questionnaire). [c]Women who answered to the Basic Nordic Sleep Questionnaire at the pregnancy point.

4.1.2 The Clinical Hospital Cohort Study

The Clinical Hospital Cohort Study comprised of pregnant women who entered the Department of Obstetrics and Gynecology, at Turku University Hospital for a planned IOL between years 2016 and 2019. Women with singleton, cephalic presented fetuses in gw 37+0─41+5 and with uncomplicated pregnancies, unripe

cervixes (Bishop score < 6), intact membranes and normal cardiotocography, who were a short distance to the hospital (less than a half-hour drive) and had Finnish knowledge were invited to participate. Women with any medical conditions or pregnancy complications, such as medically treated gestational diabetes, hypertension, preeclampsia, fetal growth restriction or other signs of fetal distress, were excluded. Altogether 117 women were enrolled in the study.

4.1.2.1 Randomization

Cervical status was examined by a gynecologist both manually and with ultrasound in order to ensure an unripe cervix (Bishop score <6). A double-balloon catheter (DBC, The Cook [Cook® Cervical Ripening Balloon Catheter J-CRBS-184000, Cook Incorporated, Bloomington, IN, USA; Cook Medical Europe Ltd., Limerick, Ireland]) was used to ripen the cervix. Both balloons were routinely filled with 80 mL saline. In case of causing constant pain, part of the saline, mostly from the lower balloon, was emptied. In six cases only a single balloon catheter filled with 60-80ml of saline was used. Thereafter, the women were randomized to either OP or IP settings. A professional statistician carried out randomization using a computer-generated random number list, and the randomization codes were saved in sequentially numbered, sealed opaque envelopes. A flow chart of the Clinical Hospital Cohort Study is presented in **Figure 10**.

After randomization and CTG control, the women in the OP group were discharged with written instructions about induction and the women in the IP group stayed in hospital. For pain management, non-pharmacological methods were encouraged in both groups. In the case of pharmacological pain management, only paracetamol was permitted in the OP group, while opioids were also available in the IP group.

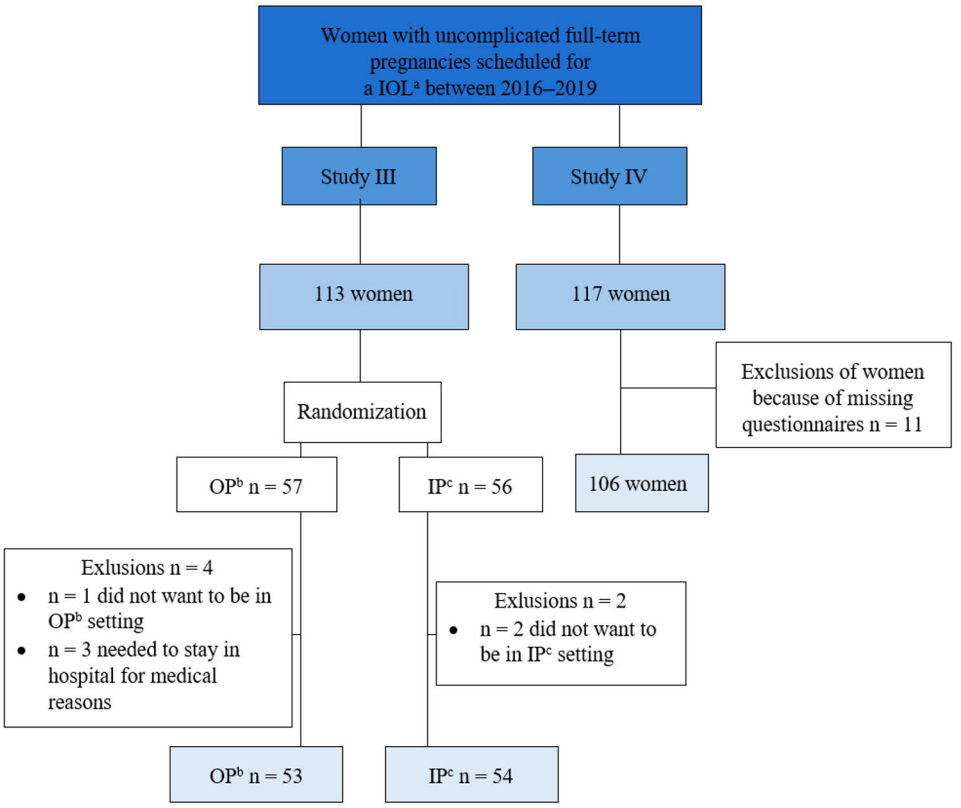

Figure 10. Flow chart of the Clinical Hospital Cohort Study (Studies III and IV). [a]Induction of labor. [b]Outpatient. [c]Inpatient.

4.1.2.2 Basic maternal, delivery and newborn characteristics

Parity (primiparous/multiparous), gw and pre-pregnancy BMI were taken from medical records. Delivery variables included use of misoprostol (yes/no), oxytocin augmentation during delivery (yes/no), spontaneous or artificial rupture of membranes, medical pain relief during delivery (paracervical or pudendal block/ epidural and/or spinal analgesia), failure of induction (yes/no), mode of delivery (vaginal/vacuum extraction/CS), the length of the delivery (min) and any kind of gynecological infection (during delivery or postpartum; yes/no). The newborn variables included birthweight (grams), Apgar scores (at 1, 5 and 15 minutes) and the pH of the umbilical artery and vein at birth**.**

4.2 Study questionnaires

All questionnaires are presented in the **Appendices**. A summary of the study questionnaires and their filling timepoints are described in **Table 8.**

4.2.1 Experience of labor

EOL was assessed using a single question: 'How was your experience of labor? ('very positive'/'quite positive'/'quite hard, but I was able to cope soon'/'very hard')'. In the statistical analysis, the responses to the EOL question were dichotomized as positive ('very positive'/'quite positive') and negative ('quite hard'/'very hard'). *The EOL question* was used in the FinnBrain Birth Cohort Study.

4.2.2 Basic Nordic Sleep Questionnaire

Sleep quality was evaluated with *The Basic Nordic Sleep questionnaire* (BNSQ)[223], which includes 12-questions regarding the previous month and is scored using a five-point scale, in which options 4 and 5 (≥ 3–5 nights/days/times) are considered indicative ('yes') of a sleep disturbance. In addition, to the question 'general sleep quality', the sum scores of Insomnia ('difficulty to fall asleep/week', 'nocturnal awakenings/week', and 'awakening too early in the morning/week'), SDB ('snoring/week' and 'witnessed apneas/week'), and Sleepiness ('sleepiness in the morning/week', 'daytime sleepiness/week', and 'daytime napping/week') are computed. Furthermore, 'sleep duration' (min) and 'sleep need' (duration that a woman would like to sleep, min) are assessed, and 'sleep loss' is computed by subtracting 'sleep need' from 'sleep duration' and expressed in minutes. In study IV an additional question of sleep was included: 'If you have problems with your sleep, what kind of problems do you have?' (free-word description of the sleep problem) *The BNSQ* was used both in the FinnBrain Birth Cohort Study and in the Clinical Hospital Cohort Study.

4.2.3 Edinburgh Postnatal Depression Scale

Depressive symptoms were evaluated using *The Edinburgh Postnatal Depression Scale* (EPDS)[260], which includes 10 questions covering the previous week and is scored on a four-point Likert scale with 0–3 points per item. A score ≥ 10 is considered a sign of clinical depression. *The EPDS* was used both in the FinnBrain Birth Cohort Study and in the Clinical Hospital Cohort Study.

4.2.4 General experience questionnaire

A general experience questionnaire was used to assess the participants' general health, pregnancy-related attitudes and experiences with the insertion of the catheter using eight 100 mm Visual anal scale (VAS) questions of: 'Physical health', 'Mental health', 'Pregnancy intention', 'Support during pregnancy', 'Fear of labor induction', 'Fear of childbirth', 'Pain during insertion of catheter' and 'Bleeding after catheter insertion'. Lower numbers indicated better options and higher numbers worse options, except for questions about physical and mental health, pregnancy intention and support during pregnancy, for which the scoring was the reverse. This *general experience questionnaire* was used in the Clinical Hospital Cohort Study and is shown in the Appendix.

4.2.5 Concurrent induction experience questionnaire

A concurrent induction experience questionnaire was filled in 1 hour, 5 hours, 9 hours and 13 hours after insertion of the catheter but before the catheter came out. A lower VAS-point indicated a better experience and fewer negations of: 'satisfaction', 'relaxedness', 'fear', 'anxiety', 'stress', 'general pain', 'contraction pain', 'frequency of contractions' and 'bleeding after insertion'. The IP group also evaluated 'adequacy of the support' and 'help of the hospital personnel' and their IOL experience. This *concurrent induction experience questionnaire* was used in the Clinical Hospital Cohort Study.

4.2.6 Postpartum induction experience questionnaire

A postpartum induction experience questionnaire, which was completed after the delivery, assessed the experience of IOL with the same nine VAS questions as in *the concurrent induction experience questionnaire* with the addition of five questions on experiences: 'painfulness of induction', 'general induction experience', 'pain during labor', 'labor experience', and 'given help and support in hospital'. Furthermore, two futuristic questions were asked: 'If your subsequent pregnancy will be induced, would you like to have a catheter IOL?' (yes/no) and 'If your subsequent pregnancy will be induced with a catheter, would you prefer the induction in outpatient setting?' (yes/no). A lower value indicated a better experience and fewer negations, except for fear of childbirth and fear of labor induction, for which a lower number indicated less fear. This *postpartum induction experience questionnaire* was used in the Clinical Hospital Cohort Study.

Table 8. Study questionnaires.

Questionnaire	Study I	Study II	Study III	Study IV
Experience of labor question (EOL)		x		
Basic Nordic Sleep Questionnaire (BNSQ)[a]	x	x		x
Edinburgh Postnatal Depression Scale (EPDS)[b]	x	x		x
General experience questionnaire[c] (after insertion of catheter)			x	x
Physical health				
Mental health				
Pregnancy intention				
Support during pregnancy				
Fear of childbirth				
Fear of labor induction				
Concurrent induction experience questionnaire			x	x
Satisfaction				
Relaxedness				
Fear				
Anxiety				
Stress				
General pain				
Contraction pain				
Frequency of contractions				
Bleeding after catheter insertion				
Postpartum induction experience questionnaire[c]			x	x
Painfulness of induction				
General induction experience				
Pain during labor				
Labor experience				
Given help and support in hospital				

In **Studies I and II,** the responses were given in early pregnancy (11+2–16+6 gws), in mid-pregnancy (22+0–27-6 gws), in late pregnancy (32+0–38+0 gws) and at delivery (0–6 days postpartum). In **Study I**, the BNSQ was assessed after delivery. In **Study II**, the BNSQ was assessed at all four pregnancy time points. In **Study IV**, the BNSQ was assessed after insertion of the catheter. In **Study I**, the EPDS was assessed in early pregnancy, and was used in the analysis as an adjusted factor. In **Study II**, the EPDS was assessed in early, mid- and late pregnancy, and early pregnancy answers were used in the analysis as an adjusted factor. In **Study IV**, after insertion of the catheter, all women completed the EPDS.

[a]Sleep disturbances for the previous month.

[b]EPDS; Depressive symptoms for the previous week. A cut-off level of ≥ 10 for the sum score (range 0–30) was used to indicate clinical depression.

[c]The postpartum induction experience questionnaire included the nine questions as the concurrent induction experience questionnaire

4.3 Statistical analysis

Detailed descriptions of the statistical analyses of the studies are presented in **Table 9**.

In *Study III*, for power calculation, a standard deviation of 25was estimated for the satisfaction VAS scale (1-100mm), and a 15-mm difference between the groups was considered a clinically meaningful difference. With a selected power of 80 % and a significance level of 5 % (two-tailed), the required sample size needed would have been 45 per group. Due to the substantial amount of uncertainty, the chosen sample size was 110 women.

In *Study IV*, the *EPDS* and *BNSQ* variables (both distinct questions and Insomnia, SDB and Sleepiness scores) were calculated as continuous variables. For all VAS questions (from *the concurrent induction experience questionnaire* and *the postpartum induction experience questionnaire)*, instructions were given to mark the VAS line with a tick. For all VAS questions (*Study III* and *IV),* the participants were instructed to reply with a tick; however, 20 women used numbers instead.

Table 9. Summary of the statistical analyses in Studies I–IV.

STUDY I
Aim of the study To study the associations between sleep quality in late pregnancy and the likelihood of ending up IOL. **Questionnaires** - *The Basic Nordic Sleep questionnaire* (BNSQ) was assessed after delivery **Statistics:** **-** The responses for the distinct sleep variables (general sleep quality, difficulty to fall asleep/week, nocturnal awakenings/week and /night, awakening too early in the morning/week, snoring/week, apneas/week morning sleepiness/week, daytime sleepiness/week and napping/week) were dichotomized **-** Insomnia, SDB, and Sleepiness scores were considered continuous variables **-** Sleep duration (continuous and categorical [< 7 h, 7–9 h and > 9 h]) and sleep loss (continuous and categorical [< 2 h and ≥ 2 h]) Additional analyses compared sleep quality between the two groups: Women who responded within 7 days and those who responded later or had an unknown response time. Depending on the variable in question, either the chi-squared test or the Wilcoxon rank-sum test was used for the comparison. Univariate logistic regression analysis -Associations between each explanatory sleep variable and the dependent variable of IOL.

Adjusted for

Age, BMI, parity, smoking, and depressive symptoms (assessed by the Edinburgh Postnatal Depression Scale (EPDS) in early pregnancy.

Post hoc

-Whether the IOL group had a moderating effect on the association between sleep quality and delivery mode (cesarean section vs. vaginal delivery) was conducted using logistic regression.

-Delivery mode was used as the dependent variable.

P-values (two-tailed) < 0.05 were considered statistically significant. The 95% confidence intervals (CIs) were calculated for the odds ratios (ORs) and adjusted odds ratios (AORs).

All analyses were performed in R (4.0.5, 2021).

STUDY II

Aims of the study

A) To study the association between sleep quality and EOL

B) To study the association between depressive symptoms and EOL

C) To study the association between IOL and EOL

D) To examine whether the association between sleep quality, depressive symptoms, and EOL differs depending on whether labor is induced.

Questionnaires

- *A question of experience of labor*
- *The Basic Nordic Sleep questionnaire*
- *The Edinburgh Postnatal Depression Scale*

Statistics

-Descriptive analysis of the basic characteristics, as well as sleep variables and depressive symptoms (both categorical and continuous), stratified into the two groups IOL and spontaneous onset of labor (SOL)

- For the adjusted odds ratios (AOR), 95% confidence intervals (95% CIs) were calculated

Models

-A binary logistic regression model: The question of whether various sleep variables separately at four pregnancy time points (early, mid- and late pregnancy and delivery) were related to EOL in the IOL and SOL groups

-Adjusted for age, BMI, parity, smoking, EPDS and mode of delivery

-EOL (negative vs. positive), IOL (IOL vs. SOL), parity (multiparous vs. primiparous), smoking (yes vs. no) and mode of delivery (CS vs vaginal) were considered categorical

-Age and BMI, were used as continuous variables.

-An interaction between sleep variables and IOL was formed to examine whether the associations between the sleep variables and EOL differed depending on the IOL group

-Similar analyses were performed to investigate the associations between EPDS scores and EOL at three pregnancy points (early, mid- and late pregnancy); however, the EPDS scores in early pregnancy were omitted as a covariate

-EPDS was considered both continuous and categorical (≥10 points)

Adjusted for

Age, BMI, parity, smoking, and the EPDS in early pregnancy

Post hoc

1. Insomnia score+Sleepiness score and SDB score+Sleepiness score (to evaluate the cumulative effect of sleep disturbances)

All *p*-values were corrected using the Bonferroni correction. *P*-values (two-tailed) <0.05 were interpreted as statistically significant. 95% CIs were calculated for the ORs and AORs.

All analyses were performed in R (4.2.2, 2022), and figures were constructed using library ggplot2.

STUDY III

Aims of the study

A) To compare the experience of IOL during induction in outpatient (OP) and inpatient (IP) settings.

B) To compare the experience of IOL in OP and IP settings evaluated after delivery.

Questionnaires:

- *The concurrent induction experience questionnaire* [Visual analogue scale questions, VAS]) asked 1h, 5h, 9h and 13h during catheter induction)

- *The postpartum induction experience questionnaire* (VAS questions)

Statistics

- Distribution of the variables: Shapiro-Wilk test

- Baseline group differences: a two-sample t test or Wilcoxon rank sum test

- Continuous variables that followed normal distribution were summarized with mean and standard deviation (SD) or 95% confidence interval (CI), skewed distributions were reported with median and lower (Q1) and upper quartiles (Q3) or 95% CI.

-The responses from all VAS questionnaires were skewed; therefore, they were square root-transformed in the analysis.

-In the VAS questionnaires:

- A hierarchical linear mixed model (HLMM) with repeated measures including a between factor (group) and within-factor (time)

- The group and time interaction were added by the statistically significant background factors of age, parity, BMI, physical health and mental health

- An unstructured covariance structure was used for time

- In group comparisons (OP vs IP settings):

- The differences between the VAS mean values were expressed as delta (Δ) values of the back-transformed original VAS scale.

- The effects of the continuous factors (age, BMI, physical health and mental health) on the VAS means were expressed as slopes (β).

-Bonferroni-corrected *p*-values were used for multiple comparisons.

-The results of these questionnaires are presented as the estimated means of group and time interactions with a 95% CI from the HLMM.

- *p*-values (two-tailed) <0.05 were interpreted as statistically significant

The analysis was carried out using -SAS System, version 9.4 for Windows (SAS Institute Inc.).

STUDY IV

Aim of the study

A) To study the associations between maternal sleep quality and depressive symptoms and the experience of IOL.

Questionnaires

- *The concurrent induction experience questionnaire* (VAS questions) asked 1 h, 5 h, 9 h and 13 h during catheter induction)
- *The postpartum induction experience questionnaire* (VAS questions)
- *The Basic Nordic Sleep questionnaire* (BNSQ)
- *The Edinburgh Postnatal Depression Scale* (EPDS)

Statistics

- Data are presented as means and standard deviations (SD) or medians with 95 % confidential intervals (CI)
- Normal distribution of the variables was evaluated visually from studentized residuals

In the analyses requiring normal distribution, all VAS questions were square root transformed and for the presentation of the results, the estimates were back transformed.

- Hierarchical linear mixed models (HLMM) with repeated measures were used to analyze different VAS questionnaires
- A univariate analysis was performed. Then correlations between the variables were evaluated to avoid collinearity in the multivariate models.
- Because of the strong correlation between a question about general sleep quality and the Insomnia score, general sleep quality was chosen for further analysis.

Multivariate models

1. To evaluate the effects of depressive symptoms and sleep quality including EPDS, general sleep quality, SDB score, sleep duration, sleep loss, Sleepiness score, age, BMI, parity and physical health.
2. To examine the effects of sleep disturbances symptom effects, including difficulties to fall asleep, nocturnal awakenings per night, too early morning awakening, daytime sleepiness, age, BMI, parity and physical health to the model.

- The models in t*he Concurrent induction experience questionnaire* included a within-factor (time).
- *p*-values (two-tailed) <0.05 were interpreted as statistically significant

The analysis was carried out using SAS System, version 9.4 for Windows (SAS Institute Inc.)

4.4 Ethics

4.4.1 The FinnBrain Birth Cohort Study

The FinnBrain Birth Cohort study was approved by the Joint Ethics Committees of the University of Turku and Turku University Hospital, Turku, Finland (no. ETMK 57/180/2011, meeting 14.6.2011 § 168). After receiving oral and written information about the study, the volunteers signed an informed consent form.

4.4.2 The Clinical Hospital Cohort Study

The Clinical Hospital Cohort Study was approved by the Ethics Committee of the Hospital District of Southwest Finland on 19 April 2016 and 18 April 2017 (3/1801/2016 and 40/1801/2017) and was registered at clinicaltrials.gov (NCT 02793609). After receiving oral and written information about the study, the volunteers signed an informed consent form.

5 Results

5.1 The FinnBrain Birth Cohort Study

5.1.1 Association between sleep quality and the likelihood of ending with induction of labor (*Study I*)

5.1.1.1 Maternal, delivery and newborn characteristics

The maternal, delivery and newborn characteristics in *Study I* are shown in **Table 10**. Compared to the women in the SOL group, those in the IOL group were more often primiparous, had higher pre-pregnancy BMI, and were delivered more often by CS. Known indications for IOL were threatening prolonged pregnancy (33.5%), spontaneous rupture of membranes (26.6%), fetal growth issues (16.6%), fear of childbirth (4.5%) and tiredness/exhaustion (2.7%). Missed reasons for IOL accounted for 16.1% of the women. In the post hoc analysis, being in the IOL group had no moderating effect on the association between sleep variables and delivery mode (CS vs. vaginal delivery).

5.1.1.2 Associations between maternal sleep quality and the likelihood of ending with induction of labor

The occurrences of sleep disturbances in *Study I* are shown in **Table 11.** There were no differences between the groups in terms of general sleep quality, Insomnia score, SDB score or Sleepiness score, or in various insomnia, SDB or sleepiness symptoms. Approximately 40% of the women in both groups had poor general sleep quality. Nearly all the women had nocturnal awakenings almost every night when considered on a weekly basis and almost half had nocturnal awakenings at least three times nightly. Difficulty to fall asleep was also frequent, occurring in almost 30% of the women. Awakening too early in the morning occurred more rarely (21% and 17% in the IOL and the SOL groups, respectively).

Table 10. Maternal, delivery and newborn characteristics of the Finnbrain Birth Cohort Study.

	Study III				Study IV			
	All n=1778	Spontaneous labor n=1447	Induction of labor n=331		All n=2405	Spontaneous onset of labor n=1962	Induction of labor n=443	
	Mean±SD	Mean±SD	Mean±SD	*p*-value	Mean±SD	Mean±SD	Mean±SD	*p*-value
Maternal age (years)	30.1±4.4	29.9±4.4	30.7±4.5	0.007	30.2±4.5	30.1±4.5	30.6±4.6	0.087
BMI (kg/m²)	24.2±4.4	23.8±4.1	25.7±5.4	< 0.001	24.2±4.4	23.9±4.1	25.8±5.4	<0.001
Gestational age	40+2±7	40+1±7	40+4±9	<0.001	40+2± 7	40+1±7	40+4±9	<0.001
EPDS	5.2±4.0	5.1±4.0	5.3±4.2	0.600				
	n (%)	**n (%)**	**n (%)**		**n (%)**	**n (%)**	**n (%)**	
Primiparous	798 (44.9)	625 (43.2)	173 (52.3)	0.002	1116 (50.6)	871 (48.5)	245(60.2)	<0.001
Smoking (yes)	289 (16.8)	234 (16.2)	55 (16.6)	0.910	376 (15.6)	304 (15.5)	72 (16.3)	0.749
Reasons for IOL								
Maternal tiredness	9 (2.7)				17(3.3)			
Fear of childbirth	15 (4.5)				18(3.5)			
Prolonged pregnancy	111(33.5)				167(32.5)			
Spontaneous rupture of membrane	91(26.6)				54(10.5)			
Fetus growth issues	55 (16.6)				26 (5.1)			
Primary method for IOL								
Prostaglandin			106 (32.0)				135	
Balloon catheter			81 (24.5)				104	
Artificial rupture of membrane			54 (16.3)				81	

	Study III				Study IV			
	All n=1778	Spontaneous labor n=1447	Induction of labor n=331		All n=2405	Spontaneous onset of labor n=1962	Induction of labor n=443	
	Mean±SD	Mean±SD	Mean±SD	*p*-value	Mean±SD	Mean±SD	Mean±SD	*p*-value
Oxytocin			81 (24.5)				96	
Failed IOL			11(3.3)					
Mode of delivery								
Vaginal delivery	1395 (78.5)	1171 (80.9)	224 (67.7)	<0.001	1878(78.1)	1591(81.1)	287(64.8)	<0.001
Vacuum extraction	235 (13.2)	186 (12.9)	49 (14.8)	0.393	309 (12.8)	240 (12.2)	69 (15.6)	0.069
Urgent cesarean section	130 (7.3)	77 (5.3)	53 (16.0)	<0.001	193 (8.0)	113 (5.8)	80 (18.1)	<0.001
Emergency cesarean section	18 (1.0)	13 (0.9)	5 (1.5)	0.356	25 (1.0)	18 (0.9)	7 (1.6)	0.202
Lenght of labor (mean minutes±SD)	495±315	507±310	433±332	<0.001	493±309	504±305	439±321	<0.001
Experience of labor (positive)[a]					953 (54.8)	821 (58.0)	132 (40.9)	<0.001
Newborn characteristics	Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
Birthweight (g)	3643.9±446	3628.7±433	3710.4±495	0.005	3637±441	3619±427	3717±488	<0.001
Newborn's uApH	7.3±0.1	7.27±0.1	7.25±0.1	0.003	7.27±0.1	7.27±0.1	7.25±0.1	<0.001
Apgar<7(15min)n(%)	19 (1.1)	15 (1.0)	4 (1.2)	0.768	41 (1.7)	32 (1.6)	9 (2.0)	0.693

The first used method of induction of labor. Missing data of the method n=27. Elective cesarean sections were excluded from the study.
[a]The options in the question of experience of labor ('very positive'/'quite positive'/'quite hard'/'very hard') were dichotomized in analysis as 'positive' ('very positive' and 'quite positive' combined) and 'negative' ('quite hard' and 'very hard' combined).
One sudden fetus mortus occurred after induction of labor has started, no other serious complications related to induction of labor.
BMI=body mass index; EPDS=Edinburg Postnatal Depression Scale; IOL=Induction of labor; uApH=umbilical artery pH; uVpH=umbilical venous pH.
Some of the reasons for IOL were absent of the information.

Among the distinct sleepiness symptoms, napping was the most frequent in both groups (35%). Furthermore, daytime sleepiness was common in both groups. Although morning sleepiness was less common, it still occurred quite frequently. (**Table 11**) The mean sleep duration was similar in both groups (**Table 11**), but when sleep duration was considered categorically, women in the IOL group were more likely to be short than those in the SOL group. **(Table 12)** In terms of sleep loss, the two groups showed no differences. (**Table 12**)

In the unadjusted model, women with a higher SDB score, snoring and short sleep (sleep < 7 h) were more likely to end up IOL. However, after adjustments (age, parity, BMI, smoking, and EPDS in early pregnancy), these differences vanished.

Table 11. Occurrences of sleep disturbances in the groups during the month before delivery (Study I).

Sleep variables	Spontaneous onset of labor *n=1 447*		Induction of labor *n=331*	
	n (%)	*mean±SD*	*n (%)*	*mean±SD*
General sleep quality (quite poor or poor)	558 (39.0)		141 (43.0)	
Insomnia score		9.9±2.1		10.1±2.2
Difficulty to fall asleep week	399 (27.8)		93 (28.2)	
Nocturnal awakenings/week	1 358 (94.6)		310 (93.9)	
Nocturnal awakenings/night	688 (48.1)		144 (43.9)	
Too early morning awakening/week	240 (16.8)		68 (20.7)	
Sleep Disordered Breathing score		3.0±1.5		3.3±1.7
Snoring/week	241 (17.0)		74 (22.7)	
Witnessed apneas/week	11 (0.8)		4 (1.2)	
Sleepiness score		8.6±2.7		8.6±2.6
Morning sleepiness/week	292 (20.4)		80 (24.3)	
Daytime sleepiness/week	403 (28.1)		94 (28.7)	
Napping/week	521 (36.6)		113 (34.5)	
Sleep duration (h)		7.8±1.3		7.7±1.4
< 7 hours	210 (15.4)		61 (20.2)	
> 9 hours	98 (7.2)		25 (8.3)	
Sleep loss (min)		58±73		64±91
Sleep loss ≥ 2 hours	324 (24.5)		77 (25.9)	

Sleep disturbances were adopted from Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) were considered indicative ('yes') of a sleep disturbance (shown in table).

Table 12. Associations between sleep disturbances and induction of labor (Study I).

	Spontaneous labor	Induction of labor			
		OR (95% CI) [a]	*p-value*	*AOR (95% CI)* [b]	*p-value*
General sleep quality (quite poor/poor)	Ref	1.18 (0.92–1.50)	0.186	1.08 (0.82–1.42)	0.566
Insomnia score[§]	Ref	1.05 (0.99–1.11)	0.104	1.03 (0.96–1.10)	0.406
Difficulty falling asleep/week	Ref	1.02 (0.78–1.33)	0.890	1.04 (0.77–1.39)	0.801
Nocturnal awakenings/week	Ref	0.89 (0.55–1.51)	0.653	0.77 (0.45–1.40)	0.369
Nocturnal awakenings/night	Ref	0.84 (0.66–1.07)	0.169	0.79 (0.60–1.02)	0.076
Too early morning awakening/week	Ref	1.29 (0.10–1.74)	0.094	1.08 (0.76–1.50)	0.667
Sleep Disordered Breathing score	Ref	1.09 (1.01–1.17)	**0.021**	0.99 (0.91–1.08)	0.835
Snoring/week	Ref	1.43 (1.06–1.91)	**0.017**	1.03 (0.73–1.44)	0.848
Sleepiness score	Ref	1.01 (0.97–1.06)	0.675	1.00 (0.95–1.05)	0.940
Morning sleepiness/week	Ref	1.26 (0.94–1.66)	0.115	1.20 (0.87–1.65)	0.258
Daytime sleepiness/week	Ref	1.03 (0.78–1.34)	0.846	0.93 (0.69–1.25)	0.636
Napping/week	Ref	0.91 (0.71–1.17)	0.468	0.87 (0.66–1.15)	0.342
Sleep duration	Ref	0.93 (0.85–1.03)	0.163	0.94 (0.85–1.04)	0.219
< 7 hours[c]	Ref	1.41 (1.02–1.94)	**0.034**	1.31 (0.91–1.85)	0.133
> 9 hours[c]	Ref	1.24 (0.77–1.94)	0.358	1.15 (0.68–1.87)	0.591
Sleep loss	Ref	1.00 (1.00–1.00)	0.252	1.00 (1.00–1.00)	0.172
≥ 2 hours	Ref	1.08 (0.81–1.43)	0.604	1.04 (0.74–1.43)	0.833

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) were considered indicative ('yes') of a sleep disturbance (shown in the table).

[a]OR = Univariate analysis (binary logistic regression analysis).

[b]AOR = Adjusted for age, BMI, parity, smoking, and the Edinburgh Postnatal Depression Scale (EPDS) in early pregnancy (binary logistic regression analysis).

[c]Compared to those who sleep 7–9 hours.

Missing data: In general 0.7–2.0% were missing, and in sleep duration 6.5% was missing.

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5.1.2 Associations between sleep quality, depressive symptoms and experience of labor (Study II)

5.1.2.1 Maternal, delivery and newborn characteristics

The maternal, delivery and newborn characteristics in *Study II* are shown in **Table 10**. Compared to the women in the SOL group, those in the IOL group were more often primiparous, had a higher BMI and had more deliveries by emergency CS (**Table 10**).

5.1.2.2 Experience of labor

The EOL was better in the SOL group than in the IOL group. Of all the women, 953 (54.8%, SOL group: 821 [58.0%], IOL group: 132 [40.9%]) reported a positive EOL ($p < 0.001$ between SOL and IOL group). (**Table 10**) In the SOL group, 251 (18.9%) felt very positive their EOL as did 17 (5.7%) women in IOL group. Furthermore, the EOL was reported to be very difficult by 80 (6.0%) women in the SOL group and 32 (10.7 %) in the IOL group.

5.1.2.3 Sleep quality

The occurrence of sleep disturbances in the four measurement points in *Study II* are shown in **Table 13a and b** and **Figure 11**. General sleep quality worsened during pregnancy similarly in both the IOL and SOL groups. The Insomnia scores, and all distinct insomnia symptoms increased similarly in both groups as pregnancy proceeded. The most frequent insomnia symptoms were nocturnal awakenings/week, which was already common in early pregnancy. At delivery almost all the women in both groups reported such symptoms. Of the SDB symptoms, snoring increased during pregnancy in both groups. However, reported witnessed apnea was rare. In mid-pregnancy, compared to the women in the SOL group, those in the IOL group had a shorter sleep duration, and more women in the IOL slept under 7 hours.

The Sleepiness scores showed a U-shaped change, being highest in early pregnancy and at delivery in both groups. Of the distinct sleepiness symptoms, daytime sleepiness was the most common symptom in early pregnancy, while napping occurred most frequently at delivery.

Table 13a. Occurrences of sleep disturbances and depressive symptoms in the spontaneous onset of labor group during the pregnancy (Study II).

	Spontaneous onset of labor							
	Early pregnancy *n=1 717*		Mid-pregnancy *n=1 434*		Late pregnancy *n=1 508*		Delivery *n=1 213*	
	n (%)	*mean±SD*	*n (%)*	*mean±SD*	*n (%)*	*mean±SD*	*n (%)*	*mean±SD*
General Sleep Quality (quite poor or poor)	238 (14.0)		202 (14.2)		423 (28.3)		469 (39.1)	
Insomnia score		7.84±2.09		7.99±2.08		9.12±1.99		9.88±2.06
Difficulty to fall asleep/week	92 (5.4)		89 (6.3)		227 (15.2)		323 (26.8)	
Nocturnal awakenings/week	1293 (76.3)		1067 (75.1)		1374 (91.8)		759 (93.4)	
Nocturnal awakenings/night	218 (12.9)		194 (13.7)		496 (33.2)		574 (47.8)	
too early morning awakening/week	120 (7.1)		99 (7.0)		169 (11.3)		198 (16.5)	
Sleep Disordered Breathing score		2.54±1.09		2.63±1.17		2.82±1.33		3.03±1.49
snoring/week	112 (6.7)		109 (7.8)		189 (12.9)		195 (16.4)	
witnessed apneas/week	4 (0.2)		7 (0.5)		7 (0.5)		8 (0.7)	
Sleepiness score[c]		8.34±2.51		7.83±2.50		8.20±2.73		8.53±2.68
morning sleepiness/week	447 (26.3)		328 (23.1)		327 (21.9)		238 (19.8)	
daytime sleepiness/week	508 (30.0)		353 (24.9)		423 (28.4)		338 (28.1)	
napping/week	310 (18.4)		200 (14.2)		346 (23.3)		435 (36.4)	
Sleep duration (hours)		7.96±0.95		7.89±0.94[b]		7.92±1.10		7.77±1.26
< 7 hours[a]	117 (6.9)		105 (7.4)[b]		157 (10.6)		177 (15.5)	
> 9 hours[a]	100 (5.9)		66 (4.7)		104 (7.0)		80 (7.0)	
Sleep loss[f] (minutes)		58.65±65.17		57.75±59.50		52.99±67.31		58.74±72.71
Sleep loss ≥ 2 hours	348 (21.0)		286 (20.6)		291 (20.1)		267 (24.0)	
EPDS score		5.06±3.93		4.88±4.01		4.77±4.03		*NA*
EPDS score ≥ 10	219 (12.8)		181 (12.7)		198 (13.3)		*NA*	

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) considered indicative ('yes') of a sleep disturbance (shown in table). All women who replied to the BNSQ at least once were included.
EPDS = Edinburg Postnatal Depression Scale. EPDS was evaluated at early, mid- and late pregnancy point.
Early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and at delivery (0–6 days after)
[a]Compared to those who slept 7–9 hours.
[b]Bonferroni corrected *p-value <0.05* in univariate model comparing the induction of labor group to the spontaneous labor group.
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Table 13b. Occurrences of sleep disturbances and depressive symptoms in the induction of labor group during the pregnancy (Study II).

	Induction of labor							
	Early pregnancy *n=391*		Mid-pregnancy *n=315*		Late pregnancy *n=333*		Delivery *n=284*	
	n (%)	*mean±SD*	*n (%)*	*mean±SD*	*n (%)*	*mean±SD*	*n (%)*	*mean±SD*
General Sleep Quality (quite poor or poor)	51 (13.2)		46 (14.8)		95 (28.6)		123 (43.6)	
Insomnia score		7.94±2.11		8.12±2.08		9.24±2.10		10.19±2.14
Difficulty to fall asleep/week	25 (6.5)		18 (5.8)		63 (19.1)		82 (29.0)	
Nocturnal awakenings/week	300 (77.7)		243 (77.9)		299 (90.6)		634 (95.5)	
Nocturnal awakenings/night	39 (10.1)		42 (13.5)		100 (30.2)		123 (43.8)	
Too early morning awakening/week	27(7.0)		23 (7.4)		39 (11.8)		57 (20.1)	
Sleep Disordered Breathing score		2.65±1.12		2.74±1.17		3.00±1.40		3.18±1.64
Snoring/week	29 (7.6)		30 (9.7)		54 (16.7)		59 (20.9)	
Witnessed apneas/week	0 (0)		0 (0)		0 (0)		3 (1.1)	
Sleepiness score		8.53±2.61		7.93±2.62		8.26±2.66		8.65±2.60
Morning sleepiness/week	123 (31.9)		78 (24.9)		74 (22.2)		70 (24.7)	
Daytime sleepiness/week	127 (33.0)		76 (24.3)		90 (27.1)		81 (28.7)	
Napping/week	78 (20.4)		40 (12.9)		71 (21.4)		102 (36.0)	
Sleep duration (hours)		7.90±1.02		7.71±1.01[b]		7.89±1.22		7.67±1.50
< 7 hours[a]	30 (7.9)		37 (11.9)		40 (12.1)		54 (20.8)	
> 9 hours[a]	20 (5.2)		13 (4.2)		24 (7.3)		24 (9.3)	
Sleep loss (minutes)		64.30±69.76		66.49±68.98		57.32±71.64		64.03±92.71
Sleep loss ≥ 2 hours	86 (23.1)		81 (26.6)		77 (23.8)		64 (25.1)	
EPDS score		5.20±4.30		4.67±4.15		4.72±4.11		*NA*
EPDS score ≥ 10	57 (14.8)		39 (12.5)		45 (13.5)		*NA*	

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) were considered indicative ('yes') of a sleep disturbance (shown in table). All women who replied to the BNSQ at least once were included.
EPDS = Edinburg Postnatal Depression Scale. EPDS was evaluated at early, mid- and late pregnancy point.
Early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and at delivery (0–6 days after)
[a]Compared to those who slept 7–9 h.
[b]Bonferroni corrected *p-value* < *0.05* in univariate model comparing the induction of labor group to the spontaneous labor group.
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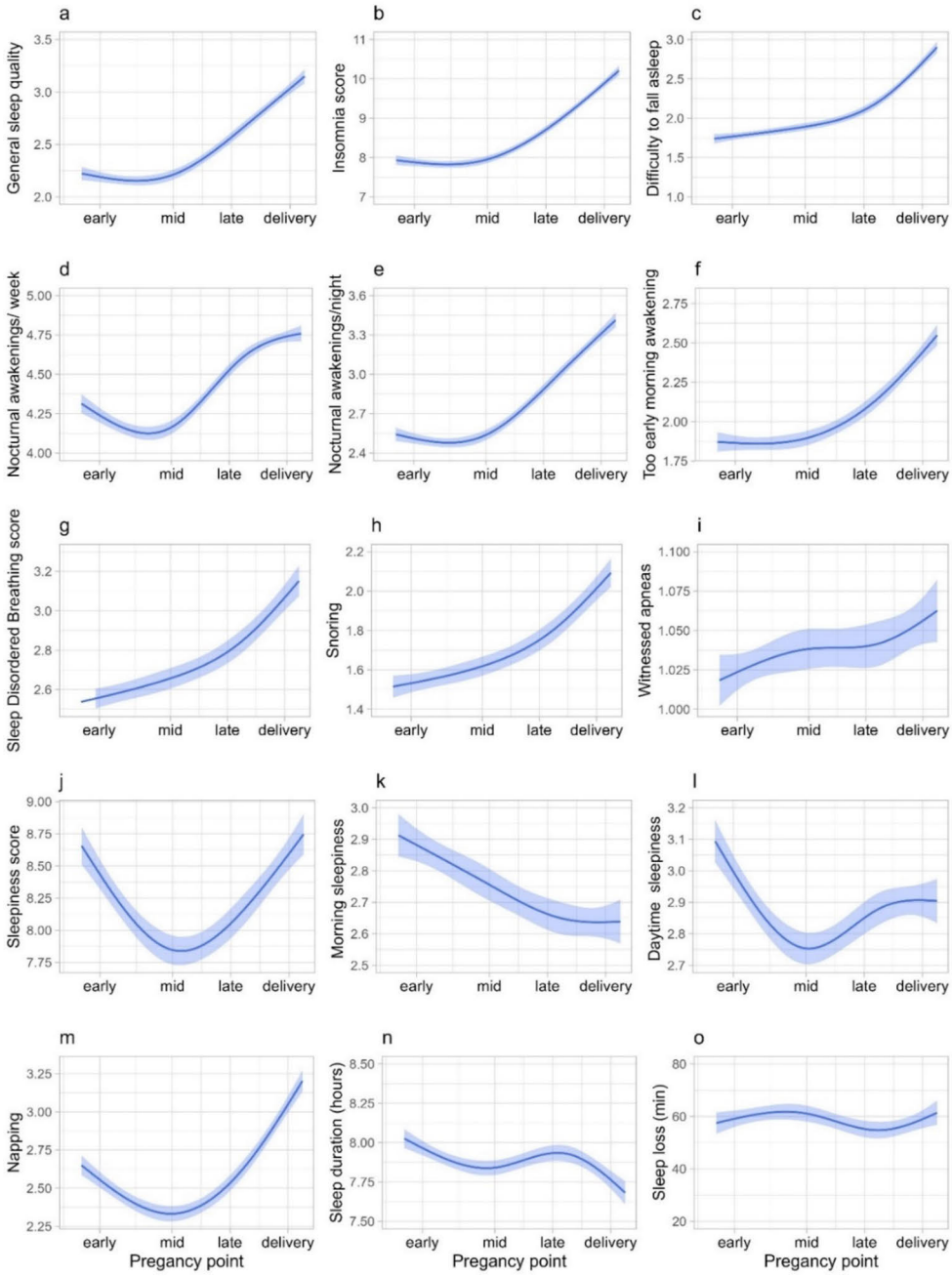

Figure 11. Sleep quality of all women in the FinnBrain sub-studies (Study II) measured using the Basic Nordic Sleep questionnaire (BNSQ) in early-, mid- and late pregnancy and at delivery. Early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and at delivery (0–6 days postpartum).

5.1.2.4 Associations between sleep quality and experience of labor

The association between sleep quality and EOL is presented in **Table 14** and **Figure 13**. Measured in early pregnancy, there was no association between sleep disturbances and EOL. In mid-pregnancy, women with higher Insomnia scores, higher Sleepiness scores, and more daytime tiredness were more likely to report

Table 14. Associations between sleep disturbances and depressive symptoms and experience of labor (Study II).

	AOR	*95% CI*	*p-value*
General Sleep Quality (quite poor or poor)	1.49^{pp4}	1.17-1.89^{pp4}	0.005^{pp4}
Insomnia score	1.08^{pp2} 1.10^{pp4}	1.02-1.15^{pp2} 1.04-1.16^{pp4}	0.042^{pp2} 0.007^{pp4}
Difficulty to fall asleep/week	1.57^{pp4}	1.21-2.03^{pp4}	0.003^{pp4}
Nocturnal awakenings/week	1.87^{pp3}	1.20-2.94^{pp3}	0.025^{pp3}
Nocturnal awakenings/night	-	-	-
Too early morning awakening/week	-	-	-
Sleep Disordered Breathing score	-	-	-
Snoring/week	-	-	-
Sleepiness score	1.10^{pp2} 1.06^{pp3} 1.06^{pp4}	1.04-1.16^{pp2} 1.02-1.11^{pp3} 1.02-1.11^{pp4}	0.001^{pp2} 0.028^{pp3} 0.034^{pp4}
Morning sleepiness/week	1.48^{pp3} 1.82^{pp4}	1.10-1.98^{pp3} 1.36-2.45^{pp4}	0.034^{pp3} <0.001^{pp4}
Daytime sleepiness/week	1.47^{pp2}	1.11-1.96^{pp2}	0.031^{pp2}
Napping/week	-	-	-
Sleep duration (hours)	-	-	-
< 7 hours	-	-	-
Sleep loss	-	-	-
Sleep loss ≥ 2 hours	-	-	-
Insomnia+Sleepiness scores	1.05^{pp1} 1.07^{pp2} 1.04^{pp3} 1.05^{pp4}	1.01-1.08^{pp1} 1.03-1.11^{pp2} 1.01-1.08^{pp3} 1.02-1.09^{pp4}	0.020^{pp1} <0.001^{pp2} 0.027^{pp2} 0.003^{pp4}
SDB+Sleepiness scores	1.09^{pp2} 1.06^{pp3}	1.04-1.14^{pp2} 1.02-1.10^{pp2}	0.001^{pp2} 0.023^{pp3}
EPDS score	1.05^{pp1} 1.04^{pp2} 1.05^{pp3}	1.02-1.08^{pp1} 1.01-1.08^{pp2} 1.02-1.08^{pp3}	0.004^{pp1} 0.026 ^{pp2} 0.003^{pp3}
EPDS score ≥ 10	1.68^{pp3}	1.24-2.27^{pp3}	0.003^{pp3}

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) considered indicative ('yes') of a sleep disturbance (shown in the table). All women who replied to the BNSQ at least once were included. EPDS = Edinburg Postnatal Depression Scale. EPDS was evaluated at early, mid- and late pregnancy points. AOR = Adjusted for age, BMI, parity, smoking, and EPDS in early pregnancy (binary logistic regression analysis), except EPDS scores that the EPDS scores were not adjusted in early pregnancy. *p-values* were Bonferroni corrected, and only statistically significant findings ($p < 0.05$) are reported. pp1=early pregnancy point; pp2=mid-pregnancy point; pp3=late pregnancy point; pp4=delivery point.

negative EOL. Further in late pregnancy, higher Sleepiness scores, more frequent nocturnal awakenings/week and more frequent morning sleepiness were related to a negative EOL. At delivery, women with higher Insomnia scores, higher Sleepiness scores, worse general sleep quality, more frequent difficulty to fall asleep and more frequent morning sleepiness were more likely to report a negative EOL. (**Table 15**.). Only one interaction between IOL and sleep disturbances was found: at delivery, women with greater sleep loss in the IOL group were more likely to report a negative EOL (AOR = 2.82, 95% CI 1.32–6.22*, p = 0.034*).

In the *post hoc* analyses, the combined scores of Insomnia and Sleepiness, as well as SDB and Sleepiness were associated with negative EOL at all pregnancy points, except for SDB and Sleepiness scores in early pregnancy and at delivery (*p = 0.416* and *p = 0.083*, respectively) (**Table 14**).

5.1.2.5 Depressive symptoms and their associations with experience of labor

The distributions of the EPDS scores at three measurement points in the FinnBrain Birth Cohort Study *(Study II)* during pregnancy are shown in **Figure 12,** and their occurrences are shown in **Tables 13a and b**. The total EPDS scores, as well as the number of women with EPDS scores ≥ 10 remained stable during pregnancy in both groups (EPDS scores ≥ 10 varied between 12.5–14.8 %). The mean EPDS score was approximately 5, and an EPDS score ≥ 10 was recorded in 13–15 % of the women. (**Table 13a and b**). Women with higher depressive symptoms in early, mid- and late pregnancy were more likely to report a negative EOL, albeit similarly in both IOL and SOL groups. A high EPDS score (≥ 10) was associated with a negative EOL only in late pregnancy (**Table 13a** and **b** and **Figure 13**). Depressive symptoms were not evaluated at delivery.

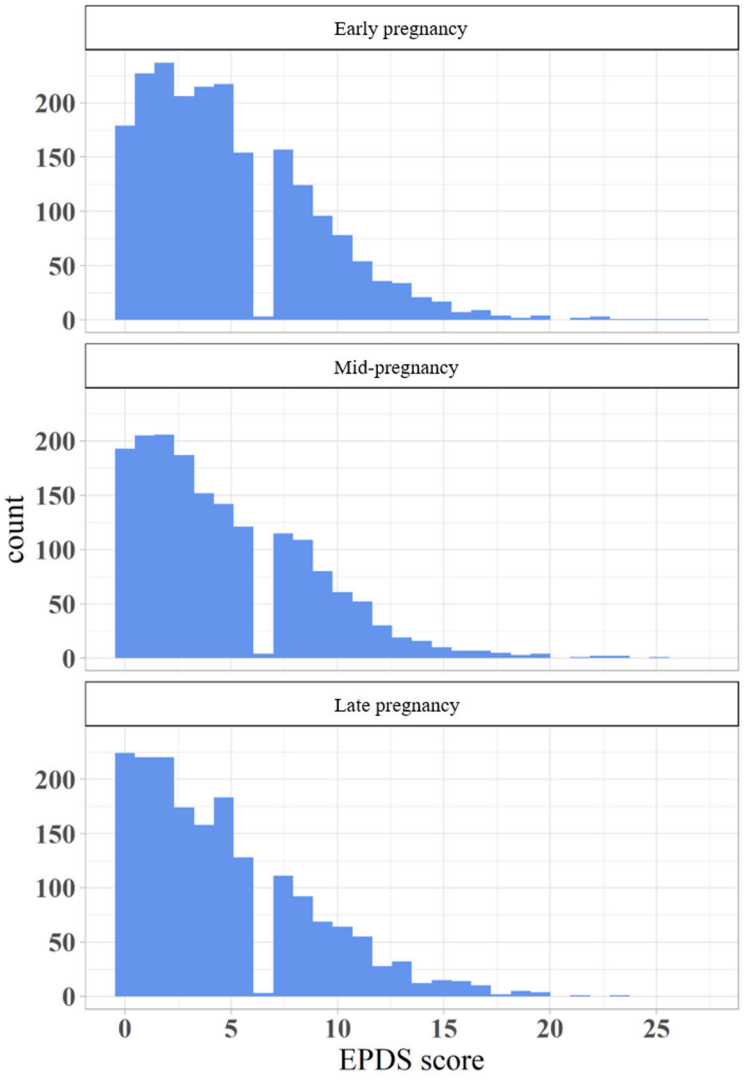

Figure 12. Distribution of Edinburgh Postnatal Depression Scale (EPDS) scores in early- mid- and late pregnancy in the FinnBrain Birth Cohort Study. Early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and at delivery (0–6 days postpartum).

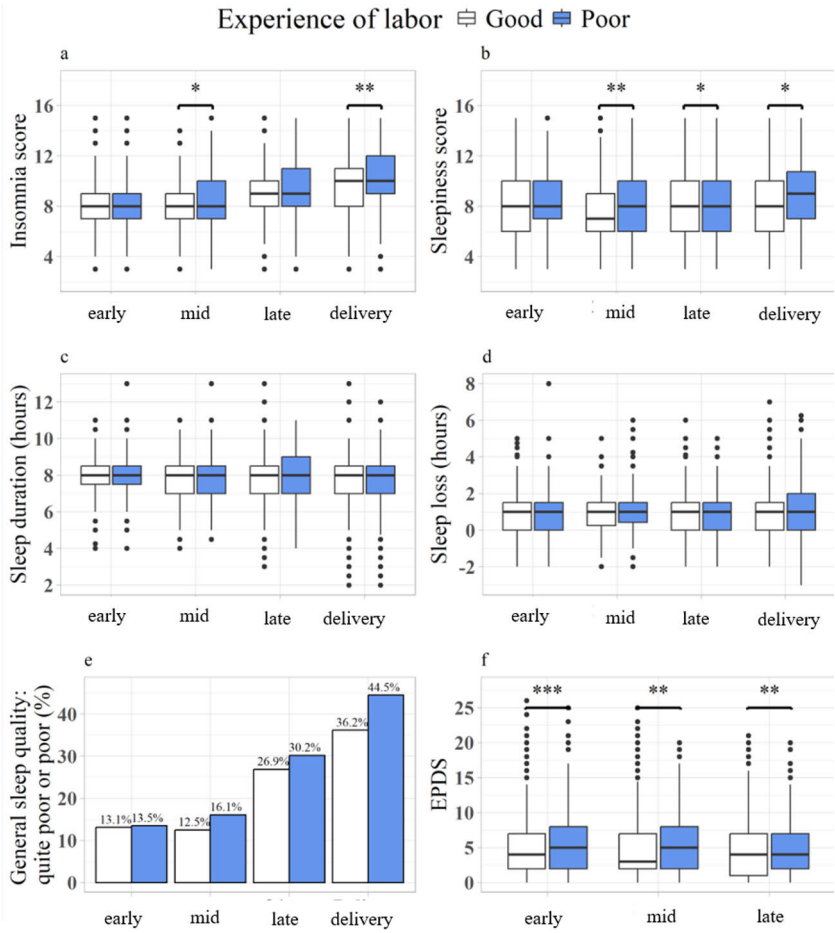

Figure 13. Associations between sleep disturbances and depressive symptoms and the experience of labor. Differences between positive and negative experiences of labor at each pregnancy points. General sleep quality is shown using Barplot and other symptoms using Boxplot. Levels of statistical difference: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. EPDS= Edinburgh Postnatal Depression Scale. Early pregnancy (11+2–16+6 gws), mid-pregnancy (22+0–27-6 gws), late pregnancy (32+0–38+0 gws) and at delivery (0–6 days postpartum).

5.2 The Clinical Hospital Cohort Study

5.2.1 Importance of the setting for the experience of induction of labor (Study III)

5.2.1.1 Maternal, delivery and newborn characteristics and pregnancy-related attitudes and experiences

The maternal, delivery and newborn characteristics were similar between the OP and IP groups (**Table 15**). There were only five (5%) newborn with uApH values ≤7.1.

Threatening prolonged pregnancy (gw 41+3–41+5) was the reason for induction in 82 (77%) women. Seven (7%) of the women had diagnosed fear of childbirth. According to *the general experience questionnaire*, pregnancies were very wished for (VAS 96–97). Women reported being quite healthy (VAS 84–88), having a good support during pregnancy (VAS 92) and having only a moderate fear either of childbirth or fear of IOL (VAS 36–40) (**Table 16**).

Table 15. Maternal, delivery and newborn characteristics in the Clinical Hospital Cohort Study.

	Study II	Study I		
	All n=106	Outpatient n=53 (%)	Inpatient n=54 (%)	*P*-value[a]
	Mean±SD	Mean±SD	Mean±SD	
Maternal age (years)	30±4	30±4	31±4	0.641
BMI (kg/m²)	26±4	26±5	26±4	0.655
Gestational age (weeks)	41+1±1	41+1 ± 1	41+0 ± 1	0.601
Baseline Bishop Score	4±1	4±1	4±1	0.211
Cervix length (mm)	31±11	30±10	33±11	0.132
	n (%)	n (%)	n (%)	n (%)
Primiparous	60 (60)	32 (60)	33 (61)	0.938
Painrelief during labor				
Epidural analgesia	70 (66)	33 (62)	38 (70)	0.450
Paracervical or pudendal block	24 (23)	12 (23)	12 (22)	0.916
Spinal analgesia	5 (4.7)	2 (4)	3 (6)	0.678
Oxytocin augmentation	59 (56)	26 (49)	31 (57)	0.567
Removed balloon catheter after 24h	26 (25)	13 (25)	14 (26)	0.913
Use of misoprostol	25 (24)	10 (19)	18 (33)	0.100
Amniotomy	80 (76)	38 (72)	41 (76)	
Mode of delivery				
Vaginal delivery	70 (66)	34 (64)	36 (67)	0.491
Vacuum extraction	16 (15)	7 (13)	10 (19)	
Cesarean section	20 (19)	12 (23)	8 (15)	
	Mean±SD	Mean±SD	Mean±SD	
Length of the labor (min)	615±447	625±410	628±484	0.975
Birthweight (g)	3902±398	3939±454	3846±353	0.237
Newborn's uApH	7.2±0.1	7.2±0.1	7.3±0.1	0.707
Newborn's uVpH	7.3±0.5	7.2±0.7	7.3±0.1	0.261
Apgar at 1min	9±1	9±1.0	9±1	0.364
5 min	9±1	9±1	9±1	0.309
15 min	9±1	9±1	9±1	0.310
Gestational age at birth	41+1±1	41+3 ±1	41+2±1	0.622

[a]Statistical difference between outpatient and inpatient groups

Table 16. Results of t*he general experience questionnaire* in the Clinical Hospital Cohort Study (Study III).

	OP *n=53* *mean*[b]±*SD*	IP *n=49* *mean*[b]±*SD*	*p-value*[a]
Pregnancy intention	96±8	97±7	0.706
Physical health	85±16	84±9	0.985
Mental health	88±12	87±10	0.689
Support during pregnancy	92±9	92±12	0.761
Fear of childbirth	40±25	36±27	0.486
Fear of induction of labor	40±29	36±26	0.938

OP=outpatient, IP=inpatient. [a]Statistical difference between the OP and IP groups. [b]A higher number from Visual analogue scale (VAS) questions indicates a better option in the Visual analogue scale, except for fear of childbirth and fear of labor induction, for which a lower number indicates less fear. Reprinted from Study III with permission from *Acta Obstetricia et Gynecologica Scandinavica*.

Table 17. Results of the *Concurrent induction experience questionnaire and the Postpartum induction experience questionnaire* (Study III).

	Concurrent induction experience		***Postpartum induction experience***	
Variables	*Median VAS*	*95 % CI*	*VAS-median*	*95 % CI*
Satisfaction	15	5-35	11	5-40
Relaxedness	23	10-43	18	6-45
Fear	10	4-24	10	4-21
Anxiety	7	2-16	7	2-17
Stress	11	4-21	10	5-25
General pain	20	10-40	20	13-47
Contraction pain	25	10-45	30	16-65
Frequency of contractions	21	10-42	32	14-52
Bleeding after catheter insertion	5	0-10	7	3-20

Statistics of the Visual analogue scale (VAS) variables in t*he concurrent induction experience questionnaire* were measured over time and included all the assessed time points (1h, 5h, 9h and 13h). Number of completed questionnaires at each time-point: concurrent 1h n=101, 5h n=89, 9h n=75, and 13h n=54; postpartum n=95. A lower median VAS indicated fewer negations. Reprinted from Study III with permission from *Acta Obstetricia et Gynecologica Scandinavica.*

5.2.1.2 Experience of induction of labor with catheter

The median values (with 95% CIs) of *the concurrent induction experience questionnaire* and *the postpartum induction experience questionnaire* are presented in **Table 17.** Further, the results of the above-mentioned questionnaires for the OP and IP groups are presented in **Figure 12**. In general, women in both groups had low VAS scores, indicating a good experience of IOL.

According to *the concurrent induction experience questionnaire*, there was a group effect on satisfaction and anxiety. Women in the OP group were less satisfied and more anxious than women in the IP group. A time effect was found in satisfaction, relaxedness, fear, contraction pain, frequency of contractions and bleeding. Over the course of the induction, the women became less satisfied. However, in terms of both relaxedness and fear, women were more relaxed and experienced less fear at 5 and 9 hours than at 1 hour. The contraction pain and frequency of contractions were higher at 5 and 9 hours than at 1 hour. There was less bleeding at 5 hours than at 1 and 13 hours. In *the concurrent induction experience questionnaire*, no group × time interaction was found. **Figure 14** shows the experiences of IOL with catheter during induction and after labor in the OP and IP settings.

When evaluated the factors associated with the experience of IOL assessed with *the concurrent induction experience questionnaire,* women with self-estimated better physical health experienced less fear ($\beta = 0.04$, $p = 0.007$), were less anxious ($\beta = 0.05$, $p = 0.001$) and had lower stress levels ($\beta = 0.05$, $p = 0.001$). Those with self-estimated better mental health reported less bleeding ($\beta = 0.04$, $p = 0.004$). Compared with primiparous women, multiparous women were more relaxed ($\Delta = 7.7$, $p = 0.043$) and experienced less fear ($\Delta = 7.0$, $p = 0.007$), anxiety ($\Delta = 5.5$, $p = 0.003$), stress ($\Delta = 6.0$, $p = 0.009$) and general pain ($\Delta = 10.1$, $p = 0.001$) (**Figure 15.**). Women in the IP group also evaluated the adequacy of the help and support of hospital personnel during the IOL at 1, 5, 9 and 13 hours. Of this group, 39 women replied and reported high levels of help and support (all VAS median under 24 [95% CI 0–37]). (**Figure 16.**) The results remained the same after adjusting for age, BMI, parity, physical health and mental health.

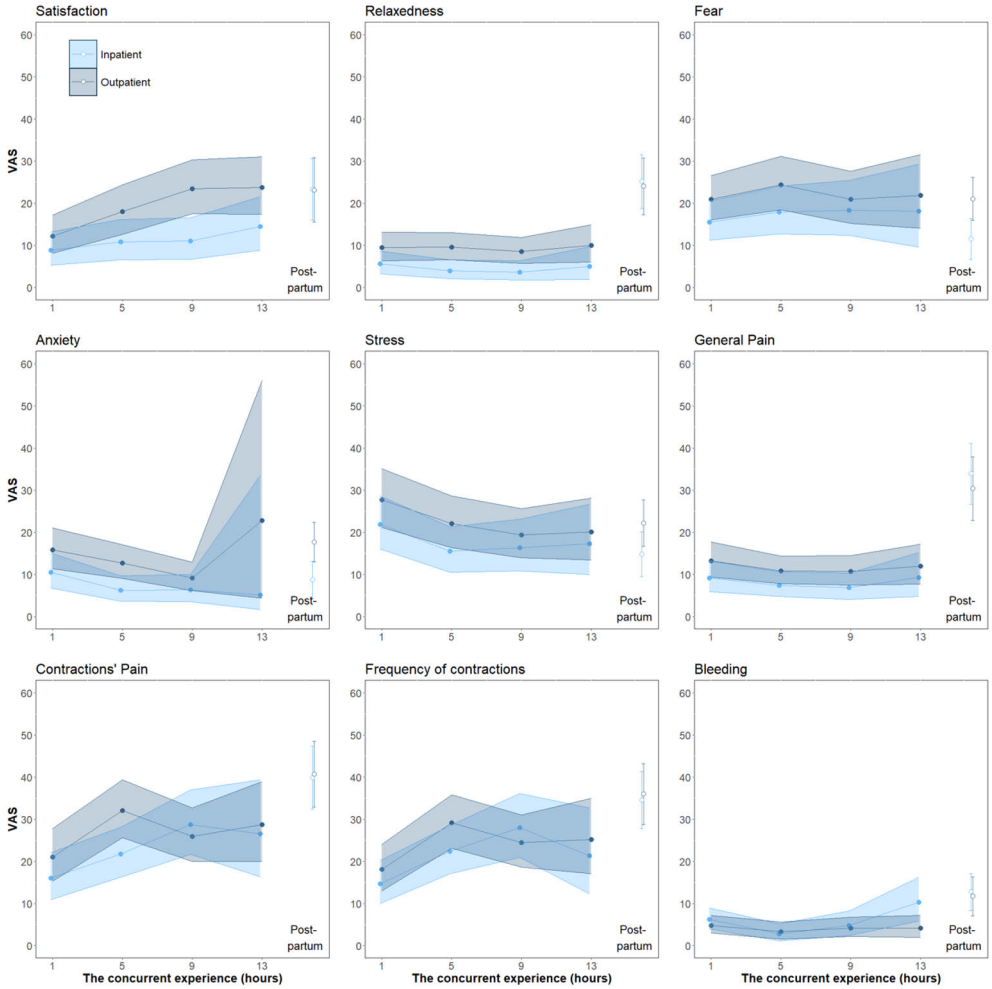

Figure 14. Experiences of induction of labor (IOL) with catheter during and after labor by the outpatient and inpatient groups. OP = outpatient group, IP = inpatient group. VAS (Visual analog scale) = groups means with 95% confidence intervals from a hierarchical linear mixed model. Scale shown in the picture: VAS 0-60 (from 100). Lower VAS indicates better experience and fewer negations. The concurrent experience = the results of the concurrent induction experience questionnaire (time-points OP: 1 h n = 51, 5 h n = 46, 9 h n = 44, 13 h n = 32; IP: 1 h n = 49, 5 h n = 42, 9 h n = 32, 13 h n = 20). Postpartum = the results of the postpartum experience questionnaire (OP n = 46, IP n = 50). Time effect: In the course of the IOL, women were less satisfied (1 hour vs 9 hours Δ = 6.2, p = *0.005*, 1 hour vs 13 hours Δ = 8.4, p = *0.001*), had more contraction pain (1 hour vs 5 hours Δ = 8.2, p = *0.025*, 1 hour vs 9 hours Δ = 8.9, p = *0.020*) and the frequency of contractions were higher (1 hour vs 5 hours Δ = 9.3, p = *0.004*, 1 hour vs 9 hours Δ = 9.9, p = 0.004), but they were more relaxed (1 hour vs 5 hours Δ = 6.1 p = 0.046, 1 hour vs 9 hours Δ = 6.9, p = *0.036*) and had less fear (1 hour vs 5 hours Δ = 3.8, p = *0.011*, 1 hour vs 9 hours Δ = 5.3, p = *0.001*). Group effect: Women in the OP group were more satisfied (mean VAS difference Δ = 7.8, p = *0.015*), but were more anxious (Δ = 4.8, p = *0.008*, postpartum: Δ = 9.0, p = *0.007*) and had more fear (postpartum: Δ = 9.5, p = *0.009*) than women in the IP group. Reprinted from Study III with permission from *Acta Obstetricia et Gynecologica Scandinavica.*

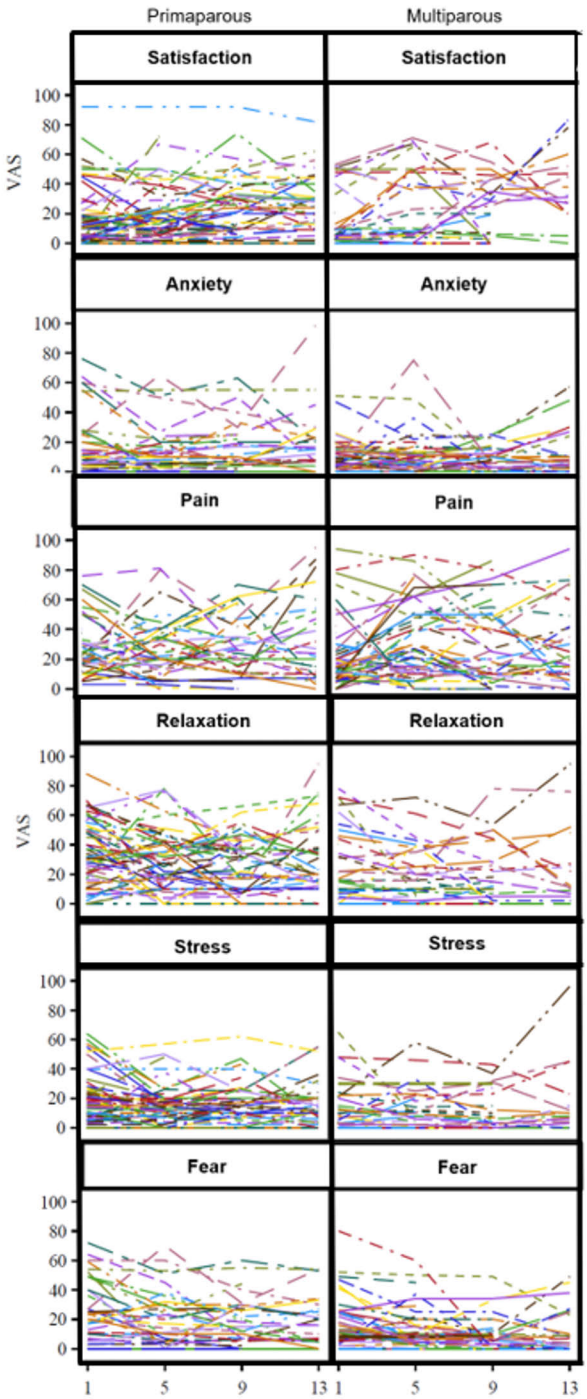

Figure 15. Experience of induction of labor according to parity. VAS=Visual Analogue Scale.

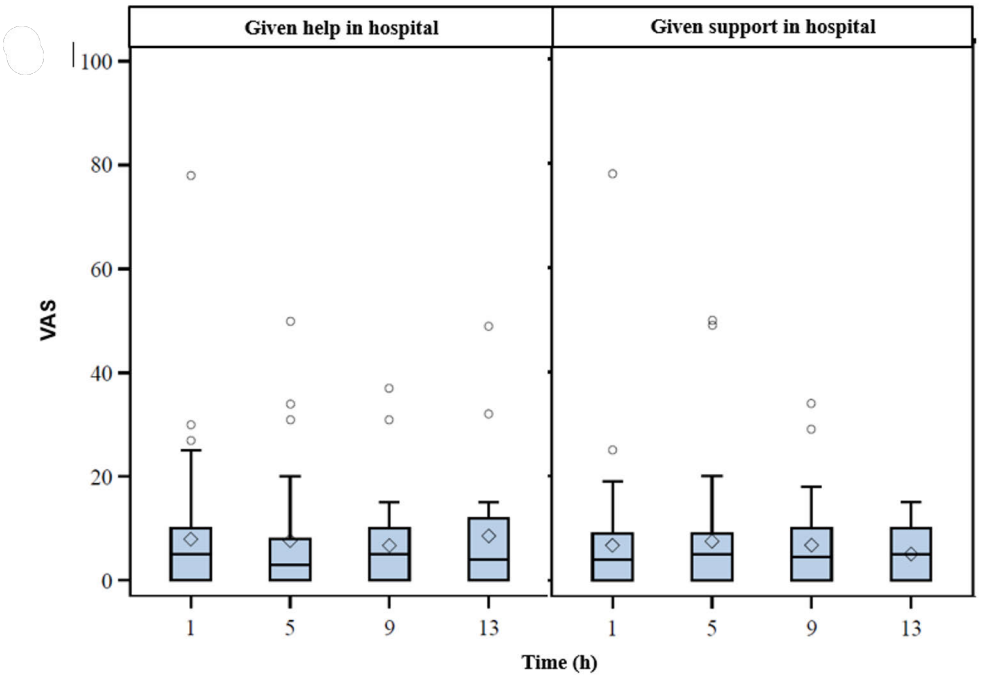

Figure 16. Experience of inpatient women about given help and support by hospital personnel. Low Visual analogue scale (VAS) score indicates 'good experience'.

According to *The postpartum induction experience questionnaire*, with VAS questions assessed after delivery mostly in maternity wards, women in the OP group had more fear of and were more anxious about IOL than women in the IP group (**Figure 12**). All women evaluated their general IOL experiences as good and their IOL pain as mild. However, the EOLs were considered quite negative and pain during labor was moderate. Among these variables, no group differences emerged (**Table 18**). According to the replies for the two futuristic questions, in a subsequent pregnancy, most of the women would have like to choose catheter IOL (total number of responses = 94, OP n = 38 [82.6%] vs IP n = 40 [87.0%], $p= 0.562$). For the question, 'If your subsequent pregnancy will be induced with a catheter, would you prefer to have the induction to take place in an outpatient setting?' (total number of responses = 94), 93.6% of the women in the OP group (n = 44/47) and 61.7% of women in the IP group (n = 29/47) ($p < 0.0001$ between the groups) reported wishing to choose an OP setting.

Table 18. Results of the general experiences of induction of labor (IOL) and labor assessed postpartum (Study III)

	VAS[a] median	*95 % CI*
General IOL experience	11.0	7.0–20.0
Pain during IOL	21.0	18.0–30.0
Labor experience	62.0	56.0–72.0
Pain during labor	75.5	70.0–80.0
Given help in hospital	5.5	4.0–10.0

VAS = Visual analogic scale, CI = confidence interval, IOL = induction of labor. [a]A lower Visual analogue score indicates a more positive experience. Number of replies = 98. Reprinted from Study III with permission from *Acta Obstetricia et Gynecologica Scandinavica.*

5.2.2 Associations between sleep quality, depressive symptoms and the experience of induction of labor (Study IV)

5.2.2.1 Sleep quality and depressive symptoms

The frequencies and mean values of sleep disturbances and EPDS scores are presented in **Table 19**. The most frequent factors inducing sleep disturbances included nocturia (23%) and physical discomfort, such as contractions, hip-pain, fetal movements (altogether 19%) and restless legs (4%).

Table 19. Sleep disturbances and depressive symptoms in Study IV (*n=106*).

	n (%)	*mean±SD*
General Sleep Quality (quite poor or poor)	25 (24)	
Insomnia score		9±2
Difficulty to fall asleep/week	19 (18)	
Nocturnal awakenings/week	96 (91)	
Nocturnal awakenings/night	43 (41)	
Too early morning awakenings/week	21 (20)	
Sleep Disordered Breathing score		3±2
Snoring/week	18 (17)	
Witnessed apneas/week	4 (3.8)	
Sleepiness score		8±3
Morning sleepiness/week	14 (13)	
Daytime sleepiness/week	26 (25)	
Napping/week	34 (32)	
Sleep duration (min)		457±72
< 7 hours	15 (14)	
≥ 9 hours	15 (14)	
Sleep loss (min)		40±83
= 0 or negative (need < duration)	12 (11)	
= sleep loss ≥ 60 min	49 (46)	
= sleep loss ≥ 120 min	16 (15)	
EPDS points		3.6±3.4
EPDS points ≥ 10	7 (6.6)	
EPDS points ≥ 13	0	

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) were considered indicative ('yes') of a sleep disturbance (shown in table). Depressive symptoms were adopted from the Edinburgh Postnatal Depression Scale. IOL= induction of labor. Reprinted from Study IV with permission from *Elsevier.*

5.2.2.2 Associations between sleep quality and the experience of induction of labor

According to *the concurrent induction experience questionnaire*, women with worse general sleep quality were less satisfied ($p = 0.019$) and less relaxed ($p = 0.008$) and reported more pain in general ($p = 0.001$) and a higher contraction frequency ($p = 0.003$). However, women with higher Sleepiness scores reported lower contraction frequencies ($p = 0.029$). However, the SDB score, sleep duration and sleep loss were not associated with *the concurrent induction experience* questions. In detail, regarding insomnia symptoms, women who experienced difficulties to fall asleep were less relaxed ($p = 0.009$) and reported more general ($p < 0.001$) and contraction

pain (*p = 0.005*), while those with more daytime sleepiness reported less contraction pain (*p = 0.033*). The results of the multivariate models are shown in **Table 20**.

According to *the postpartum induction experience questionnaire*, women with worse general sleep quality reported experiencing more pain (*p = 0.003*), but those with higher SDB scores experienced less pain in general (*p = 0.041*). Women with longer sleep durations experienced more anxiety (*p = 0.009*) while those with higher sleep loss experienced more anxiety (*p = 0.024*) and were less satisfied (*p = 0.053*, tendency). Regarding distinct insomnia symptoms, women with more frequent nocturnal awakening reported being more relaxed (*p = 0.014*) and experiencing less pain in general (*p = 0.033*). However, women who frequently woke up too early without being able to sleep again were less satisfied (*p = 0.042*), were less relaxed (*p = 0.004*) and reported more pain in general (*p = 0.018*). (**Table 20**.)

5.2.2.3 Associations between depressive symptoms and the experience of induction of labor

According to *the concurrent induction experience questionnaire*, women with more depressive symptoms reported a higher frequency of contractions (*p = 0.030*). According to *the postpartum induction experience questionnaire*, women with more depressive symptoms reported experiencing less pain in general (*p = 0.027*) (**Table 20**).

Table 20. Associations between sleep disturbances and depressive symptoms and experiences of induction of labor in multivariate models.

	Satisfaction		Relaxedness		Fear[a]	Anxiety		Stress[a]	General pain		Contraction pain		Frequency of contractions		Bleeding[a]
	CIOL[b]	PP[c]	CIOL	PP		CIOL	PP		CIOL	PP	CIOL	PP	CIOL	PP	
	β CI	*β CI*	*β CI*	*β CI*		*β CI*	*β CI*		*β CI*	*β CI*	*β CI*	*β CI*	*β CI*	*β CI*	
General sleep quality	0.44 *0.08–0.81*		0.46 *0.13–0.80*						0.47 *0.19–0.76*	0.62 *0.22–1.02*			0.35 *0.06–0.64*		
Sleep disordered breathing										-0.30 *-0.58–-0.02*					
Sleepiness													-0.13 *-0.25–-0.01*		
Sleep duration							0.01 *0.001–0.02*								
Sleep loss							0.01 *0.003–0.02*								
Difficulty to fall asleep/night			0.42 *0.11–0.73*						0.50 *0.24–0.76*		0.39 *0.12–0.66*				
Nocturnal awakenings/night				-0.56 *-1.01 – -0.12*						-0.64 *-1.21–-0.05*					
Too early morning awakening/night		0.48 *0.02–0.94*		0.63 *0.21–1.05*						0.46 *0.08–0.83*					
Daytime sleepiness											-0.30 -0.57– *-0.03*				
EPDS										-0.14 *-0.26–-0.02*			0.11 *0.01–0.19*		

Sleep disturbances were adopted from the Basic Nordic Sleep Questionnaire (BNSQ) with ratings of 1–5, where 4–5 (≥3-5 nights/days/times) considered indicative ('yes') of a sleep disturbance. Depressive symptoms were adopted from the Edinburg Postnatal Depression Scale. [a]No associations in models, [b]CIOL=*The concurrent induction experience questionnaire*, [c]= *The postpartum induction experience questionnaire*, *β* = beta coefficient, CI = confidence interval. Only statistical meaningful associations are shown in the table. Multivariate model adjusted by age, BMI, parity, and physical health. Higher value in sleep variables or EPDS indicated higher depressive symptoms or worse sleep. Higher value in experience of IOL variables indicated worse experience

Results

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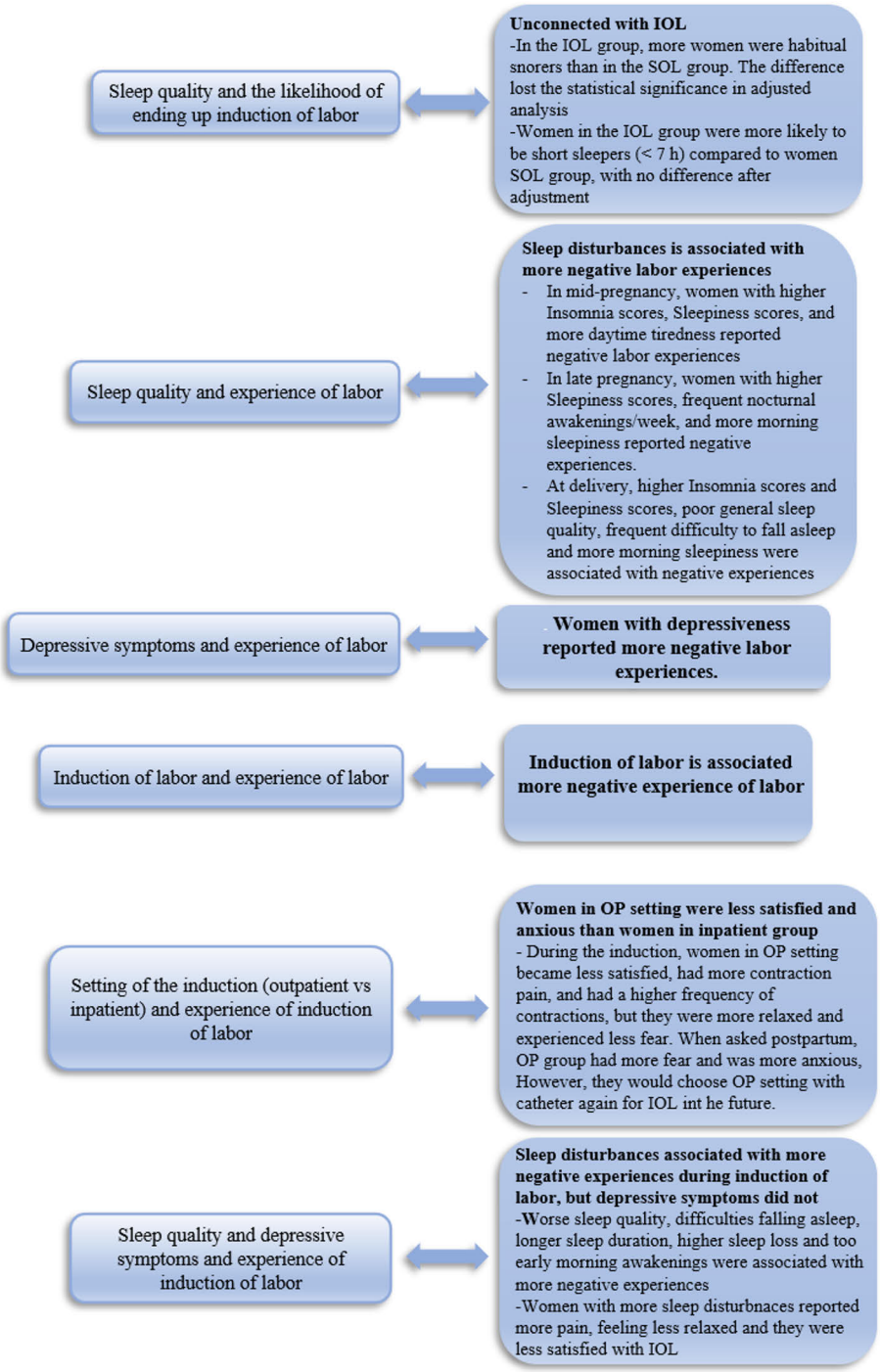

Figure 17. Summary of the results.

6 Discussion

6.1 Associations between sleep quality and the likelihood of induction of labor

Even though the literature is unanimous about an increase in sleep disturbances during pregnancy,[22,24,216,217,235,239,293,294] research assessing the relationship between maternal sleep quality and the likelihood of ending with IOL is sparse. This is surprising, since therapeutic rest, usually applied with medication for pain relief in early labor, has been shown to decrease the risk of ending with IOL.[295] Furthermore, maternal tiredness is an important indication for IOL. According to a Norwegian study of 1663 women with term pregnancies, approximately 10% of IOL cases were elective; in other words, they were performed because of maternal requests and in the absence of maternal and fetal indications.[5] The indications for these elective IOL cases were maternal fatigue and tiredness (17%), maternal anxiety (15%), maternal request (35%) or a previous negative delivery experience (1%).[5] Maternal request was the third biggest reason for IOL (together, post-term and PROM accounted for 48% of the indications for IOL). In our study (Studies I and II), we found the indication for IOL being elective accounted for 7% of IOLs. Furthermore, the reason for IOL being maternal tiredness or exhaustion accounted for 38% of elective IOLs.

In a study of 35 women five days before labor that used a wrist actigraphy for measurement of sleep quality, Beebe and Lee (2007)[226] found no differences between the IOL and SOL groups in terms of sleep duration and nightly wake-time after sleep onset. However, in this thesis, habitual snorers and short sleepers were more likely to have IOL. It is noteworthy that these two studies are not comparable because of their different methodologies. Actigraphy measures sleep architecture, while the sleep questionnaires, utilized in this thesis, measure subjective sleep quality. The mismatch between subjectively and objectively measured sleep is acknowledged.[229]

The results in this thesis were adjusted for several factors, leading to the loss of the associations between sleep disturbances and IOL. Of the adjusted factors, age and obesity are independent risk factors for SDB[233] and other comorbidities, which may predispose to IOL.[243,244,259] Regarding sleep duration, short sleep (< 6 hours) was shown to be a risk factor for CS,[188] in a study that included only women with IOL.[258] In addition, short sleep has been shown to be associated with gestational

diabetes,[259] typically related to an increased risk of IOL. Thus, taking the results together, sleep disturbances did not have independent importance. Yet, sleep disturbances can act as stressors,[166,252,253] such as for inflammatory mechanisms, which may also lead to IOL; therefore, maternal sleep quality should not be ignored.

6.2 Factors associated with the experience of induction of labor

In line with previous studies, this thesis showed, that women with IOL reported a more negative EOL than those with SOL.[12,16,145,155,181,186,187] In addition, the IOL method, setting of the IOL (OP or IP) and length of induction have been shown to be associated with the experience of IOL.[17,202] Furthermore, physiological and psychological stress may negatively influence labor and consequently, the EOL.[289] However, emotional strength, positive attitude to labor and learned coping strategies are known to be associated with a better EOL.[196] In addition, several basic factors, such as parity[181] and physical health[28,155,290] may interfere with the EOL. In this thesis, during IOL, multiparous women were more relaxed and experienced less fear, anxiety, stress and general pain than primiparous women. Furthermore, women with better physical health experienced less fear, were less anxious and had lower stress levels. The association between the EOL and the IOL setting, as well as between the EOL and maternal sleep quality and depressive symptoms, is of special interest in this thesis.

6.2.1 Importance of the setting on the experience of induction on labor

In this thesis, the importance of setting on the experience of IOL was evaluated from the Clinical Hospital Cohort Study. Induction was performed with catheter, because at that time only the catheter approach was acceptable in an OP setting in Finland. Although some minor differences between the groups in the two settings (OP and IP) emerged, as women in the OP setting were less satisfied and more anxious during IOL and reported more feelings of fear and anxiety during IOL when assessed after delivery, the overall experience in both settings was good. This was further verified, with the majority of the women in both groups reporting that they would prefer to repeat induction in the same setting for future labors. Maternal preferences are an important factor in decision-making regarding the setting for induction of labor. In the one hand, in an OP setting, women have more autonomy and freedom, and they can stay with their families. On the other hand, in an OP setting, it may be more difficult to consult health personnel; thus, women may experience uncertainty, possibly causing dissatisfaction and anxiety.

It is challenging to compare the results of this thesis to previous studies in OP settings, since the majority of those studies compared catheter induction in an OP setting to PGE induction in an IP setting or PGE induction between OP and IP settings.[203,214,296,297] Only a few studies have evaluated the experience of catheter IOL between OP and IP settings,[212,213] mainly confirming good satisfaction in both settings. Wilkinson et al. (2015)[213] and Wang et al. (2021)[212] found no difference in satisfaction between women in OP and IP settings; however, those in an OP setting reported feeling less isolated and emotionally alone.[213] However, in Waldron et al's (2022)[298] study of 26 women, only 13% agreed to discharge with a double balloon catheter.

Previously, the experience of IOL has been assessed only at certain time points during IOL or, more typically, retrospectively after delivery.[8,86,212,213] Thus, the experience could have been influenced by factors related to delivery, such as duration,[168] mode[18,194] or the time of day of the delivery.[181] In this thesis, the experience of IOL was assessed during IOL (i.e. prior to delivery) four times. Over the course of the induction, women became less satisfied but more relaxed and experienced less fear in both OP and IP settings.

Usually, studies of OP induction include only low-risk patients without pregnancy complications or other women's health issues. Normal CTG and ultrasound findings are required when it is planned for IOL to be performed in an OP setting. Thus, the results of the IOL studies cannot be generalized to all populations of pregnant women. OP cervical ripening is a strategy that reduce hospital stay duration and may offer a practical solution to logistical challenges in maternity care. A reduction in hospital stay of at least 3.5 hours during IOL may offer cost benefits to the healthcare system; however, this could result in cost shifting from the system to women and their families.[286]

6.2.2 Association between sleep quality and experience of labor

Emerging evidence indicates that maternal sleep disturbances, such as poor general sleep quality, various insomnia symptoms (e.g. difficulty falling asleep, nocturnal awakenings and too early morning awakening), and nocturnal breathing problems are frequent during pregnancy.[22,24,216,217,235,239,293,294] Sleep disturbances have been found to be associated with negative experiences during pregnancy, such as anxiety, stress, pain and fear of childbirth.[25,26,27,287] Further, women with poor sleep quality have shown to have more pregnancy complications,[242,244] longer duration of labor[188,247, 288] and more CS.[188,243] Accordingly, it is plausible that sleep disturbances could also deteriorate the EOL.

This study is one of the first studies to evaluate the association between maternal sleep quality and the EOL. On a general level, the research question on labor experiences was evaluated from the FinnBrain cohort. Women with poor general sleep quality during the month before delivery, as well as those with insomnia and sleepiness symptoms from mid-pregnancy onwards, were more likely to report a negative EOL. However, SDB, sleep duration and amount of sleep loss were not related to the EOL. However, as the associations between sleep disturbances and the EOL were independent of IOL, the results emphasized the importance of good sleep quality for a better EOL in all women. Contrary to the results of this thesis, Ramlee et al. (2023)[17] found no association between maternal sleep quality and satisfaction with the birth experience among 769 women. They used the Pittsburgh Sleep Quality Index to evaluate sleep during the participants' recruitment and the Depression, Anxiety and Stress Scale-21 Items to evaluate their psychological well-being. At hospital discharge, the mothers rated their satisfaction with their birth experience, on 5-point Likert scale, starting from labor induction.

In this thesis, the association between maternal sleep quality and experience of IOL was evaluated from the Clinical Hospital Cohort Study. The results on this subject were novel. Several sleep disturbances were associated with a poorer experience of IOL assessed both during IOL and after delivery. Women with worse general sleep quality reported more pain and higher contraction frequency and were less relaxed and less satisfied. Of the distinct insomnia symptoms, difficulty to fall asleep appeared the most important, as symptomatic women experienced more general and contraction pain and were less relaxed. Surprisingly, women with a higher Sleepiness score reported a lower frequency of contractions, while those with more daytime sleepiness reported less contraction pain. This finding is contrary to expectations. However, sleepiness has been shown to be associated with altered levels of pro-inflammatory markers,[289] which can assist in cervix ripening.[290] Thus, this faster ripening of the cervix in this way could explain the association between higher sleepiness and reduced contraction pain.

In terms of experiences with IOL assessed postpartum, women with worse general sleep quality reported more pain during IOL. Awakening too early in the morning was the most important insomnia symptom, with symptomatic women experiencing more pain and being less relaxed and less satisfied. Conversely, women who experienced nocturnal awakenings reported having less pain and being more relaxed. Finally, in the postpartum evaluation, women who reported longer sleep duration and more sleep loss were more anxious during IOL. These results are partly in accordance with the findings of Beebe and Lee (2007)[226], who found that women with sleep deprivation the night before labor reported more pain and discomfort in early labor.

6.2.3 Association between depressive symptoms and experience of labor

Similar to sleep disturbances, depressive symptoms also occur frequently during pregnancy[254] and increase as pregnancy proceeds.[261] Women with depressive symptoms have been shown to experience higher labor pain,[83,191] and thus, depressive symptoms presumably also deteriorate the EOL. Whelan et al's (2022)[28] study used the Labour Agentry Scale (LAS), a validated tool to evaluate patients' experiences of control over their deliveries. They found that the mean scores on the LAS were lower for those with depression/anxiety than for those without a prior diagnosis. The findings were repeated after adjustments (mode of delivery, reason for admission, Foley balloon use, and use of spinal or intravenous anesthesia/analgesia). Moreover, Waldenström et al. (2004)[155] showed that depressive mood, evaluated using the EPDS during early pregnancy, was associated with a negative birth experience (asked 2 month postpartum).

In the FinnBrain cohort, women with depressive symptoms during pregnancy were more likely to report a negative EOL. This association was identified in early pregnancy and was constant throughout pregnancy. However, the finding was independent of IOL. Previously, Ramlee et al. (2023)[17] found no correlation between depression and satisfaction with labor among induced women. The different outcomes may be attributed to the distinct sample sizes and questionnaires used.

No previous studies have evaluated whether maternal depressive symptoms during pregnancy relate to the experience of IOL. In this thesis, in the Clinical Hospital Cohort Study, only random associations between depressive symptoms and the experience of IOL were found. During IOL, women with more depressive symptoms reported a higher contraction frequency, but in postpartum, they reported less pain in general.

6.3 Strengths and limitations

One main strength in this thesis was the use of the BNSQ[223] to evaluate sleep disturbances and the EPDS[260] to evaluate depressive symptoms, as both questionnaires have been validated and are widely used in different populations, including during pregnancy.[22,24,263] The BNSQ contains an inclusive panel of sleep questions, making it possible to distinguish various insomnia, SDB and sleepiness symptoms. The EPDS can be used as a continuous and categorical variable, as performed in this thesis. Notably, in both cohorts, sleep quality and depressive symptoms were assessed only before labor; therefore, possible changes in sleep and mood during the postpartum period could not be evaluated. Furthermore, no objectively measured sleep data, (e.g polysomnography) were collected, which limits the interpretation of the results especially regarding sleep duration and sleep

loss. Conducting polysomnography on such a large population as in this thesis, would not have been feasible due to laboratory resources, time constraints and cost-effectiveness. However, although the use of subjective estimation of sleep quality may be prone to a report bias in terms of both under- and overestimation of disturbances, in clinical practice, the evaluation of subjective sleep quality normally identifies patients who require further investigation or treatment.[303] It was not known to the researchers whether the participants had been diagnosed with clinical depression or sleep disorders during pregnancy or whether they had received treatment for these conditions, which could have been informative.

In this thesis, the term 'EOL' was used instead of 'experience of childbirth'. While the terms can be used interchangeably, EOL more accurately reflects the focus of this thesis on IOL. Although, it can be challenging to clearly separate the labor phase from the time after delivery, Studies III and IV specifically addressed the experience of IOL during the labor process, emphasizing experiences during labor.

In obstetrics maternal exhaustion is commonly diagnosed during pregnancy. However, exhaustion should be distinguished from general tiredness because it refers to a state of extreme physical or mental fatigue, rather than a symptom of sleep disturbance which is the focus of this thesis.

In this thesis, EOL was assessed using question based on a 4-Likert point in studies I and II and VAS questionnaires in Studies III and IV. This could be considered a limitation, since according to a Cochrane review on this issue,[304] the validation of experience questionnaires is not comprehensive. However, since similar VAS items have previously been used in other induction studies,[113,135,136,167,169,209,236,305] utilizing the VAS questionnaires enabled a comparison of the results and could therefore also be considered a merit. In addition, Mäkelä et al. (2023)[161] showed that the VAS was suitable for screening posttraumatic stress symptoms by evaluating EOL. It could not be ruled out whether various emotions and involvements during and after delivery may have influenced the answers given postpartum in a positive or negative direction. However, at the group level, no differences were found in maternal basic characteristics, in delivery and in newborn variables in the Clinical Hospital Cohort or in the results of the FinnBrain Cohort which were adjusted by maternal characteristics and the mode of delivery. In addition, in the Clinical Hospital Cohort Study, when used *the postpartum induction experience questionnaire* which was similar to that of *the concurrent induction experience questionnaire,* the women were instructed to evaluate only their experience of IOL, but it is possible that some women evaluated their labor experiences instead. Furthermore, in the Clinical Hospital Cohort Study, some of the postpartum questionnaires were incomplete; therefore, the respective women were re-contacted, which may have caused some level of recall bias in the responses.

As for the sample sizes, the large sample size of the FinnBrain Cohort was another main strength. However, the sample size of the Clinical Hospital Cohort Study was only moderate. Nevertheless, it was similar in size to the samples of previous studies evaluating the importance of setting on the experience of IOL, which ranged between 33 and 112 women.[8,86,212,213,284] Information on deliveries and newborn data for the FinnBrain Cohort were retrieved from FMBR, while for the Clinical Hospital Cohort Study, these were taken from medical records. Based on validation studies, the accountability and coverage of data in Finnish health care registers are high and reliable.[306]

The women in both cohorts were volunteers, which may have caused some bias. Maternal personality has been shown to be associated with labor experiences[167]; thus, voluntariness could lead to the exclusion of women with, for instance, a higher propensity for dissatisfaction or fear and anxiety regarding IOL or labor. In the Clinical Hospital Cohort Study, some women refused to participate due to a strong preference to stay either at home or in hospital. Furthermore, three women were required to change their settings immediately after randomization leading to their exclusion from the study. Questionnaire data were not collected from them; thus, an intention-to-treat analysis was not possible. Since these women may have had a more negative experience, this exclusion could have led to a positive bias in the results. However, the bias was probably marginal because of the small number of these women.

The women in both cohorts had uncomplicated full-term pregnancies. Thus, the results cannot necessarily be applied to women with pregnancy complications or preterm deliveries. Furthermore, in the Clinical Hospital Cohort Study, only healthy women neither with baseline diseases nor on medication were enrolled. However, in the FinnBrain Cohort, some of the women may have had baseline diseases or been on medication. Importantly, the level of depressive symptoms in the cohorts was low; therefore, the results could not be generalized to all women with depression.

6.4 Clinical implications

From our research, we found evidence that insomnia and sleepiness during pregnancy are associated with a poorer EOL. Healthcare professionals could screen for these by asking how the pregnant woman perceives the quality of her sleep, whether she has difficulty to fall asleep, and if she feels tired during the day. The EPDS is widely used among nurses and midwives in primary health care and can be checked even more often. Treating sleep disturbances and depressive symptoms could lead to a better EOL. Also, even though our study did not find an association between sleep disturbances and the risk of ending with IOL, we know that some women receive IOL because of exhaustion, which can be a consequence of disturbed

sleep and depressive symptoms. Sleep disturbances and depressive symptoms should be better recognized so that women can receive help through counselling, medications, therapies and lifestyle interventions.

Although sleep complaints are extremely common among pregnant women, we are only beginning to learn about the potential adverse effects of sleep disturbance symptoms on maternal-fetal health. However, pregnancy-related insomnia is highly treatable. One non-pharmaceutical way to improve healthy sleep patterns in the general population, and also during pregnancy, is to engage in physical activity.[307] Pharmacotherapies can be effective, but carry the risk of preterm labor and infants with low birthweight.[230] Furthermore, cognitive behavioral therapy for insomnia can be recommended during pregnancy.[308,309] When women in late pregnancy complain about tiredness, they can be admitted to the ward to have therapeutic rest.[295] However, data on therapeutic rest are remarkably limited, especially the impact it may have on obstetrical and neonatal outcomes.

Our research also emphasizes that IOL in an OP setting can cause more anxiety and fear than IOL in an IP setting. This is why, we should offer better counseling and additional support for women who are induced in an OP setting. By keeping in contact through phone calls or chats with women who are inducted in an OP setting, we can reduce fear and anxiety during induction. In addition, professionals have strict rules regarding who is eligible for OP IOL, and for now it is only for low-risk pregnancies. By screening the right women in the OP setting we can make IOL safer and more comfortable for women.

6.5 Future aspects

Maternal sleep disturbances and depressive symptoms are common, especially in late pregnancy; therefore, they may interfere with the EOL. Nevertheless, more research, especially on mothers with pregnancy complications, is needed. Since the rates of IOL are increasing, additional studies in the risk factors for IOL are warranted. In addition, when planning patient guidance for IOLs, hospital resources should be taken into account. In this way, we can ensure that different patient groups receive optimal care during IOL and delivery. Furthermore, to fully understand the positive and negative factors that influence the EOL, both the factors that promote positive experiences and those that pose risks for negative experiences during labor need to be further explored. Understanding the factors that contribute to a positive experience of IOL can enhance maternal quality of life and health during both pregnancy and the postpartum period, improve maternal-newborn bonding and even possibly decrease pregnancy complications, especially fear for childbirth and the wish for elective CS.

7 Conclusion

In summary, the rise in IOL rates is due to a combination of medical indications, evolving clinical practices, and societal expectations. Advances in prenatal care have led to the earlier detection of complications such as preeclampsia, gestational diabetes, and fetal growth restriction. The rise in induction rates is also partly explained by increased maternal age and obesity, which are increasingly leading to the above-mentioned pregnancy complications, and to worse maternal sleep quality and mental health. Other principal factors for the rise in IOL rates include increasing patient autonomy and desire for IOL, especially elective IOL. Of note, women with IOL report a worse EOL, as shown in this thesis. A poor EOL can have significant effects on maternal physical and emotional well-being, both in the immediate aftermath of childbirth and in the long term. Labor is a transformative and intense experience, and if it does not proceed as expected — whether due to medical complications, unanticipated interventions, or psychological distress — it can leave emotional and physical scars.

The main conclusions of the present thesis were as follows:

1. Although maternal sleep disturbances, especially insomnia symptoms, occurred frequently, they were not associated with the likelihood of a pregnancy ending with IOL. Still, some of the women had IOL because of maternal tiredness, given that sleep disturbances and plausible daytime consequences, such as sleepiness and tiredness, cannot totally be ignored in pregnant women.
2. Maternal sleep disturbances and depressive symptoms during pregnancy were associated with worse EOL. However, although women with IOL reported a more negative EOL than those with SOL, sleep and mood symptoms were equally common in both groups. Therefore, for a more positive EOL, sleep disturbances and depressive symptoms should be assessed by healthcare providers and treated during pregnancy in all women.
3. The women in the outpatient (OP) setting were slightly less satisfied and more anxious during IOL than those in the inpatient (IP) setting.

Furthermore, they reported experiencing more fear and anxiety during IOL when evaluated after delivery. However, the differences between the OP and IP groups were minor; thus, the clinical importance of the findings was marginal. Accordingly, IOL in an OP setting with a catheter was acceptable and thus is a viable option for appropriately screened women with low-risk, full-term pregnancies.

4. This thesis provides novel data on the associations between maternal sleep quality and depressive symptoms and the experience of IOL in various settings. Women with sleep disturbances reported more negative feelings towards IOL, experiencing more pain, and being less relaxed and less satisfied. However, only random associations between depressive symptoms and the experience of IOL were identified with women with higher depressive symptoms reporting a higher contraction frequency evaluated during IOL, but less pain in general, evaluated postpartum. These findings may be due to the low level of depressive symptoms in the sample. To improve maternal experiences of IOL, clinicians should assess maternal sleep quality and mood, identify sleep disturbances and depressive symptoms during pregnancy and offer treatment options when necessary.

Acknowledgements

This work was carried out in the Department of Obstetrics and Gynaecology, at the University of Turku and at Turku University Hospital, Turku, Finland, between 2018 and 2025. I sincerely wish to express my gratitude to the following persons and to everyone who has encouraged me during this project.

I would like to thank the head of the Department of Obstetrics and Gynaecology at Turku University Hospital, professor Kaarin Mäkikallio for providing me with the opportunity to work with this fascinating topic.

My deepest gratitude goes to my thesis supervisors, Professor Päivi Polo-Kantola and MD, PhD Kirsi Rinne. Thank you for your trust in my work. Päivi, thank you for introducing me to the world of research. Thank you for your fast answers and your always positive attitude towards research. Your enthusiasm for science has made you an exceptional supervisor, and in many ways, you have also been a guiding and supportive figure, much like a parent in the world of research. Your guidance has gone beyond academic matters. I am grateful that you have supported me as a new researcher but also at the turning point of my life during the last few years. Your encouragement and understanding have been a constant source of strength, and for that, I am truly thankful. It has been an honor to have you as my supervisor, and I am deeply appreciative of everything you have done to help me grow both personally and professionally. Your impact on my journey will stay with me throughout my career and life.

Thank you Kirsi for your constructive comments and ideas, and for leading me to a deeper understanding of research on the induction of labor. I would like to express my deepest gratitude for your unwavering support and guidance throughout my early career as a researcher. Your mentorship has been invaluable in helping me navigate the complexities of research. You have not only shared your extensive knowledge of the scientific process but also shown me how to approach challenges with perseverance and resilience. It has been a privilege to receive your supervision and friendship.

Professor Hasse Karlsson and Professor Linnea Karlsson, thank you for giving me the opportunity to work with the FinnBrain Birth Cohort, for coauthoring and for all your encouraging words.

Also, thank you Adjunct Professor Juulia Paavonen in FinnBrain research group for your constructive comments which improved the work considerably. MSc Terhi Kolari, thank you for your patience and help with our first two manuscripts' statistics. Your friendliness has inspired everyone to collaborate to achieve great science together. Thanks for the chats and support. MSc Laura Perasto, thank you for all your help and patience with the complex statistics from the Finnbrain Birth Cohort Studies, as well as for your fast comments and replies and editorial approach. MD Ella Anttila, thank you for your help in gathering participants for the Clinical Hospital Cohort Study. MSc Elina Ojala, thank you for the utmost valuable work of recruiting patients for the Clinical Hospital Cohort studies, as well as for proofreading. MD Viliina Varis and MD Reetta Ilvonen, thank you for collecting data of the department patients for clinical works in this thesis. I would also like to express my deepest gratitude to all the midwives and colleagues who assisted with patient recruitment and data collection in the Clinical Hospital Cohort studies. Your contributions have been truly invaluable. I am also deeply thankful to all the participants in the FinnBrain Birth Cohort and the Clinical Hospital Cohort studies.

I dedicate my thanks to my steering group, Professor Kaarin Mäkikallio and MD, PhD Nanneli Pallasmaa. Thank you for your encouragement over these years.

I also appreciate the contributions of Professor Marja Vääräsmäki and Adjunct Professor Terhi Saisto, the official reviewers of this thesis. Your insightful comments have significantly enhanced this study. And of course, Adjunct Professor Kati Tihtonen, thank you for agreeing to be my opponent.

I also want to thank MD, PhD Heidi Kruit for giving me permission to use their figures in my thesis. And MD Heikki Halkosaari, thank you for helping me with the image for the cover.

My heartfelt appreciation goes to all my past and present colleagues at Turku University Hospital, with whom I have had the great privilege of working. Thank you colleagues, (especially Joosefiina, Titta, Felicia and Katja M.) and midwifes (especially Johanna, Mari and Reetta), for helping me get through these years. Our countless conversations have been a blessing, and your friendliness means a great deal to me. And the team of teachers in obstetrics and gynecology at Turku university: Hilla, Sara, Eija, Seija, Anna, Mari, Raija and Maija – thanks for your help!

I wish to address my deep gratitude to my loved ones, my friends and family, without whom this book would never have been realized.

To my sister-friend Katja, my warmest gratitude to you my dear. Without you by my side, without your weekly calls, and calming support I would not have managed to do this. My friends, Salla and Nea, thank you for always being there when I need you. Tanja, who has been there almost always, thank you for supporting

me. Arttu, I know that I can trust you always. To all the other important friends of my life: thank you. Without you I would be lost.

Thanks to my family. Firstly, my parents. To my mum, Päivi, you inspire me a lot. You have always trusted me and because of you I have a passion for to medical science. Thank you for your unwavering support. With you I feel that we can solve every challenge together. To my dad, Juha, thank you. I know you have always been there for me, and you are truly the man in my life. You are the rock that my kids and I can lean on. To my little brother, Antti, I am very grateful for your support and patience. And of course, to my grandmother, Mirja-mummu, you have taught me how to enjoy free time in nature and outside of the office, thanks for these addictions.

Miika, hope that you know how super you are. Thank you for all the time and space to complete this work. Your positive life attitude makes everything easier and you know how to reassure my inner gerbil.

And finally, biggest thanks to my two wonderful, adorable and wise children. Thank you for all the delight and hope that you have generated in my life. We are a dream team. Sulo ja Aili, kiitos rakkaat lapseni. Olette parhaita!

I have been fortunate to receive several grants for this thesis. Thank you to the following for believing in this project: the TYKS Foundation, Turku University Hospital and the Department of Gynecology and Obstetrics (research funds from specified government transfers, VTR), the Finnish Medical Foundation, the Turku University Foundation, and the University of Turku Faculty of Medicine, and Doctoral Programme in Clinical research.

Lieto 14.4.2025

Henna Zahde

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List of Figures, Tables and Appendices

Figures

Tables

Appendices

Appendices

Appendix 1. The Basic Nordic Sleep Questionnaire (BNSQ).

1. Have you had difficulties to fall asleep during the past month?

1 never or less than once per month
2 less than once per week
3 on 1–2 nights per week
4 on 3–5 nights per week
5 every night or almost every night

2. How often have you woken up at night during the past month?

1 never or less than once per month
2 less than once per week
3 on 1–2 nights per week
4 on 3–5 nights per week
5 every night or almost every night per week

3. How many times do you usually wake up during a night (during the past month)?

1 I do not wake up at night usually
2 once per night
3 twice per night
4 3–4 times per night
5 at least 5 times per night

4. How often have you awakened too early in the morning without being able to fall asleep again during the past month?

1 never or less than once per month
2 less than once per week
3 on 1–2 days per week
4 on 3–5 days per week
5 every night or almost every night

5. How well have you been sleeping during the past month? (general sleep quality)

1 well
2 quite well
3 neither well nor poorly
4 quite poor
5 poor

6. Do you snore while sleeping? (ask other people if you are not sure)

1 never or less than once per month
2 less than once per week
3 on 1–2 nights per week
4 on 3–5 nights per week
5 every night or almost every night

7. Have you had breathing pauses (sleep apneas) while sleeping? (ask other people if you are not sure)

1 never or less than once per month
2 less than once per week
3 on 1–2 nights per week
4 on 3–5 nights per week
5 every night or almost every night

8. Do you feel excessively sleepy in the morning after awakening during?

1 never or less than once per month
2 less than once per week
3 on 1–2 days per week
4 on 3–5 days per week
5 every day or almost every day

9. Do you feel excessively sleepy during the daytime ?

1 never or less than once per month
2 less than once per week
3 on 1–2 days per week
4 on 3–5 days per week
5 every day or almost every day

10. How often do you take naps during the day?

1 never or less than once per month
2 less than once per week
3 on 1–2 days per week
4 on 3–5 days per week
5 every day or almost every day

11. How long do you usually sleep per night? ___hours ___minutes

12. How many hours of sleep do you need per night (how many hours would you like to sleep if you had possibility to sleep as long as you need to)? ___hours ___minutes

The experience of labor (asked after labor)

How was your experience of labor?

1 very positive
2 quite positive
3 quite hard, but I was able to cope soon
4 very hard

Edinburgh Postnatal Depression Scale (EPDS)

Please choose the answer that comes closest to how you have felt in the past 7 days.

1. I have been able to laugh and see the funny side of things

0 As much as I always could
1 Not quite so much now
2 Definitely not so much now
3 Not at all

2. I have looked forward with enjoyment to things

0 As much as I ever did
1 Rather less than I used to
2 Definitely less than I used to
3 Hardly at all

3. I have blamed myself unnecessarily when things went wrong

0 Yes, most of the time
1 Yes, some of the time
2 Not very often
3 No, never

4. I have been anxious or worried for no good reason

0 No, not at all
1 Hardly ever
2 Yes, sometimes
3 Yes, very often

5. I have felt scared or panicky for no very good reason

0 Yes, quite a lot
1 Yes, sometimes
2 No, not much
3 No, not at all

6. Things have been getting on top of me

0 Yes, most of the time I haven't been able to cope at all
1 Yes, sometimes I haven't been coping as well as usual
2 No, most of the time I have coped quite well
3 No, I have been coping as well as ever

7. I have been so unhappy that I have had difficulty sleeping

0 Yes, most of the time
1 Yes, sometimes
2 Not very often
3 No, not at all

8. I have felt sad or miserable

0 Yes, most of the time
1 Yes, quite often
2 Only occasionally
3 No, never

9. I have been so unhappy that I have been crying

0 Yes, most of the time
1 Yes, quite often
2 Only occasionally
3 No, never

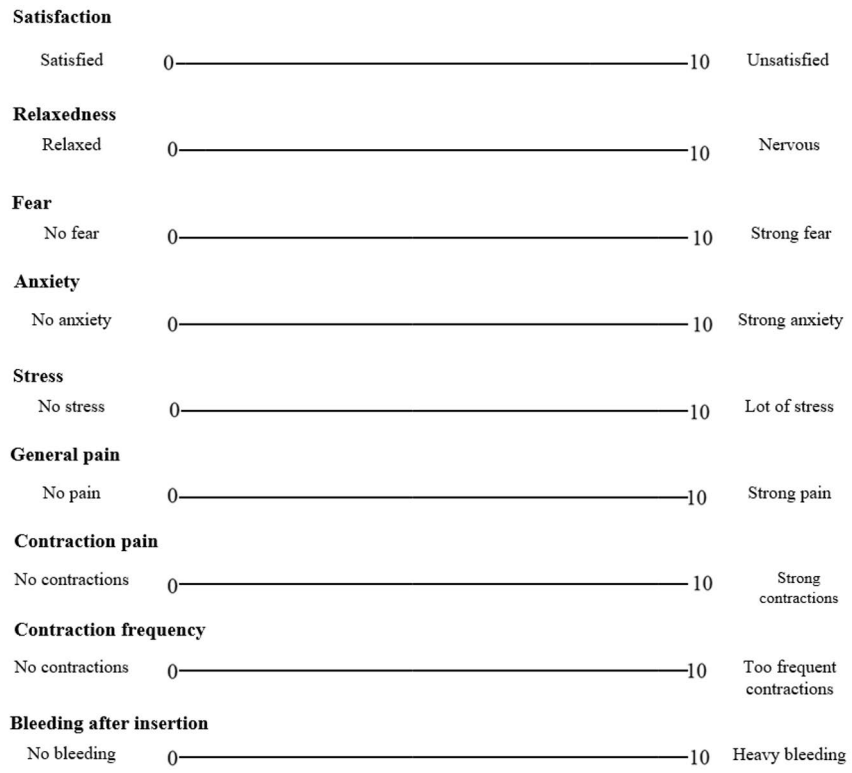
10. The thought of harming myself has occurred to me

0 Yes, quite often
1 Sometimes
2 Hardly ever
3 Never

Scoring

Questions 1, 2 and 4 are scored 0, 1, 2 or 3 with top number scored as 0 and the bottom number scored as 3. Questions 3 and 5─10 are reverse scored, with the top number scored as a 3 and the bottom number scored as 0.

Appendix 2. The concurrent induction experience questionnaire (assessed at the time points of 1h, 5h, 9h and 13h after insertion of the catheter until the expulsion of the catheter)



Appendix 3. The pospartum induction experience questionnaire (assessed after delivery in the postpartum department)

Painfulness of induction

No pain 0——————————————————10 Strong pain

Induction experience

Good experience 0——————————————————10 Negative experience

Pain during labor

No pain 0——————————————————10 Strong pain

Labor experience

Easy 0——————————————————10 Difficult

Given help in the hospital

Sufficient 0——————————————————10 Insufficient

Additional questions after delivery assessed in postpartum department

If your subsequent pregnancy will be induced, would you want to have a catheter IOL?

Yes No

If your subsequent pregnancy will be induced with a catheter, would you want that the induction would take place in an outpatient setting?

Yes No

TURUN YLIOPISTO
UNIVERSITY OF TURKU

ISBN 978-952-02-0201-9 (PRINT)
ISBN 978-952-02-0202-6 (PDF)
ISSN 0355-9483 (Print)
ISSN 2343-3213 (Online)

Painosalama, Turku, Finland 2025