

PIA SEPPÄNEN

# Critically Ill Obstetric Patients

*A retrospective study of intensive care unit-admitted  
obstetric patients' episode of care*



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ACADEMIC DISSERTATION

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# Abstract

The purpose of this study is to describe intensive care unit (ICU)-admitted obstetric patients' episodes of care. The episode of care has been approached from three different perspectives: the course of pregnancy and delivery, intensive care processes, and the patients' health-related quality of life (HRQoL). The perspectives are partially overlapping, but each aspect tells a specific story about the episode of care or part of it. Examining these three perspectives simultaneously rather than separately provides a comprehensive understanding of the episode of care. The intensive care process of these patients' has not been described to this extent in previous research, covering the course of pregnancy and delivery, and HRQoL before intensive care and six months after discharge. Moreover, there have been few previous studies on ICU admitted mothers and their HRQoL. From this point of view, the scientific value of the study is significant. Factors related to pregnancy and delivery, infant health status, intensive care processes and HRQoL provide an opportunity for the development of health care system both within an organization and between organizations. The results of this research can also be utilized for healthcare education on degree programmes and professional extension studies for nurses and midwives.

This was a retrospective register-based study, and four multidisciplinary ICUs in Finnish university hospitals participated. Intensive care processes, adverse events, ICU mortality and HRQoL data were collected from clinical information systems. Data regarding parturients, deliveries and infants were collected from the MBR database at the National Institute of Health and Welfare (THL). The study considered data from all obstetric patients aged 18–50 admitted to ICU during any trimester of pregnancy and up to 42 days post-partum over a five-year period (2007–2011).

ICU-admitted obstetric patients' course of pregnancy and delivery was analysed in terms of diseases during pregnancy, other pregnancy-related factors, procedures related to delivery, and diagnoses related to delivery. The infant health status was analysed by gestational age, birthweight, treatment to newborn, and child status at the age of seven days (homeward, postnatal ward, neonatal ward, other hospital, died). Obstetric patient

intensive care processes were assessed using severity-of-illness scores (APACHE II, SAPS II, SOFA), intensity-of-treatment scores (TISS-76), types of interventions, length of stay (LOS), adverse events (prolonged stay, readmission), and mortality in ICU. HRQoL of ICU-admitted obstetric patients was assessed using generic European Quality of Life Five Dimensions (EQ-5D) measurements before intensive care and six months after discharge. EQ-5D measurements consist of the EQ-5D dimensions – physical (mobility, self-care, pain/discomfort), social (usual activities) and mental (depression/anxiety) – the EQ Summary Index (EQsum) and the Visual Analogue Scale (EQ-VAS). ICU-admitted obstetric patients' course of pregnancy and delivery, infant health status and HRQoL were also compared with the reference population.

Maternal characteristics associated with obstetric ICU admission were advanced maternal age ( $\geq 35$  years), and nulliparous and multiple pregnancies. The majority of ICU-admitted mothers delivered by unscheduled caesarean section. The commonest reason for admission was hypertensive complications, followed by obstetric haemorrhage. Mothers admitted for hypertensive complications and non-obstetric reasons more likely to deliver preterm. Obstetric haemorrhage was associated with full-term birth. Infants born to ICU admitted mothers were more likely preterm, had lower birthweight and more likely needed treatment in a neonatal intensive care unit (NICU) or an observation unit. Of mothers who needed intensive care, 4.6% lost their infant before the age of one week.

ICU-admitted obstetric patients' severity-of-illness and organ failure scores describe a good probability of recovery, and they had a short length of stay in ICU. Nonetheless, the causes for admission and mode of delivery were associated with both the severity-of-illness scores and the level of intervention required. Those who were admitted for non-obstetric causes and who had a vaginal delivery demonstrated higher severity-of-illness scores, organ failure scores and levels of intervention compared with those admitted for obstetric reasons or who delivered by caesarean section. ICU-admitted obstetric patients' HRQoL was below the reference population at baseline but improved over time. Nonetheless, one fifth of patients had a below-reference value at follow-up.

In conclusion: ICU-admitted obstetric patients had a good probability of recovery, and their HRQoL remained good after discharge. Nonetheless, these patients' situation was often complicated by the fact that the newborn was seriously ill and needed treatment in NICU or an observation unit.

**Keywords:** critical care, labour complications, pregnancy complications, quality of life

# Tiivistelmä

Tämän tutkimuksen tarkoituksena oli kuvata tehohoitoon joutuneiden obstetristen potilaiden hoitokokonaisuutta. Hoitokokonaisuutta on tarkasteltu raskauden ja synnytyksen aikaisten tapahtumien, tehohoitoprosessin sekä elämänlaadun näkökulmista. Näkökulmat ovat osittain päällekkäisiä, mutta jokainen osa kertoo erityisen tarinan hoitokokonaisuudesta tai sen osasta. Näiden kolmen näkökulman tutkiminen samanaikaisesti antaa kokonaisvaltaisemman käsityksen hoitokokonaisuudesta, kuin minkään yksittäisen osan erillinen tarkastelu. Näiden potilaiden tehohoitoprosessia ei ole aikaisemmin kuvattu tässä laajuudessa, käsittäen raskauden ja synnytyksen aikaiset tapahtumat sekä elämänlaadun arvioinnin ennen tehohoitoon joutumista ja kuusi kuukautta hoitojakson päättymisen jälkeen. Lisäksi aikaisemmin on julkaistu vain muutamia tutkimuksia tehohoitoon joutuneiden obstetristen potilaiden elämänlaadusta. Tästä näkökulmasta tämän tutkimuksen tieteellinen arvo on merkittävä. Raskauteen ja synnytykseen, vastasyntyneen terveydentilaan, tehohoitoprosessiin sekä elämänlaadun mittaamiseen liittyvät tekijät antavat mahdollisuuden terveydenhuoltojärjestelmän kehittämiseen organisaatioiden sisällä sekä niiden välillä. Tämän tutkimuksen tuloksia voidaan hyödyntää lisäksi sairaanhoitajien ja kättilöiden tutkintoon johtavassa koulutuksessa sekä ammatillisessa täydennyskoulutuksessa.

Tämä tutkimus oli retrospektiivinen rekisteritutkimus, johon osallistui neljä teho-osastoa suomalaisista yliopistosairaaloista. Tehohoitoprosessia, tehohoidon haittavaihtokuituksia, teho-osastokuolleisuutta sekä elämänlaatua kuvaava aineisto kerättiin potilastietojärjestelmistä. Raskauteen ja synnytykseen sekä vastasyntyneen terveydentilaan liittyvä aineisto kerättiin Syntyneiden lasten rekisteristä. Tutkimusaineiston muodosti kaikki teho-osastolla hoidetut 18–50-vuotiaat obstetriset potilaat raskauden ensimmäisestä trimesteristä jatkuen 42 päivää synnytyksen jälkeen. Tutkimusaineisto kerättiin viiden vuoden ajalta (2007–2011).

Teho-osastolla hoidettujen obstetristen potilaiden raskauden ja synnytyksen kulkua kartoitettiin tarkastelemalla raskauden aikana ilmenneitä sairauksia, muita raskauteen liittyviä tekijöitä sekä synnytykseen liittyviä toimenpiteitä. Vastasyntyneen terveydentilaa tarkasteltiin gestaatioiän, syntymäpainon, vastasyntyneen saaman hoidon sekä viikon

ikäisen lapsen tilanteen osalta (poistunut kotiin, edelleen synnytysvuodeosastolla, edelleen samassa sairaalassa muualla kuin synnytysvuodeosastolla, edelleen muussa sairaalassa, lapsi kuollut). Obstetristen potilaiden tehohoitojaksoa kuvattiin sairauden vakavuutta kuvaavilla APACHE II-, SAPS II- ja SOFA-pisteytyksillä, hoidon intensiteettiä kuvaavalla TISS-76-pisteytyksellä, tehohoitjakson pituudella, tavallisimmilla interventioilla, invasiivisella monitoroinnilla, tehohoidon haittavaikutuksilla sekä tehohoitokuolleisuudella. Obstetristen tehohoitopotilaiden elämänlaatua mitattiin geneerisellä EuroQOL-5D (EQ-5D) -mittarilla ennen tehohoitoon joutumista ja kuusi kuukautta tehohoidon päättymisen jälkeen. EQ-5D-mittari sisältää fyysisen ulottuvuuden (liikkuminen, itsestä huolehtiminen, kipu/epämukavuus), sosiaalisen ulottuvuuden (päivittäiset toiminnot), psyykkisen ulottuvuuden (ahdistuneisuus/masentuneisuus) sekä EQ summa indeksin ja EQ-VAS mittauksen. Raskauden ja synnytyksen aikaisia tekijöitä, vastasyntyneen terveydentilaa sekä elämänlaatua verrattiin referenssiaineistoon.

Korkeampi synnytysikä ( $\geq 35$  vuotta), ensisynnyttäneisyys ja monisikiöraskaus olivat yhteydessä tehohoitoon joutumiselle. Suurin osa teho-osastolle joutuneista äideistä synnytti päivystysaikana keisarileikkauksella. Yleisin indikaatio tehohoitajaksoon oli hypertensiiviset komplikaatiot sekä obstetrinen verenvuoto. Tehohoitoon joutuneiden obstetristen potilaiden lapset syntyivät todennäköisemmin ennenaikaisesti, olivat matalapainoisempia sekä tarvitsivat hoitoa vastasyntyneiden teho- tai tarkkailuosastolla. Tehohoitoon johtaneista syistä hypertensiiviset komplikaatiot sekä ei-obstetriset syyt olivat yhteydessä ennenaikaiseen synnytykseen. Teho-osastolle joutuneista äideistä 4,6 % menetti vastasyntyneen yhden viikon ikään mennessä.

Tehohoitoon joutuneiden obstetristen potilaiden sairauden vakavuutta ja elinöhäiriöiden määrää kuvaavat pisteytykset ennustavat näiden potilaiden hyvää mahdollisuutta toipumiseen. Lisäksi tehohoitajakso olivat lyhyitä. Tehohoitoon johtanut syy ja synnytystapa olivat kuitenkin yhteydessä sairauden vakavuuteen sekä tarvittujen interventioiden määrään. Potilaat, jotka joutuivat tehohoitoon ei-obstetrisistä syistä tai olivat synnyttäneet alakautta demonstroivat korkeampia pisteytyksiä sekä tarvitsivat enemmän interventioita tehohoidon aikana verrattuna niihin potilaisiin, jotka joutuivat tehohoitoon obstetrisistä syistä tai olivat synnyttäneet sektiolla.

Tehohoitoon joutuneilla obstetrisilla potilailla elämänlaatu oli matalampi ennen tehohoitoon joutumista verrattuna normaaliväestöön. Elämänlaatu kuitenkin parani seurantaajan kuluessa, eikä enää eronnut referenssiaineistosta kuusi kuukautta tehohoidon päättymisen jälkeen. Kuitenkin noin viidesosa potilaista raportoi alentunutta elämänlaatua seurantamittauksessa kuuden kuukauden jälkeen.

Yhteenvetona: tehohoitoon joutuneet äidit toipuvat hyvin ja heidän elämänlaatunsa on hyvää tehohoitjakson jälkeen. Kuitenkin näiden äitien tilannetta komplisoi se, että vastasyntynyt on monesti vakavasti sairaana ja tarvitsee hoitoa vastasyntyneiden teho-osastolla.

**Avainsanat:** elämänlaatu, raskauskomplikaatio, synnytyskomplikaatio, tehohoito



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## List of Original Publications

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

- I Seppänen P, Sund R, Uotila J, Helminen M, Suominen T 2018. Maternal and neonatal characteristics in obstetric intensive care unit admissions. Submitted.
- II Seppänen P, Sund R, Roos M, Unkila R, Meriläinen M, Helminen M, Ala-Kokko T, Suominen T. Obstetric admissions to ICUs in Finland: a multicentre study. *Intensive and Critical Care Nursing* 2016; 35: 38–44
- III Seppänen P, Sund R, Ala-Kokko T, Uotila J, Roos M, Helminen M, Suominen T. Obstetric patients' health-related quality of life before and after intensive care. *Australian Critical Care*. DOI:10.1016/j.aucc.2018.02.009
- IV Seppänen P, Sund R, Ala-Kokko T, Uotila J, Helminen M, Suominen T. Health-related quality of life after obstetric intensive care admission: comparison with the general population. *Journal of Critical Care* 2018; 43: 276–280

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# List of Abbreviations

APACHE	Acute Physiology and Chronic Health Evaluation
EQ-5D	European Quality of Life Five Dimensions
EQ-6D	European Quality of Life Six Dimensions
EQsum	EQ Summary Index
EQ-VAS	Visual Analogue Scale
EU	European Union
GDPR	General Data Protection Regulation
HRQoL	Health-related quality of life
ICU	Intensive care unit
IQR	Interquartile range
IUGR	Intrauterine growth restriction
LBW	Low birthweight
LOS	Length of stay
MBR	Medical Birth Register
NBW	Normal birthweight
NICU	Neonatal intensive care unit
QOL	Quality of life
QOLI	Quality of Life Inventory
SAMM	Severe acute maternal morbidity
SAPS	Simplified Acute Physiology Score
SF-12	Short-Form 12
SF-36	Short-Form 36
SMM	Severe maternal morbidity
SOFA	Sequential Organ Failure Assessment
TISS	Therapeutic Intervention Scoring System
VLBW	Very low birthweight
WHO	World Health Organization
WHOQOL	WHO Quality of Life
WHOQOL-BREF	WHO Quality of Life Brèf

# 1 Introduction

Pregnancy, childbirth and recovery constitute an aggregate of care that is most often natural and end a good outcome for the mother and the entire family. However, sometimes pregnancy and childbirth undergoes a crisis and results in severe maternal morbidity (SMM). An SMM incident can be defined as “a very ill pregnant or recently delivered woman who would have died had it not had been that luck and good care was on her side” (Say et al. 2004). Women in SMM cases are more likely to deliver by caesarean section and preterm. In addition, multiple gestations and multiparous women who have had a prior caesarean delivery are at increased risk of SMM (Kilpatrick et al. 2016). The occurrence of severe complications and near-miss cases during pregnancy and delivery is low, but they still receive intensive care in high-resource countries (Say et al. 2004).

According to previous studies, the commonest reason for intensive care during pregnancy and post-partum is hypertensive disorders, followed by obstetric haemorrhage (Pollock et al. 2010). Non-obstetric reasons that lead to admission are sepsis or infections (Rojas-Suarez et al. 2014; Wanderer et al. 2013) and cardiac disease (Wanderer et al. 2013; Zwart et al. 2010). In addition, anaesthesia complications, such as in the management of airways and respiratory failure (Chantry et al. 2015; Paxton et al. 2014; Zwart et al. 2010; Cartin-Ceba et al. 2008), have been causes of obstetric intensive care admissions. Although the frequency of maternal intensive care treatment is low, all pregnancies and births entail a potential risk of morbidity and mortality, excluding pre-existing risk factors (Pollock et al. 2010; Zeeman 2006). The causes of maternal mortality are diverse and may be related to obstetric or non-obstetric factors such as chronic disease or malignancy (Zwart et al. 2010; Keizer et al. 2006; Selo-Ojeme et al. 2005; Cheng & Raman 2003; Zeeman et al. 2003; Heinonen et al. 2002).

Previous studies of intensive care unit (ICU)-admitted obstetric patients have been conducted (Pollock et al. 2010). The effectiveness of intensive care treatment in obstetric populations has been assessed with a short-term outcome (mortality), but slightly is known about these patients' health-related quality of life (HRQoL) before intensive care and after

discharge. In addition, there is scant detailed description of foetal outcomes in pregnant women admitted to ICU. Furthermore, risk factors during pregnancy and delivery have been little investigated (Madan et al. 2009; Cartin-Ceba et al. 2008).

Finland has a comprehensive system of national registers, and these are internationally unique. In addition, a considerable amount of data is available in clinical information systems that can be utilized for research purposes. The use of this data for scientific research can be justified under the Healthcare Act (1326/2013), which requires the monitoring of the health and well-being of citizens and the factors affecting them. In addition, the use of limited resources requires an evaluation of effectiveness, which should be evidence-based.

A register-based study is an appropriate method to investigate infrequent phenomena such as complications resulting in intensive care treatment during pregnancy or postpartum. Considering the minor amount of obstetric intensive care admissions, register-based study is a justifiable method, because small samples might yield random outcomes. Routinely collected databases (as a source of secondary data) can provide a large study population of obstetric patients and a long retrospective observational period (Räsänen et al. 2013; Sund et al. 2013). In this study, it was significant to study the course of pregnancy and delivery, intensive care processes and HRQoL in order to outline the episodes of care for these patients.

The overall purpose of this study is to describe ICU-admitted obstetric patients' episodes of care. The episode of care has been approached from three different perspectives: the course of pregnancy and delivery, intensive care processes, and the patients' health-related quality of life (HRQoL). The perspectives are partially overlapping, but each aspect tells a specific story about the episode of care or part of it. Examining these three perspectives simultaneously rather than separately provides a comprehensive understanding of the episode of care. The intensive care process of these patients' has not been described to this extent in previous research, covering the course of pregnancy and delivery, and HRQoL before intensive care and six months after discharge. Moreover, there have been few previous studies on ICU admitted mothers and their HRQoL. From this point of view, the scientific value of the study is significant.

Data derived from clinical information systems and the Medical Birth Register (MBR) was analysed. The aim of the study is to understanding the background of ICU-admitted obstetric patients and determining their HRQoL before intensive care admission and after discharge.



## 2 Overview of the Literature

The literature review in this study is divided into three sections: first, literature on pregnancy- and delivery-related risk factors; second, literature on obstetric patients' intensive care processes; third, literature on maternal HRQoL during pregnancy and after obstetric complications. These three topics comprise ICU-admitted obstetric patients' episodes of care. This literature review is based on a search of the electronic databases MEDLINE (EBSCO), CINAHL (EBSCO) and the Cochrane Library. Relevant articles were also hand-searched from the reference lists of the selected studies.

The search covering risk factors during pregnancy and delivery was conducted using the following medical subject heading (MeSH) terms and Boolean operators: ('risk factors') AND ('pregnancy' OR 'labour, obstetric' OR 'delivery, obstetric'). Obstetric ICU admissions were sought using the following MeSH terms and Boolean operators: ('pregnancy complications') AND ('critical care') OR ('intensive care units'). The search for maternal HRQoL during pregnancy and after obstetric complications was conducted using the following MeSH terms and Boolean operators: ('pregnancy complications') AND ('quality of life'), ('infant', 'low birthweight') OR ('infant', 'very low birthweight') OR ('infant', 'extremely low birthweight') AND ('quality of life'). The limits were set as: 1) English language, 2) date of publication January 2008 to December 2017, 3) abstract available, 4) research article, 5) peer-reviewed. The literature review included specialist consultant information. Table 1 describes the databases, MeSH terms and limiters used.

The Cochrane Library was searched using 1) 'pregnancy' or 'delivery' AND 'risk factor', 2) 'pregnancy complication' or 'obstetric complication' AND 'critical care' or 'intensive care', and 3) 'pregnancy complication' or 'obstetric complication' AND 'quality of life'. The results were sought in titles, abstracts and keywords. No results from the Cochrane database were found for these searches.

Table 1. Databases, MeSH terms and limiters used

Section	Databases	MeSH terms	Limiters
Risk factors during pregnancy and delivery	MEDLINE (EBSCO) CINAHL (EBSCO)	'risk factors' 'pregnancy' 'labour' 'delivery' 'obstetric'	English language
Obstetric ICU admissions	MEDLINE (EBSCO) CINAHL (EBSCO)	'pregnancy complications' 'critical care' 'intensive care units'	Date of publication: 1.1.2008–31.12.2017  Abstract available
Obstetric patient HRQoL	MEDLINE (EBSCO) CINAHL (EBSCO)	'pregnancy complications' 'quality of life' 'infant' 'low birthweight' 'very low birthweight' 'extremely low birthweight'	Research article  Peer-reviewed

The search for risk factors during pregnancy and delivery described in Table 1 yielded a total of 1,049 articles. After abstracts were searched and duplicates removed, a total of 17 articles were selected.

The search for obstetric patient ICU admissions described in Table 1 yielded a total of 497 articles. After abstracts were searched and duplicates removed, a total of 18 articles were selected pertaining to the clinical characteristics and outcomes of obstetric patients requiring intensive care admission. All the selected studies of obstetric ICU admissions are presented in Appendix 1.

The search described in Table 1 found a total of 706 articles dealing with obstetric complications and HRQoL. After abstracts were searched and duplicates removed, a total of 12 articles were selected pertaining to maternal HRQoL and obstetric complications. The selected studies are presented in Appendix 2.

## 2.1 Pregnancy and delivery-related risk factors

Severe maternal morbidity (SMM), also called 'near miss', includes unexpected outcomes of labour and delivery that result in short- or long-term consequences for the woman's and neonate's health (Kilpatrick et al. 2016). Advanced maternal age, maternal obesity and pre-eclampsia increase the risk of severe complications. Women in SMM cases are more likely to deliver by caesarean section and preterm. In addition, multiple gestations and multiparous women who have had a prior caesarean delivery are at increased risk of SMM (Kilpatrick et al. 2016).

Advanced maternal age is considered a risk factor for poorer maternal and neonate outcomes. The proportion of operative deliveries increases substantially with maternal age (Burke et al. 2017; Mesterton et al. 2016; Omih & Lindow 2016). Herstad et al. (2014)

found that in low-risk primiparae there is an association between age and emergency operative delivery, particularly emergency caesarean section. Primiparity at very advanced maternal age ( $\geq 45$ ) carries a significant risk of adverse pregnancy and birth outcomes such as gestational diabetes, gestational hypertension and pre-eclampsia. In addition, women with very advanced maternal age are more likely to have chronic health conditions. Advanced maternal age entails a higher risk of severe haemorrhage (Pallasmaa et al. 2015), emergency peripartum hysterectomy (Macharey et al. 2015) and blood transfusion at delivery (Jakobson et al. 2013). In addition, higher maternal age is associated with rates of labour induction, perineal tears and length of hospital stay (Mesterton et al. 2016). Infants of mothers at very advanced maternal age have a risk of low birthweight (LBW) (Goisis et al. 2017; Alon et al. 2016) and are more likely to need neonatal intensive care unit (NICU) admission (Alon et al. 2016).

Obesity increases the risk of severe birth-related complications among the population (Burke et al. 2017; Pallasmaa et al. 2015). Pre-pregnancy obesity entails an increased risk of large-for-gestation-age births and a need for delivery by caesarean section or instrumental procedures (Ng et al. 2010). The risk of emergency caesarean section is increased among women with a body mass index (BMI) of 30 or more (Pallasmaa et al. 2015). In addition, the risk of adverse neonatal outcome is increased with higher maternal BMI, regardless of mode of delivery (Blomberg 2013). Bird et al. (2017) found that women who have an LBW infant are more likely to have had a pre-pregnancy BMI in the overweight or obese categories. In addition, pre-pregnancy obesity has serious adverse impacts on infant health status, including complications such as infant resuscitation or transferal to NICU (Ng et al. 2010). Neonates born to morbidly obese women are at increased risk of birth injury to the peripheral nervous system and skeleton, respiratory distress syndrome, bacterial sepsis, convulsions and hypoglycaemia (Blomberg 2013). NICU admission and low Apgar scores are more likely to occur in neonates born to overweight mothers after spontaneous and induced labour (Minsart et al. 2013). However, pre-pregnancy obesity is the principal modifiable risk factor for obstetric complications (Ng et al. 2010).

Pre-eclampsia increases the risk of all obstetric complications, and women with any maternal hypertensive disease have an increased risk of severe haemorrhage and blood transfusion during delivery (Pallasmaa et al. 2015). Placenta praevia has been found in the literature to be a risk factor for blood transfusion (Spiegelman et al. 2017), and infants born to mothers with placenta praevia are more likely to be delivered preterm, have lower birthweight and need NICU admission (Lal & Hibbard 2015). Moreover, women with prior preterm births and prior obstetric complications are also more likely to have late preterm births than term births (Trilla et al. 2014).

The impact of obstetric risk factors for life-threatening maternal complications varies by delivery mode and risk group. Maternal age, parity, foetal presentation and multiple births are all indicators for caesarean section, induction rate and length of stay (Mesterton et al. 2016). However, vaginal delivery is the safest way to deliver even for high-risk women,

excluding women with pre-eclampsia. The latter have similar risks in vaginal delivery and elective caesarean section (Pallasmaa et al. 2015).

Severe acute maternal morbidity (SAMM) is defined by the World Health Organization (WHO) as “a woman who nearly died, but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy” (Pattinson et al. 2009). Say et al. (2004) describe a near miss as “a woman who almost died but survived”. However, the definition of SAMM varies widely across the studies in this literature review, and it is not possible to set out strict criteria for near-miss cases. The use of organ system-based criteria seems to be a useful approach for identifying SAMM cases. In addition, definitions could be made according to what authors mean by SAMM, or in response to events such as admission to ICU, hysterectomy, massive blood transfusion or eclampsia.

In the literature, the commonest SAMM indication leading to intensive care is vascular dysfunction related to haemorrhage and severe pre-eclampsia (Zanconato et al. 2012; Almerie et al. 2010; Murphy et al. 2009). Factors associated with SAMM cases are preterm birth and surgical mode of delivery (Zanconato et al. 2012). The occurrence of severe complications and near-miss cases during pregnancy and delivery is low, but they receive intensive care in high-resource countries (Say et al. 2004).

## 2.2 Obstetric patients' intensive care processes

Of the selected studies concerned with obstetric patients' intensive care admissions, eight report data from France (N=1), Australia (N=2), the USA (N=3), Italy (N=1) and the Netherlands (N=1). Ten studies report data from non-Western countries: Argentina (N=3), Colombia (N=1), Hong Kong (N=2), Saudi Arabia (N=1), China (N=1), Brazil (N=1) and Turkey (N=1). The data collection periods vary between one and 11 years. The numbers of patients vary widely: the largest cohort was 15,447 ICU-admitted obstetric patients and the smallest 50 patients.

Most of the published studies of obstetric and post-partum admissions are of retrospective (N=10) design, followed by prospective (N=4). Three studies are descriptive, and one is a case-control study. Ten studies are multicentre studies, and the remaining eight are single-centre studies. The definitions of study participants vary. Six studies define participants as all ICU-admitted pregnant and post-partum patients up to 42 days; six studies define them as all obstetric patients; one study defines them as women at 14 weeks or more, and one at 24 weeks or more. Two studies define cases based on pre-partum period. One study is based on all ICU-admitted patients versus non-ICU-admitted.

Overall, 12 studies report the ICU admissions rate among all deliveries: the incidence varies between 0.13 and 1.6% (mean 0.8%). Fourteen studies report the obstetric ICU utilization rate among all ICU-admitted patients: pregnant and post-partum women account for 0.2–19% (mean 3.6%) of all admissions. Data on ICU length of stay (LOS) is reported in 15 studies. The LOS varies from a few hours (zero days) to seven days. Eighteen

studies report maternal mortality in ICU. Maternal ICU mortality rates range from 0.15 to 12%. Two studies report no maternal deaths. Table 2 summarizes studies reporting incidence of obstetric ICU admissions of all deliveries, obstetric ICU admissions of all ICU admitted patient, length of stay and maternal deaths in ICU.

Table 2. Studies (N=18) reporting incidence of obstetric ICU admissions of all deliveries, obstetric ICU admissions of all ICU admitted patient, length of stay and maternal deaths in ICU

Study	Incidence of all deliveries %	Obstetric ICU admissions %	ICU LOS (days)	Maternal deaths N (%)
Yuqi et al. (2017)	1.6	12.6	4.1 (range 2–27)	9 (1.8)
Chantry et al. (2015)	NR <sup>1</sup>	0.36	3.0±0.1	154 (1.3)
Vasquez et al. (2015)	0.69	NR <sup>1</sup>	2 (range 2–4)	13 (3.6)
Bandeira et al. (2014)	1.27	NR <sup>1</sup>	5.0 (range 0–53)	14 (4.7)
Ng et al. (2014)	0.23	2.34	1.8±1.2	2 (3)
Paxton et al. (2014)	1.2	19	1.3 (range 0.3–9.5)	0 (–)
Rojas-Suarez et al. (2014)	1.24	NR <sup>1</sup>	3/4 (IQR 2-5/1–19) <sup>2</sup>	31 (4.26)
Vasquez et al. (2014) <sup>1</sup>	0.61/1.26 <sup>2</sup>	7/3.4	NR <sup>1</sup>	2 (3.2)
Wanderer et al. (2013)	NR <sup>1</sup>	0.4	2 (range 1–94)	53 (1.8)
Donati et al. (2012)	NR <sup>1</sup>	0.2	NR <sup>1</sup>	90 (7)
Rios et al. (2012)	0.81	3.9	2 (range 2–4)	5 (2)
Aldawood (2011)	0.15	0.75	2 (IQR 2–3)	6 (8)
Crozier & Wallace (2011)	0.4	0.7	1.5 (range 0.8–2.1)	0 (–)
Leung et al. (2010)	0.13	0.65	2	3 (6)
Togal et al. (2010)	1	4.0	7±2 (range 1–136)	9 (12)
Zwart et al. (2010)	NR <sup>1</sup>	0.24	2.9 (range 1–71)	29 (3.5)
Madan et al. (2009)	NR <sup>1</sup>	1.54	NR <sup>1</sup>	23 (0.15)
Cartin-Ceba et al. (2008)	NR <sup>1</sup>	NR <sup>1</sup>	0.9 (range 0.7–1.7)	2 (0.6)

<sup>1</sup> NR: not reported

<sup>2</sup> Uninsured (public)/insured (private)

Maternal characteristics are variously reported in the selected studies. Maternal age is reported in 15 studies and ranges from 26 to 34 years (mean 30.6 years) (Yuqi et al. 2017; Chantry et al. 2015; Vasquez et al. 2015; Bandeira et al. 2014; Ng et al. 2014; Paxton et al. 2014; Rojas-Suarez et al. 2014; Vasquez et al. 2014; Donati et al. 2012; Rios et al. 2012; Aldawood 2011; Crozier & Wallace 2011; Leung et al. 2010; Togal et al. 2010; Cartin-Ceba et al. 2008). Advanced maternal age ( $\geq 35$  years) is reported in 10 studies. Among ICU-admitted patients, a mean of 31% (range 8.4–45%) are of advanced maternal age (Chantry et al. 2015; Bandeira et al. 2014; Ng et al. 2014; Paxton et al. 2014; Rojas-Suarez et al. 2014; Wanderer et al. 2013; Rios et al. 2012; Leung et al. 2010; Zwart et al. 2010; Madan et al. 2009). Gestational age is reported in 13 studies, and the mean is 33.3 weeks of gestation (range 25–37) (Yuqi et al. 2017; Vasquez et al. 2015; Bandeira et al. 2014; Ng et al. 2014;

Paxton et al. 2014; Rojas-Suarez et al. 2014; Vasquez et al. 2014; Rios et al. 2012; Crozier & Wallace 2011; Leung et al. 2010; Togonal et al. 2010; Zwart et al. 2010; Cartin-Ceba et al. 2008). The commonest type of delivery is caesarean section (77.9%, range 57.7–93.2%) (Yugi et al. 2017; Chantry et al. 2015; Vasquez et al. 2015; Ng et al. 2014; Paxton et al. 2014; Vasquez et al. 2014; Donati et al. 2012; Rios et al. 2012; Leung et al. 2010; Togonal et al. 2010), and the time of entry into ICU is mainly during the post-partum period (mean 82.2%, range 62.8–98%) (Yugi et al. 2017; Chantry et al. 2015; Vasquez et al. 2015; Bandeira et al. 2014; Ng et al. 2014; Paxton et al. 2014; Rojas-Suarez et al. 2014; Aldawood 2011; Crozier & Wallace 2011; Leung et al. 2010; Zwart et al. 2010; Cartin-Ceba et al. 2008). Table 3 describes the characteristics of ICU-admitted obstetric patients (N=18).

Table 3. Studies (N=18) reporting characteristics of ICU-admitted obstetric patients

Descriptor	Number of studies reporting	Mean	Range
Maternal age (years)	15	30	23–34
Advanced maternal age (%)	10	31	8.4–45
Gestational age (week)	13	33.75	31–37
Caesarean section (%)	10	77.9	57.7–93.2
Post-partum admissions (%)	12	82.2	30.7–97

### 2.2.1 Causes leading to obstetric intensive care unit admission

In the selected studies, the causes of obstetric ICU admission are grouped into obstetric and non-obstetric causes or direct and non-direct obstetric causes. Obstetric patients are most frequently admitted to ICU with hypertensive disorders of pregnancy or in the context of obstetric haemorrhage. In the literature reviewed, 37.8% (range 14–63%) are admitted to ICU for hypertensive disorders and 30.7% for obstetric haemorrhage (range 15.9–58%). In the selected studies, post-partum haemorrhage is caused by uterine atony, placenta accreta, placenta praevia, or birth canal injury and uterine rupture (Yuqi et al. 2017; Ng et al. 2014). In a study by Madan et al. (2009), patients with placental abruption are more likely to be admitted to ICU, and placenta praevia increases the risk of ICU admission. Rios et al. (2012) report that hypertensive disorders are the main indicator for admission to ICU. These include pre-eclampsia, eclampsia, and the syndrome of haemolysis, elevated liver enzymes and low platelet count.

In the literature reviewed, the commonest non-obstetric reason for admission is infection/sepsis (mean 11.7%, range 3–33%), followed by cardiac disease (8.3%, range 4–18.3%). Other reported non-obstetric causes are anaesthesia complications and respiratory failure. Table 4 describes the leading causes of obstetric intensive care admissions.

Table 4. The leading causes of obstetric intensive care admissions

Study	Obstetric causes		Non-obstetric causes	
	Hypertensive disorders of pregnancy N (%)	Obstetric haemorrhage N (%)	Infectious disease/sepsis N (%)	Cardiac N (%)
Yuqi et al. (2017)	212 (43.5)	133 (43.5)	26 (5.3)	39 (8)
Chantry et al. (2015)	2636 (22.3)	4043 (34.2)	425 (3.6)	545 (4.6)
Vasquez et al. (2015)	172 (58)	96 (32)	21 (33)	NR <sup>2</sup>
Bandeira et al. (2014)	162 (46)	56 (15.9)	50 (14.2)	17 (5.7)
Ng et al. (2014)	17 (25)	39 (58)	NR <sup>2</sup>	NR <sup>2</sup>
Paxton et al. (2014)	103 (41)	68 (27)	10 (4)	21 (8.4)
Rojas-Suarez et al. (2014)	330 (45.5)	167 (23)	81 (11)	NR <sup>2</sup>
Vasquez et al. (2014) <sup>1</sup>	21 (33)/42 (48) <sup>1</sup>	7 (11)/24 (27) <sup>1</sup>	12 (19)/6 (7) <sup>1</sup>	NR <sup>2</sup>
Wanderer et al. (2013)	875 (29.9)	551 (18.8)	207 (7.1)	536 (18.3)
Donati et al. (2012)	371 (29)	496 (40)	36 (3)	NR <sup>2</sup>
Rios et al. (2012)	152 (63)	49 (20)	4 (1.7)	NR <sup>2</sup>
Aldawood (2011)	21 (28)	16 (21)	12 (16)	NR <sup>2</sup>
Crozier & Wallace (2011)	9 (15)	20 (33)	6 (10)	8 (13)
Leung et al. (2010)	7 (14)	19 (38)	7 (14)	2 (4)
Togal et al. (2010)	43 (59)	20 (27)	2 (3)	NR <sup>2</sup>
Zwart et al. (2010)	221 (26.8)	376 (45.5)	50 (6.6)	50 (6.6)
Madan et al. (2009)	NR <sup>2</sup>	NR <sup>2</sup>	NR <sup>2</sup>	NR <sup>2</sup>
Cartin-Ceba et al. (2008)	NR <sup>2</sup>	NR <sup>2</sup>	9 (10)	9 (10)

<sup>1</sup> Uninsured (public)/insured (private)

<sup>2</sup> NR: not reported

## 2.2.2 Severity of illness, intensity of treatment and types of intervention

The severity of illness, organ dysfunctions and prognosis of critically ill patients can be described with internationally used scoring systems. The commonest are the Acute Physiology and Chronic Health Evaluation (APACHE) and the Simplified Acute Physiology Score (SAPS). The Sequential Organ Failure Assessment (SOFA) scoring system is used to assess patients' organ dysfunctions. Table 5 describes severity of illness classification, physiological measurements and scores.

Table 5. Severity of illness classification, physiological measurements and scores

	<b>APACHE II</b> (Knaus et al. 1985)	<b>SAPS II</b> (Le Gall et al. 1993)	<b>SOFA</b> (Vincent et al. 1996)
	min-max		
<b>Vitals</b>			
Heart rate (beats/min)	0-4	0-11	-
Mean arterial pressure (mmHg)	0-4	-	0-4
Systolic blood pressure	-	0-13	-
Body temperature	0-4	0-3	-
Glasgow coma score	0-15	0-26	0-4
<b>Oxygenation</b>			
Respiratory rate	0-4	-	-
PaO <sub>2</sub> (mmHg)/FiO <sub>2</sub> (%) if MV or CPAP	0-4	0-11	0-4
<b>Renal</b>			
Urine output (24 hours)	-	0-11	0-4
<b>Chemistry</b>			
pH arterial	0-4	-	-
Thrombocyte	-	-	0-4
Sodium	0-4	0-5	-
Potassium	0-4	0-3	-
Bicarbonate	0-4	0-6	-
Bilirubin	-	0-9	-
Creatinine	0-4	-	0-4
Haematocrit	0-4	-	-
White blood cell count	0-4	0-12	-
Serum urea	-	0-10	-
<b>Other</b>			
Chronic diseases	0-5	0-17	-
Type of admission	-	0-8	-
Age, years	0-6	0-18	-
<b>TOTAL</b>	<b>0-74</b>	<b>0-163</b>	<b>0-24</b>

The APACHE scoring system was developed by qualifying physiological changes in a variety of critical illnesses during the first 24 hours of intensive care. The first version of the current APACHE scoring system was called the Acute Physiology Score. The APACHE classification was later developed into APACHE II, APACHE III and APACHE IV. The purpose of the revised classifications was to improve the predictability of mortality risk. The revised versions have altered the weight of variables, as well as adding variables to increase the sensitivity of the instrument (Zimmerman et al. 2006; Knaus et al. 1991, 1985, 1981). The APACHE II classification includes a total of 15 vital functions, chronic illnesses and age-related variables. A patient's APACHE II score is based on the maximum deviation of the variable to be measured from the normal physiological baseline over the first 24 hours: 0=no deviation, 4=maximum deviation.

The SAPS score is based on the APACHE II scores and predicts hospital mortality for intensive care-treated patients. The SAPS II scoring system was developed by validating



several variables in extensive international research. The purpose of the scoring system is to better evaluate the mortality of ICU-treated patients, regardless of the primary diagnosis that led to the intensive care. The SAPS II scoring system contains 15 variables, and some of the physiological variables in SAPS are the same as those in APACHE II (LeGall et al. 1993, 1984).

The SOFA scoring system describes patients' organ dysfunctions and evaluates changes in function in the respiratory, circulatory, coagulation, liver, kidney and nervous systems. Patients accumulate one to four points for each physiological variable, and their total scores may vary between zero and 24. High scores indicate serious dysfunctions in the patients' vital functions; those with over 15 SOFA points have been found to have a 10% survival potential (Vincent et al. 1998, 1996). Of the selected studies, eight reported the APACHE II scores (range 6–19.59) (Yugi et al. 2017; Vasquez et al. 2015; Bandeira et al. 2014; Ng et al. 2014; Vasquez et al. 2014; Rios et al. 2012; Aldawood 2011; Leung et al. 2010), four the SAPS II scores (range 9–38) (Chantry et al. 2015; Vasquez et al. 2015; Leung et al. 2010; Togonal et al. 2010) and four the SOFA scores (range 1–3.1) (Vasquez et al. 2015; Vasquez et al. 2014; Rios et al. 2012; Leung et al. 2010) of ICU-admitted obstetric patients. Table 7 describes severity-of-illness scores in the selected studies.

The Therapeutic Intervention Scoring System (TISS) is one of the oldest and most used intensive care intensity indicators (Gunning & Rowan 1999). TISS was developed specifically for intensive care. It focuses on monitoring patients' vital functions, and on monitoring and measuring the amount of care. Initially, the purpose of TISS was to describe both the intensity of treatment and the severity of illness (Cullen et al. 1974). However, the later-developed APACHE, SAPS and SOFA scores have replaced the TISS classification for assessing severity of illness. The original TISS classification has been modified by TISS-76, which is intended to describe the number and quality of medical treatments required by patients. The TISS-76 classification consists of 76 selected intensive care functions, divided into four categories. Usually, the TISS-76 score obtained by intensive care patients is 10–30; a score of more than 50 points represents very heavy and demanding intensive care (Keene & Cullen 1983). However, the number of TISS-76 points does not necessarily indicate the patient's need for care, as some of the treatment may have been given before the intensive care admission. The TISS-76 scoring system also excludes proceedings and administrative tasks relevant to the patient's intensive care period (Reis Miranda et al. 1996). In this literature review, one study reported ICU-admitted obstetric patients' TISS-76 scores (Vasquez et al. 2014). Table 6 describes therapeutic intervention scoring system.

Table 6. Therapeutic intervention scoring system

1 POINT	2 POINTS	3 POINTS	4 POINTS
ECG monitoring Hourly vital signs	Central venous pressure 2 peripheral IV catheters	Chest tubes Pacemaker on standby	Peritoneal dialysis Controlled ventilation with or without PEEP
1 peripheral IV catheter	Haemodialysis (stable patient)	Central IV hyperalimentation	Controlled ventilation with muscle relaxants
Chronic anticoagulation	Fresh tracheotomy (less than 48h)	IMV or CPAP	Balloon tamponade of oesophageal varices
Standard intake and output (24h)	Spontaneous respiration by endotracheal tube or tracheotomy	Concentrated K+ infusion by central catheter	Continuous arterial infusion
Stat blood tests	Gastrointestinal feeding	Nasotracheal or orotracheal intubation	Pulmonary artery catheter
Intermittent scheduled IV medications Routine dressing changes	Replacement of excess fluid loss Parenteral chemotherapy	Blind intratracheal suctioning	Atrial or ventricular packing
Standard orthopaedic traction Tracheotomy care	Hourly neuro vital signs Multiple dressing changes	Complex metabolic balance (frequent intake and output) Multiple ABG bleeding or stat studies (>4/shift) Bolus IV medication (non-scheduled)	Haemodialysis in unstable patients Cardiac arrest or countershock within 48h Induced hypothermia
Decubitus ulcer	Pitressin infusion IV	Arterial line	Pressure-activated blood infusion
Urinary catheter		Vasoactive drug infusion (1 drug)	Intracranial pressure monitoring
Supplemental oxygen		Continuous antidysrhythmia infusions	vasoactive drug infusion (> 1 drug)
Antibiotics (2 or fewer)		Cardioversion for dysrhythmia	IABP
Chest physiotherapy Extensive irrigations, pickings or debridement of wounds, fistula or colostomy Gastrointestinal decompression Peripheral hyperalimentation/intralipid therapy		Hypothermia blanket Frequent infusion or blood products (>5 units/24h)	Platelet transfusion Emergency operative procedures within past 24h
		Acute digitalization (within 48h) Measurement of cardiac output by any method	Lavage of acute gastrointestinal bleeding Emergency endoscopy or bronchoscopy
		Active diuresis for fluid overload or cerebral oedema Active Rx for metabolic alkalosis Active Rx for metabolic acidosis Emergency thora-, para- and pericardiocentesis Active anticoagulation (initial 48h) Phlebotomy for volume overload Coverage with more than 2 IV antibiotics Rx of seizures or metabolic encephalopathy (within 48h) Complicated orthopaedic traction	

In the selected studies (N=18) the commonest reported type of intervention performed in ICU is mechanical ventilation (N=11), followed by central venous insertion (N=8). In the selected studies, blood transfusion is infrequently reported (N=2), despite the fact that obstetric haemorrhage is a frequent cause of admission. Table 7 describes common interventions in the selected studies (N=18).

Table 7. Studies (N=18) reporting severity-of-illness scores, intervention scores and common interventions

Descriptor	Number of studies reporting	Reported values
Severity of illness and level of interventions (scores)		
APACHE II	8	19.59, 17, 14, 11, 10, 9.8, 9.5, 8, 6
SAPS II	4	38, 27, 19.7, 9
SOFA	4	3.1, 3, 1, 1
TISS-76	1	22.5
Types of intervention (%)		
Blood transfusion	2	60.3, 54
Mechanical ventilation	11	85, 52, 45, 45, 43, 34.8, 28.5, 18, 15, 14, 13.6, 11.7, 10
Non-invasive ventilation <sup>1</sup>	2	2, 6
Haemodialysis	5	5, 3, 2, 1.9, 0.8
Arterial pressure	5	75, 70, 66, 36, 33.7
Central line	8	90.6, 70, 52, 48, 27, 26, 22, 14.7
Pulmonary artery catheter	4	3.6, 3.3, 2.5

<sup>1</sup> Continuous/bi-level positive airway pressure

## 2.3 Maternal health-related quality of life during pregnancy and after obstetric complications

Health-Related Quality of Life is a multi-dimensional concept that includes domains related to person physical, mental and social functioning. Many of HRQoL instruments have been developed worldwide. Of the selected studies (N=12), four were conducted in the Netherlands, three in the USA, two in Austria, and one each in Brazil, Hong Kong and Macao. They focus on specific obstetric complications including hypertensive complications and pre-eclampsia during pregnancy (N=5); post-partum haemorrhage (N=1); intrauterine growth restriction (IUGR) (N=2); and preterm birth (N=6). Three studies concern more than one obstetric complication. One study reviews HRQoL outcomes of obstetric patients admitted to ICU.

A total of five generic HRQoL instruments are used in the selected studies: 1) Short-Form 36 (SF-36), 2) Short-Form 12 (SF-12), 3) the European Quality of Life Six Dimensions Three Levels (EQ-6D<sub>3</sub>D), 4) the WHO Quality of Life-Brèf (WHOQOL-BREF), and

5) the Quality of Life Inventory (QOLI). The commonest instruments are SF-36 (N=6) followed by SF-12 (N=3).

SF-36 is a widely used HRQoL measure developed as a short-form measure of functioning and well-being in the Medical Outcome Study. The questionnaire contains 36 items measuring eight health status subscales: physical functioning, role limitations due to physical health problems, bodily pain, general health perception, vitality, social functioning, role limitations due to emotional health, and general mental health. The scores on the subscales are aggregated into summary scores: a physical component score and a psychological component score (Ware et al. 1992). There is a literature to support the validity and reliability of the SF-36 instrument and its adequacy for use in HRQoL measures (Coons et al. 2000). SF-12 is an abbreviation of the original SF-36.

The EQ-6D instrument is based on the generic European Quality of Life Five Dimensions (EQ-5D) measure and provides a simple descriptive profile of general health. EQ-5D consists of five dimensions (mobility, self-care, usual activities, pain/discomfort and depression/anxiety), and each dimension has three possible answers (no problems, moderate problems, severe problems). EQ-6D is an extended EQ-5D with a cognitive dimension: memory, concentration, coherence and IQ. A person's health description can be expressed on a scale between zero (death) and one (perfect health), combining the six dimensions into one overall utility score. The EQ-6D instrument's validity has been examined by comparing it with SF-36, with good results (Hoeymans et al. 2005).

The WHO Quality of Life (WHOQOL) project developed an international and cross-culturally comparable quality-of-life instrument. It assesses the individual's perceptions in the context of their culture and value system, personal goals, standards and concerns. The WHOQOL instrument was developed collaboratively in a number of centres worldwide and has been widely tested. WHOQOL-BREF is a 26-item short version of the WHOQOL questionnaire and measures the following domains: physical health, psychological health, social relationships and environment. The domains are linearly transformed into 0–100. Higher scores in all domains indicate a better HRQoL. This shorter version of the original instrument may be more convenient for use in large research projects (Mautner et al. 2009).

QOLI is a self-reported instrument measuring life satisfaction in 16 defined domains (health, self-esteem, goals and values, money, work, play, learning, creativity, helping, love, friends, children, relatives, home, neighbourhood and community). For each domain, respondents first rate the importance of that domain to their happiness: 0=not at all important, 1=not important and 2=extremely important. Next they rate their satisfaction with each domain, from -3=very dissatisfied to 3=very satisfied. The QOLI is scored by multiplying importance scores by satisfaction scores for each of the 16 domains and then calculating an average across domains. QOLI has been found to have good psychometric properties (Thomas et al. 2012).

In the selected studies, the following instruments are used to measure stress, fatigue, depression and anxiety, and adequacy of resources in households with small children: 1)

Perceived Stress Scale and Impact of Events Scale (for stress); 2) Lee's Fatigue Scale (for fatigue); 3) Edinburgh Postnatal Depression Scale, Hospital Anxiety and Depression Scale, and Symptom Checklist SCL-90 (depression and anxiety); 3) Family Resources Scale (for adequacy of resources in households with small children).

### 2.3.1 Obstetric complications and physical quality of life

In the literature, there is a difference in the physical quality of life (QOL) domain between pregnant women and post-partum women with obstetric complications. Mautner et al. (2009) investigated the effect of gestational diabetes, hypertensive disorders, and preterm birth as risk factors for physical QOL. Women in the preterm group have lower HRQoL scores in the physical domain during pregnancy than those without complications. However, physical HRQoL improves significantly from late pregnancy and the early post-partum period to late post-partum. Prick et al. (2015) investigate women with obstetric complications and HRQoL six weeks post-partum. Gestational hypertension, neonatal admission, and delivery in an academic hospital are negatively related to physical HRQoL. Mode of delivery in Prick's study seems to have a profound impact on QOL, and caesarean section has the largest. These findings by Prick are not consistent with Mautner et al. (2009), who find no effect of mode of delivery on physical QOL.

Mothers of LBW or very low birthweight (VLBW) infants experience worse physical HRQoL than mothers of normal birthweight (NBW) infants. Moura et al. (2017) assessed the QOL of mothers of preterm infants with VLBW. At the time of maternal discharge, the majority of these women reported pregnancy-related complications, mainly hypertensive disorders, and these were the main cause of preterm delivery. This study found no changes in the women's QOL as measured by WHOQOL-BREF, except in the physical health domain. Mothers reported better physical well-being during the first year after delivery. The reasons may be physical problems relevant to the post-partum period, such as perineal and lumbar pain, gastrointestinal disorders, urinary incontinence, breast discomfort and fatigue. However, clinical severity during the neonatal period, bronchopulmonary dysplasia and post-haemorrhagic hydrocephalus are associated with poorer maternal QOL. Further, caring for a VLBW child is negatively associated with mothers' HRQoL, and these mothers experience worse physical HRQoL than mothers of NBW children. This finding is from Witt et al.'s (2012) investigation of mothers of five-year-old VLBW and NBW children. Lau (2013) reports that women with poor HRQoL in the physical domain are more likely to have infants with LBW. In addition, among mothers with LBW preterm infants in NICU at early post-partum, poor sleep quality is associated with fatigue, which in turn contributes to poor physical HRQoL (Lee & Hsu 2012).

Bijlenga et al. (2011a) investigate the effect of labour induction compared with expectant monitoring in women with gestational hypertension or mild pre-eclampsia after 36 weeks of gestation. Their physical health improves over time in both groups between baseline and

six months post-partum. Physical component scores are even higher than the population average. In another study, Bijlenga et al. (2011b) investigate maternal HRQoL and IUGR beyond 36 weeks of gestation. The physical component scores are below norm values at inclusion, but improve over time and are above population norms at six months post-partum.

Leung et al. (2010) review the HRQoL of obstetric patients admitted to ICU. The main reasons for admission are post-partum haemorrhage, followed by pregnancy-associated hypertension. In three domains – physical functioning, bodily pain and social functioning – scores are significantly lower than population norms. However, it is difficult to determine whether the low scores are directly related to the obstetric complications that led to the ICU admission.

### 2.3.2 Obstetric complications and mental quality of life

Women's health problems during pregnancy are associated with worse maternal psychological HRQoL during pregnancy and post-partum (Lau 2013; Witt et al. 2012), and they score worse than non-pregnant women on the psychological level (Stern et al. 2014). In addition, multiparous women score worse on the psychological scale than primiparae (Stern et al. 2014). Pregnancy-specific health problems, especially risks of preterm delivery, are associated with psychological symptoms and decreased HRQoL in pregnancy (Mautner et al. 2009). In addition, NICU admission and perinatal death have been found to be contributing factors for poorer psychological QOL (Hoedjes et al. 2011).

In the literature, hypertensive complications have been found to be contributing factors in reduced maternal HRQoL. Women who have had severe pre-eclampsia present serious distress in psychological HRQoL compared with population norms (Stern et al. 2014). Mautner et al. (2009) investigate the influence of different pregnancy-related health problems as risk factors for decreased HRQoL. They find the highest rate of depressive symptoms and decreased HRQoL during late pregnancy in women who have been treated for hypertensive disorders. Depressive symptoms decrease from late pregnancy and the early post-partum period to late post-partum. Prick et al. (2015) find that women with pregnancies complicated by hypertensive disorders and IUGR have lower psychological QOL scores post-partum. Hoedjes et al. (2011) investigate post-partum women who have experienced pre-eclampsia. This study shows that post-partum women have a poor HRQoL after pre-eclampsia, especially after severe pre-eclampsia. HRQoL improves from six to 12 weeks post-partum, but those who have experienced severe pre-eclampsia still have poor psychological HRQoL. Stern et al. (2014) report similar results: psychological QOL is worse in all patients who have had pre-eclampsia, especially severe pre-eclampsia, compared with reference values.

Witt et al. (2012) find that mothers of VLBW infants experience worse psychological HRQoL than mothers of NBW infants. However, findings by Donohue et al. (2008)

contradict this: although VLBW infants have poorer health at 12 to 18 months of age and require more healthcare resources than full-term infants, their caregivers, especially biological mothers, report a QOL that is similar to or better than that of caregivers of full-term infants. This might be because most caregivers in both groups indicate a strong social support system and frequent communication with friends and family.

## 2.4 Summary from the literature

SAMM is defined as a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days post-partum. Demographic factors that increase the risk of SMM are advanced maternal age and obesity. Factors associated with obstetric ICU admission are preterm birth and surgical mode of delivery. Additionally, pre-eclampsia increases the risk of all obstetric complications. The occurrence of severe complications and near-miss cases during pregnancy and delivery is low, but they still receive intensive care in high-resource countries. In this literature review, ICU admissions complicate 0.8% of pregnancies, representing 3.6% of all critically ill patients admitted to ICU. The commonest indications leading to intensive care are obstetric haemorrhage and hypertensive complications.

In earlier research, severity-of-illness and organ failure scores described a good probability of obstetric patients' recovery, and maternal mortality in ICU was low. However, severity-of-illness scores were developed by specifically excluding obstetric patients, and therefore they might overestimate mortality in the obstetric population. In addition, TISS-76 scores only describe interventions delivered in ICU and disregard previous interventions that may have occurred in the delivery room or operating theatre.

Previous literature has found risk factors for decreased maternal HRQoL during pregnancy and after obstetric complications. Hypertensive complications, and LBW and VLBW infants, are associated with worse maternal physical and mental HRQoL. In addition, NICU admission and perinatal death have been found to be contributing factors to poorer mental QOL.



### 3 The Purpose, Aim and Research Questions of This Study

The purpose of this study is to describe ICU-admitted obstetric patients' episodes of care. The episode of care has been approached from three different perspectives: the course of pregnancy and delivery, intensive care processes, and the patients' health-related quality of life (HRQoL). The perspectives are partially overlapping, but each aspect tells a specific story about the episode of care or part of it. Examining these three perspectives simultaneously rather than separately provides a comprehensive understanding of the episode of care.

The aim of the study is to understanding the background of ICU-admitted obstetric patients and determining their HRQoL before intensive care admission and after discharge. Factors related to pregnancy and delivery, intensive care processes and HRQoL permit the development of maternity care during pregnancy and post-partum.

The specific research questions are the following:

1. What factors pertain to the course of pregnancy and delivery for ICU-admitted mothers? (Article I)
  - 1.1 What is ICU-admitted obstetric patients' course during pregnancy?
  - 1.2 What is ICU-admitted obstetric patients' course during delivery?
  - 1.3 What is the health status of infants born to ICU-admitted obstetric patients?
2. What are obstetric patients' intensive care processes? (Article II)
3. What is obstetric patients' HRQoL before intensive care admission and after discharge? (Articles III and IV)



## 4 Material and Methods

This chapter describes the study design, the data collection and the data analysis related to the study.

### 4.1 Study design

This is a retrospective register-based study of ICU-admitted obstetric patients and their episode of care. The episode of care has been approached from three different perspectives: the course of pregnancy and delivery (Article I), intensive care processes (Article II), and the patients HRQoL (Article III, IV). The perspectives are partially overlapping, but each aspect tells a specific story about the episode of care or part of it. Examining these three perspectives simultaneously rather than separately provides a comprehensive understanding of the episode of care. Figure 1 describes the conceptual model of the study and shows three different perspectives to approach ICU admitted obstetric patient episode of care.

ICU-ADMITTED OBSTETRIC PATIENT		
COURSE OF PREGNANCY AND DELIVERY (Article I)	INTENSIVE CARE PROCESSES (Article II)	HEALTH-RELATED QUALITY OF LIFE (Articles III, IV)
Factors relating to pregnancy: Diseases during pregnancy Other pregnancy-related factors  Factors relating to delivery: Procedures relating to delivery Diagnosis relating to delivery  Infant health status: Gestational age Birthweight Treatment to newborn Child at age of 7 days	Severity-of-illness scores: APACHE II SAPS II SOFA  Intensity-of-treatment scores: TISS-76  Types of interventions  Invasive monitoring  Length of stay  Adverse events: Prolonged stay ( $\geq 144$ hours) Readmission ( $< 48$ hours)  ICU mortality	EQ-5D dimensions: <i>Physical</i> Mobility Self-care Pain/discomfort <i>Social</i> Usual activities <i>Mental</i> Depression/anxiety  EQ Summary Index (EQsum)  EQ-VAS
EPISODE OF CARE		

Figure 1. Conceptual model of ICU-admitted obstetric patients

## 4.2 Data collection

Data was collected retrospectively concerning January 2007 to December 2011. Data concerning pregnancy, delivery and infant health-status was collected from the MBR database at the National Institute for Health and Welfare (THL) (DnroTHL/809/05.05.00/2014). Intensive care processes (severity-of-illness scores, intensity-of-treatment scores, types of interventions, LOS, adverse events, ICU mortality) and HRQoL (EQ-5D dimensions, EQsum, EQ-VAS) data was collected from the clinical information systems. Four multidisciplinary university hospitals in Finland participated. Data from all obstetric patients aged 18–50 admitted to ICU during any trimester of pregnancy and post-partum up to 42 days was considered in the study.

Permission to maintain a study register and approval for data collection were granted by THL (Dnro THL/231/5.05.01/2012). The study register consists of data from the clinical information systems and the MBR. The study used personal identification codes so that data from different registers and hospital databases could be combined. Figure 2 describes the procedure of the register-based study data collection.

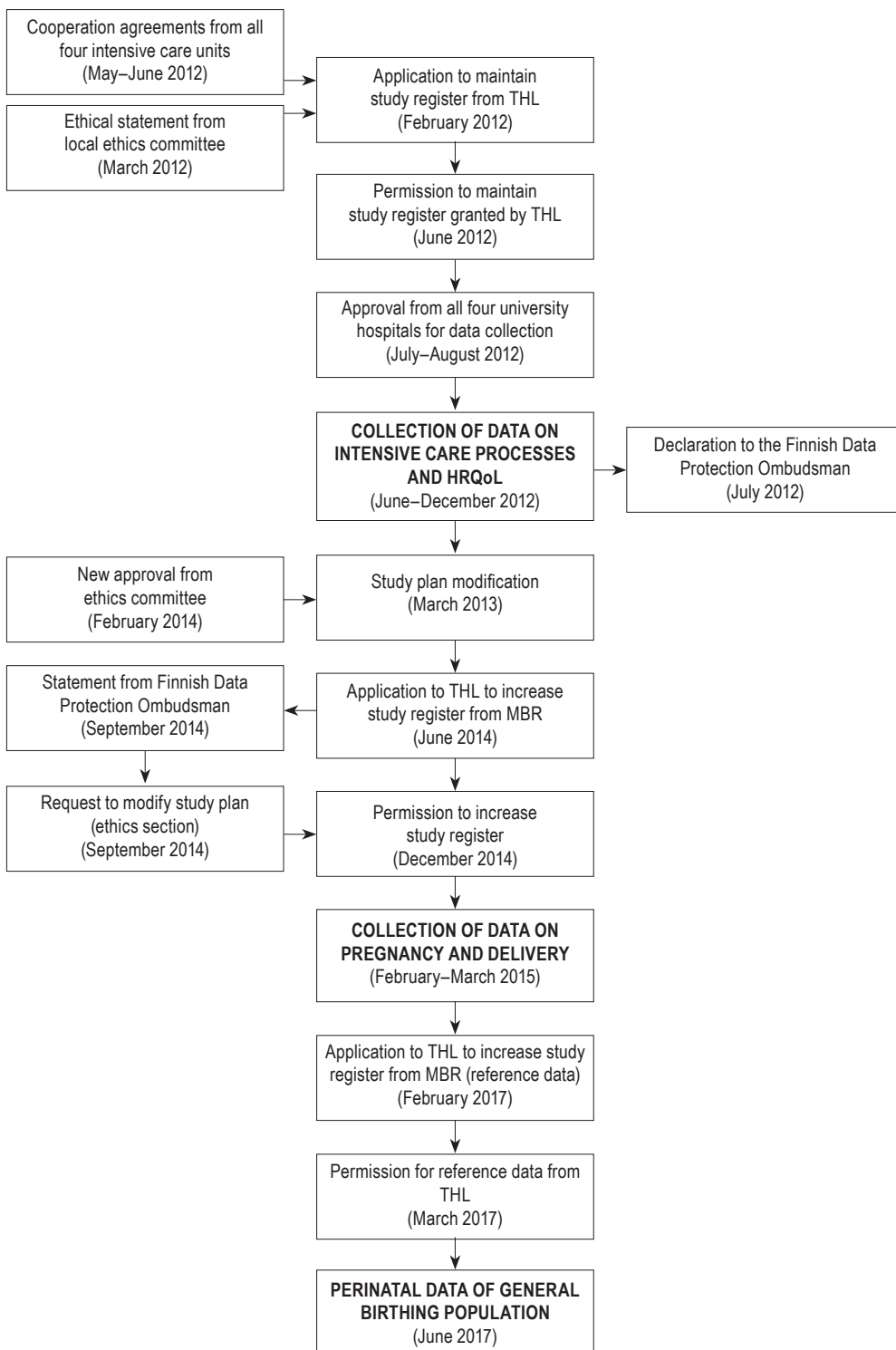


Figure 2. Procedure of register-based study data collection

#### 4.2.1 Collection of data on intensive care processes and health-related quality of life

Data on intensive care processes and HRQoL was collected from the three clinical information systems: CliniSoft, the Finnish Intensive Care Quality Consortium (Intensium) and Miranda. Defined variables and information systems concern intensive care processes are displayed in Article II (Figure 1.). Data concern ICU-admitted obstetric patients' HRQoL were conducted from Clinisoft.

Obstetric intensive care admissions were identified retrospectively by using the APACHE III classification, which is compulsorily recorded data for all ICU-admitted patients. In this study, patient selection used the disease category "other gynaecological disease", which includes diagnoses related to pregnancy, delivery and the post-partum period. The disease category was used only for patient selection.

Cooperating units took part in the national data collection. One nominated contact person integrated all of the data and recorded it in the study register. The collected data describes obstetric patients' intensive care processes and HRQoL. The following data is included: 1) severity-of-illness scores (APACHE II, SAPS II, SOFA); 2) intensity-of-treatment scores (TISS-76); 3) types of interventions (blood transfusion, mechanical ventilation, continuous positive airway pressure (CPAP)/bilevel positive airway pressure (BiPap), haemodialysis); 4) invasive monitoring (arterial pressure, central line, pulmonary artery catheter); 5) LOS; 6) adverse events (prolonged stay, readmission); 7) mortality in ICU. HRQoL was assessed using the EQ-5D dimensions; physical (mobility, self-care, pain/discomfort) social (usual activities) mental (depression, anxiety), EQ summary index (EQsum) and EQ-VAS.

EQ-5D is a non-disease-specific instrument. It is suited for measuring QOL in ICU admitted patients and is extensively used in intensive care research (Angus & Carlet 2002; Oeyen et al. 2010). EQ-5D is available in many languages in a standardized format and includes population reference data for specific countries or international regions (Szende et al. 2014). There are previous studies to support the validity and reliability of the EQ-5D instrument and its suitability for use in HRQoL measures (Coons et al. 2000). EQ-5D consists of two parts: a descriptive system and the Visual Analogue Scale (EQ-VAS). The descriptive system consists of five dimensions: the physical dimensions of 1) mobility, 2) self-care and 3) pain or discomfort; the psychological dimension of 4) depression or anxiety; and the social dimension of 5) usual activities (work, study, housework, family or leisure activities). Each of these five dimensions has three levels: no problems, moderate problems and severe problems. A person completing EQ-5D indicates the level that best describes his or her experience of problems in each domain. The chosen five options create a numeral series, e.g. 11213, from which one summary index (EQsum) is calculated. For example, numeral series 11213 produces the following EQsum: mobility=1 (minus 0), self-care=2 (minus 0.113), usual activities=2 (minus 0.061), pain/discomfort=3 (minus 0.167), depression/anxiety=3 (minus 0.222), total=0.437, i.e. QOL is about 44% of the optimum (Ohinmaa & Sintonen 1995). Table 8 describes the value of the response options. EQ-VAS

records respondents' self-rated state of health on a scale of 0–100: 100 represents the “best imaginable health state” and zero the “worst imaginable health state” (Brooks & EuroQol Group 1996).

Table 8. The value of the EQ-5D response options

EQ-5D domain	1	2	3
Mobility	0	0.079	0.258
Self-care	0	0.113	0.195
Usual activities	0	0.061	0.158
Pain/discomfort	0	0.115	0.167
Depression/anxiety	0	0.186	0.222

#### 4.2.2 Collection of data on pregnancy and delivery

The Finnish health information system is based on registers, which include the personal identification code launched in 1964. Personal identification codes provide an opportunity to increase the compilation of health and welfare registers, and enable the more efficient use of secondary data for research purposes. In addition, the collection of personal identification codes improves the quality of data and augments the available information. Currently there are several national registers in Finland that contain comprehensive information for health research purposes and to improve welfare and healthcare services. Finland has strict data protection laws, and under the Personal Data Act health information can only be gathered with the informed consent of the patient, with the exception of data collected for statistical or scientific research (Gissler & Haukka 2004).

Medical birth registers are common in many countries, but all Nordic countries have separate birth registers containing detailed data on parturients, deliveries and infants (Sund et al. 2013). In Finland the MBR is maintained by THL. The MBR was established in 1987, and its purpose is to collect data in order to develop and organize maternity care, obstetrical services and neonatal care. The MBR contains data on all mothers who have given birth in Finland and on all infants up to the age of seven days. It includes data on all live births, and on stillbirths of foetuses with a birthweight of at least 500 grams or a gestational age of at least 22 weeks. For each infant, a form has to be completed by the hospital no later than seven days after delivery. (National Institute of Health and Welfare 2018.) It is possible to utilize a large number of variables for research purposes from the MBR, as well as to consider many interactions of the phenomena under consideration. The MBR also contains less commonly available data such as socio-economic background and occupation (Räisänen et al. 2013).

Collected data includes the following: personal data on the mother (personal identity code, marital or cohabitation status); previous pregnancies and deliveries; present

pregnancy and its monitoring (check-ups during pregnancy, mother's weight and height before pregnancy, mother's smoking habits during pregnancy, risk factors and interventions relating to pregnancy, diseases during pregnancy (International Classification of Diseases-10 codes), hospital care during pregnancy); delivery (best estimation of gestational age at time of delivery, method of delivery, pain relief during labour, other procedures relating to delivery, mother's diagnoses relating to pregnancy and delivery); the infant (sex, whether born alive or dead, number of foetuses, weight at birth); data on the infant by the age of seven days or at discharge (care interventions relating to the infant, infant at the age of seven days or at discharge from hospital (homeward, postnatal ward, neonatal ward, other hospital, died), hospital LOS for mother).

#### 4.2.3 Perinatal data of general birthing population

Perinatal data of general birthing population was collected from the MBR at THL (Dnro THL/391/5.05.00/2017). The reference data comprises all women who delivered during the same time period (2007–2011) and at the same university hospitals as the study population, excluding the study population. The reference data includes precisely the same variables as the data collected at the second time-point concerning the study population. The reference data includes 79,340 parturients and 80,829 infants, because of multiple pregnancies.

### 4.3 Data analysis

In Article I ICU-admitted obstetric patients' course of pregnancy and delivery and the health status of infants born to ICU-admitted mothers was to compare with Finnish reference values. Categorical data is presented as percentages or frequencies; continuous data as means, and standard deviations or medians, and interquartile ranges (IQR 25th–75th percentiles) according to the distributions. Continuous variable comparisons were made using one sample t-test. Factorial variable comparisons between groups were made using chi-square or Fisher tests in R, version 3.3.0 (R Core Team 2016).

In Article II a test to compare reasons for admission and types of delivery across severity-of-illness and intervention scores and LOS was performed using the non-parametric Mann-Whitney U and Kruskal-Wallis tests. Group comparison in common interventions and invasive monitoring were performed using the Fisher exact test.

In Article III maternal and neonatal demographic data were compared in four subgroups based on EQ-5D questionnaire responses: 1) baseline and follow-up, 2) baseline only, 3) follow-up only, and 4) missing. The demographic data were compared using the Kruskal-Wallis test, the Fisher exact test and the Mann-Whitney U test. The EQ-5D domains were analysed separately using the McNemar test. The EQsum and EQ-VAS scores were compared between baseline and follow-up using the Wilcoxon test. Changes in

EQsum and EQ-VAS between baseline and follow-up were reported as worsened, the same or improved. A minimum difference of EQsum was defined as 0.074 in EQsum (Walters & Brazier 2005) and seven points in EQ-VAS (Pickard et al. 2007) was considered clinically important.

In Article IV for HRQoL comparison, age-appropriate reference values were used. The EQ-5D population norms are reported in the literature, including reference values from the general Finnish population of females aged 17–44 years (Ohinmaa & Sintonen 1995). Impaired QOL at follow-up was defined as measurements lower than the reference population values minus the clinically important difference, which was 0.074 for EQsum (Walters & Brazier 2005). For the comparison between the study population and reference values, the Mann-Whitney U test and Fisher's exact test were used.

For comparison,  $p < 0.001$  was considered significant in Article I and  $p < 0.05$  in Articles II–IV. However, in Article III's demographic data comparisons between patient groups, a Bonferroni-adjusted  $p$  value of 0.0083 was used. Statistical analyses were performed using SPSS statistics version 15.0, version 20.0 and version 23.0.

Table 9. summarizes the study population, purposes and statistical analyses used in Articles I–IV.

Table 9. Summary of study population, purposes and statistical analyses used in Articles I–IV

Article	Episode	Population	Purpose	Statistical analysis
I	Course of pregnancy and delivery	283* ICU-admitted obstetric patients with data from the MBR, the reference data from MBR includes 79,340 parturients and 80,829 infants	To determine ICU-admitted obstetric patients' course of pregnancy and delivery, to determine the health status of infants born to ICU-admitted mothers, and to compare with Finnish reference values	Chi-square test Fisher exact test One sample t-test
II	Intensive care processes	291 obstetric patients who were admitted to the four ICUs	To describe obstetric patient intensive care processes, adverse events and ICU mortality during pregnancy and post-partum and to compare reason for admission (obstetric and non-obstetric) and type of delivery with severity of illness, intervention scores, LOS and common interventions.	Mann-Whitney U test Kruskal-Wallis test Fisher's exact test
III	Health-Related Quality of Life	99 obstetric patients who completed the baseline and follow-up EQ-5D questionnaires. Among these, the self-rated health evaluation (EQ-VAS) was completed by 65 patients	To assess and compare obstetric patients' HRQoL before intensive care admission (from before ICU stay) and at six months after discharge (from six months after ICU discharge)	Mann-Whitney U test Kruskal-Wallis test Fisher's exact test McNemar test Wilcoxon test
IV	Health-Related Quality of Life	214 baseline EQ-5D measurements and 114 follow-up EQ-5D measurements	To examine HRQoL in obstetric patients after ICU discharge, with comparison with age-appropriate reference values from the general Finnish female population	Mann-Whitney U test Fisher's exact test

\* A total of 291 obstetric patients were identified from the clinical information systems, of whom 283 had MBR data



## 5 Results

The results of this study are presented in accordance with the research questions outlined in Section 3. The detailed results of the study are presented in original Articles I–IV.

### 5.1 Study population

The study population covered the years 2007–2011. A total of 328 patients were identified retrospectively from clinical information systems according to the search strategy, i.e. the APACHE III classification of ‘other gynaecological disease’. Of these, 37 were excluded because they were gynaecological patients (i.e. non-pregnant). A total of 291 ICU-admitted obstetric patients’ intensive care processes were analysed (Article II). Of these, 283 had MBR data enabling the analysis of ICU-admitted obstetric patients’ course of pregnancy and delivery and the infant health status (Article I). A total of 214 patients had HRQoL measurements at baseline, and 114 had follow-up measurements six months after discharge (Article IV). Of these, 99 completed EQ-5D questionnaires at both baseline and follow-up (Article III). Figure 3 presents a flowchart describing ICU-admitted obstetric patients in the study. The maternal characteristics and mode of delivery of ICU-admitted obstetric patients are displayed in Article I (Table 2, Table 3).

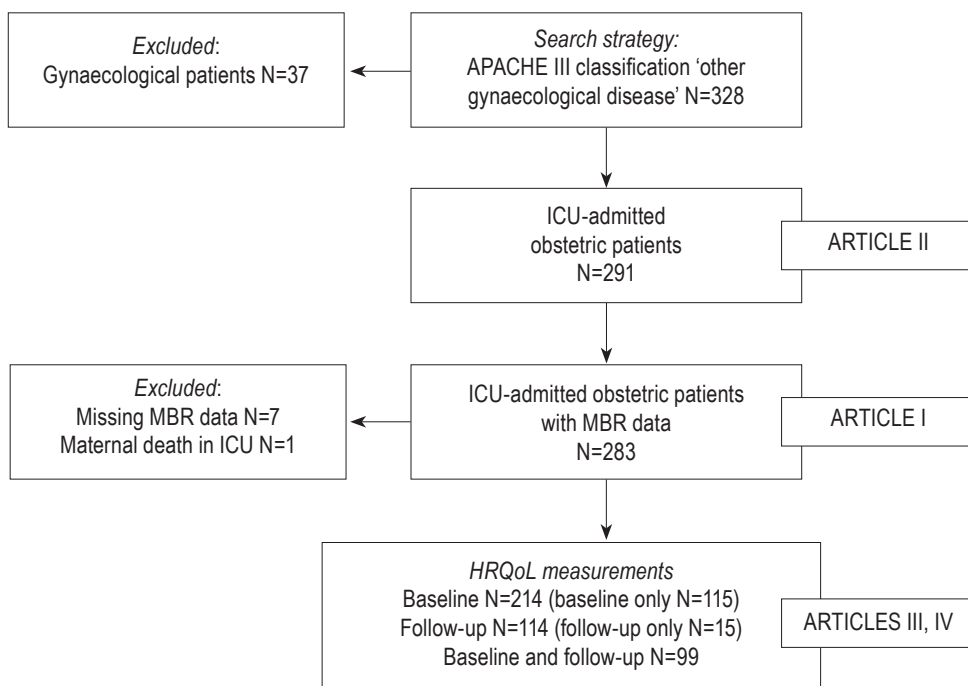


Figure 3. Flowchart describing ICU-admitted obstetric patients in the study

## 5.2 Intensive care unit-admitted obstetric patients' course of pregnancy and delivery

ICU-admitted obstetric patients' course of pregnancy and delivery was analysed according to factors related to pregnancy (diseases during pregnancy, other pregnancy-related factors), factors related to delivery (procedures related to delivery, diagnosis related to delivery) and infant health status (gestational age, birthweight, treatment to newborn, and child status at the age of seven days) (Article I). Parturient and infant results were also compared with the reference population.

The commonest reasons for admission were hypertensive complications (58%), followed by obstetric haemorrhage (25.1%) (Article I, Table 1). Mothers admitted for hypertensive complications and non-obstetric reasons were more likely to deliver preterm (76.8% and 74.7%). Obstetric haemorrhage was associated with full-term birth (74.7%). Factors related to obstetric haemorrhage were manual removal of the placenta ( $p < 0.001$ ), uterus evacuation ( $p < 0.001$ ) and blood transfusion during delivery ( $p < 0.001$ ). Severe complications of eclampsia ( $p < 0.001$ ) and placental abruption ( $p < 0.001$ ) appeared in this population more frequently (Article I, Table 3). The maternal characteristics associated with obstetric ICU admission were advanced maternal age ( $\geq 35$  years old) (27.2% versus

17.0%) and nulliparous (63.3% versus 41.7%) and multiple pregnancies (7.8% versus 3.6%) compared with the reference population (Article I, Table 2). The majority of ICU-admitted mothers delivered by unscheduled caesarean section (68.9% versus 9%) (Article I, Table 3).

Infants born to ICU-admitted mothers were more likely to be born preterm (59.6% versus 6.6%) and to have lower birthweight (55.1% versus 5.6%). Infants were more likely to need treatment in NICU or an observation unit, and nearly one fifth needed respiration care (reference value 1.9%). Mothers who needed intensive care were more likely to lose their infant before the age of one week (4.6% versus 0.6%) (Article I, Table 4).

### 5.3 Obstetric patients' intensive care processes

Obstetric patients' intensive care processes were assessed using severity-of-illness scores, intensity of treatment, types of interventions, LOS, adverse events (prolonged stay, readmissions), and mortality in ICU (Article II).

The findings showed that the severity-of-illness and organ failure scores described a good probability of obstetric patients' recovery. The median severity-of-illness scores for APACHE II, SAPS II and SOFA were nine, 14 and two respectively. The median intensity-of-treatment score for TISS-76 was 21.5 (daily). However, the reasons leading to the obstetric ICU admission and the mode of delivery were associated increasingly with both the severity-of-illness scores and the level of intervention required. Patient admitted for non-obstetric causes and who had a vaginal delivery demonstrated higher severity-of-illness scores, organ failure scores and levels of intervention compared with those admitted for obstetric causes or who delivered by caesarean section.

The commonest intervention during ICU stay was blood transfusion (26.5%) followed by mechanical ventilation (18.2%). The majority of patients required invasive arterial pressure (97.9%). Haemodialysis ( $p=0.008$ ), central line ( $p=0.001$ ) and pulmonary artery catheter ( $p=0.001$ ) were commoner in patients who were admitted to ICU for non-obstetric causes (Article II, Table 3). The LOS in ICU was on average 21 hours (IQR 16.00–26.00). Over 90% had an ICU stay shorter than two days (Article II, Table 2). There were three patients who had prolonged stays in ICU: 6.6 days, 8 days and 11.7 days. Three patients had readmission. One maternal death in ICU occurred.

### 5.4 Intensive care unit-admitted obstetric patients' health-related quality of life

The HRQoL of ICU-admitted obstetric patients were assessed using generic EQ-5D measurements before intensive care admission and six months after discharge. EQ-5D measurements consist of the EQ-5D dimensions – physical (mobility, self-care, pain/discomfort), social (usual activities) and psychological (depression/anxiety) – the EQsum

and EQ-VAS (Article III). These results were also compared with the age- and sex-matched Finnish reference population (Article IV).

The findings of this study showed that there were no differences in the EQ-5D physical dimensions of self-care and pain/discomfort, the social dimension of usual activities or the psychological dimension of depression/anxiety, before intensive care admission and six months after from ICU. Mobility showed an improvement ( $p=0.021$ ) at follow-up (Article III, Table 2). The direction of change in EQ-5D dimensions following intensive care showed that 15% of patients had more pain/discomfort, and 11% expressed more depression/anxiety (Article III, Table 3). ICU-admitted obstetric patients' HRQoL remained good or increased in 80.8% of the patients six months after discharge. Patients reported improved self-rated health status on the EQ-VAS at six months' follow-up ( $p=0.001$ ). However, 19.2% of patients reported worsened HRQoL at follow-up (Article III, Table 4). Multiparous patients were more likely result worsened depression/anxiety ( $p=0.024$ ).

HRQoL was compared with the age-appropriate Finnish female reference values. Obstetric patients showed impaired baseline EQ-5D results in the dimensions of mobility ( $p<0.001$ ), self-care ( $p=0.014$ ), pain/discomfort ( $p=0.009$ ) and usual activities ( $p=0.033$ ). These values were increased at six months after ICU discharge, such that the follow-up values did not significantly differ from the reference values (Article IV, Figure 2). At the baseline, the mean EQsum score was lower than the reference value ( $p<0.001$ ). However, EQsum increased over six months, and follow-up values were similar to the reference population. EQ-VAS scores were lower at baseline ( $p<0.001$ ) but increased over six months and were similar to reference values (Article IV, Table 2). However, at follow-up 18.4% of patients result poorer HRQoL compare to the reference values and multiparous patients showed worse scores compared to primiparous women.

## 5.5 Summary of study findings

In this study, advanced maternal age and nulliparous and multiple pregnancies were associated with obstetric ICU admissions. The main indications for admissions were hypertensive complications and obstetric haemorrhage. Infants born to these mothers were more frequently born preterm, had lower birthweight and were more likely to need treatment in NICU or an observation unit. Mothers' severity-of-illness and organ failure scores described a good probability of recovery, and they had a short LOS in ICU. Nonetheless, the reasons for ICU admission and mode of delivery were associated with both the severity-of-illness scores and the level of intervention required. Patient admitted for non-obstetric causes and having had a vaginal delivery demonstrated higher severity of illness scores, organ failure scores, and levels of intervention when compared to those admitted for obstetric causes or those who had delivered by caesarean section. ICU-admitted obstetric patients' HRQoL was below the reference population before ICU stay, but improved six months after discharge and was similar to reference values. Nonetheless,

one fifth of patients had below-reference values at follow-up. In conclusion: ICU-admitted obstetric patients had a good probability of recovery, and their HRQoL remained good after discharge. However, these patients' situation was often complicated by the fact that their newborns were seriously ill and needed treatment in NICU. Figure 4 summarizes the study findings.

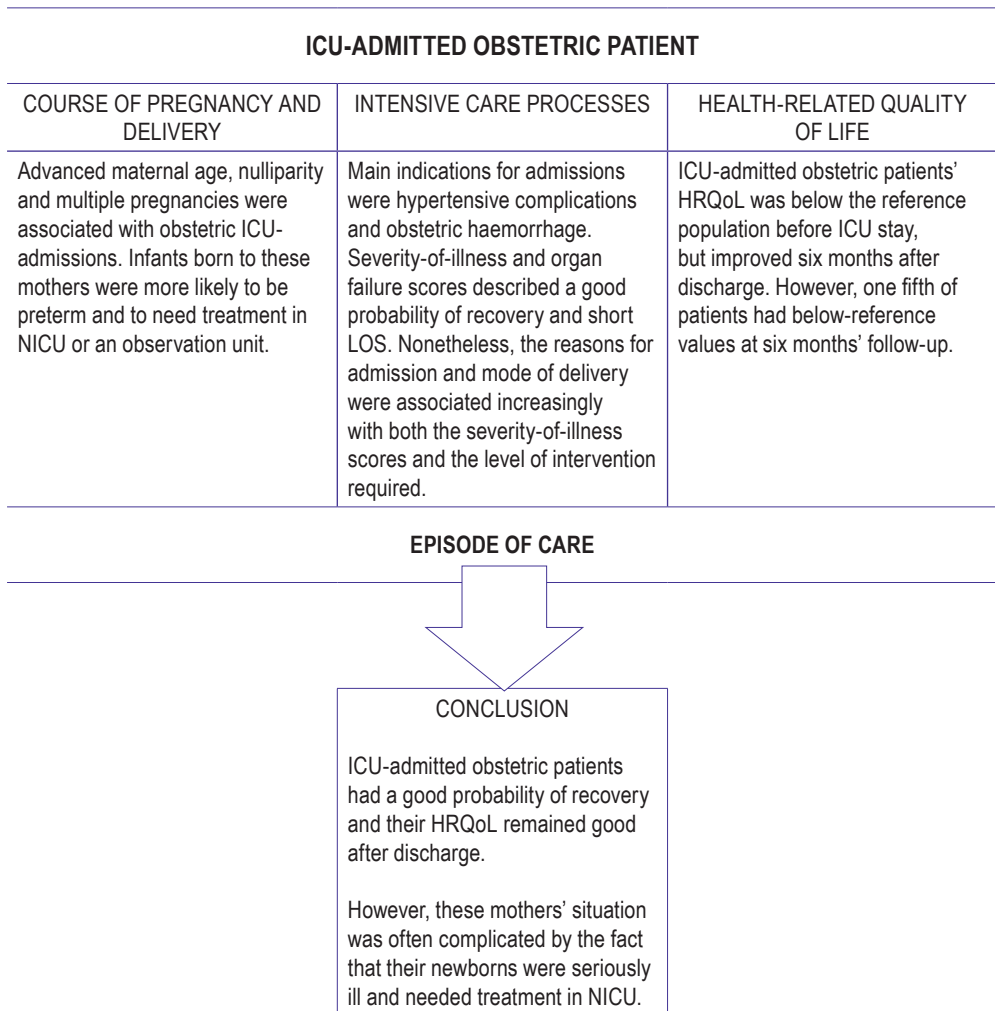


Figure 4. Summary of study findings

## 6 Discussion

The purpose of this study was to describe ICU-admitted obstetric patients' episodes of care. The episode of care has been approached from three different perspectives: the course of pregnancy and delivery, intensive care processes, and the patients' HRQoL before intensive care admission and six months after discharge. The perspectives are partially overlapping, but each aspect tells a specific story about the episode of care or part of it. Examining these three perspectives simultaneously rather than separately provides a comprehensive understanding of the episode of care. The data analysed was derived from clinical information systems and the MBR.

The aim of the study is to understand the background of ICU-admitted obstetric patients and determine their HRQoL before intensive care admission and after discharge. Factors related to pregnancy and delivery, infant health status, intensive care processes and HRQoL provide an opportunity for the development of maternity care during pregnancy and post-partum. The results of this research can also be utilized in healthcare education on degree programmes and professional extension studies.

### 6.1 Strengths and limitations of register-based study

In Finland, there are several different national registers in which a substantial amount of information is stored. Additionally, a lot of information that can be used alongside register material for research purposes is accumulated in patient data systems. Conducting a register-based study is a useful method when the focus is on a rarely occurring phenomenon, such as obstetric patient admission to intensive care. Additionally, studies with a small sample size may produce arbitrary results, and controlled experimental designs may be impossible to carry out (Räisänen et al. 2013).

In this study, the investigated phenomenon was viewed in relation to the past, and incidents related to the phenomenon were studied retrospectively. By means of register-based research it was possible to obtain long-term data on the entire group of research

participants, and to study this group nationally. By utilizing the identification data (personal identity codes) of the participants, it was possible to combine one person's separate data from patient data systems and the MBR. Moreover, the register-based approach made it possible to create a time dimension, which in this study referred to the course of pregnancy and delivery, events taking place during the intensive care process, and analyses of QOL before admission and six months after discharge.

Material collected from the MBR formed a whole related to pregnancy and delivery. Among other things, the register provided useful, less frequently recorded data concerning definitions of health such as smoking or weight before pregnancy (BMI). Furthermore, material collected from the MBR gave an opportunity to analyse the health of the neonates of obstetric patients admitted to intensive care, on which little previous study data exists. In this study it was possible to analyse neonates' need for hospital care, among other things, and to obtain new information on neonates' health status at the age of one week. Material collected from the MBR could be used to compare the research participants with the general population with regard to events during pregnancy and delivery and the health status of neonates. It was essential to review each stage of the episode of care received by ICU-admitted obstetric patients.

It is possible that the data stored in registers includes errors or has been recorded deficiently. There may also be variation in the data's comprehensiveness or reliability (Räisänen et al. 2013). In this study, data for seven obstetric patients who were treated in intensive care was not found in the MBR. The reason for this may be that during intensive care the patient was pregnant but the pregnancy ended before the criteria for entering data into the register were met (i.e. live births, and stillbirths of foetuses with a birthweight of at least 500 grams or a gestational age of at least 22 weeks). Alternatively, the personal identity code may have been entered incorrectly, in which case it was not possible to combine data from the MBR with data from the patient data system.

In addition, this study is limited by the relevance of the search strategy in regard to searching obstetric patient data from clinical information systems. Although the APACHE III diagnosis group is a compulsory element of recorded information, obstetric patients cannot be located if they are recorded under a diagnosis code other than "other gynaecological disease". It might that obstetric patient information relating to the pregnancy and post-partum phases were missed in the research material. This may have influenced the number of obstetric ICU admissions that were found in this study.

## 6.2 Strengths and limitations of the measurements

In this study, severity of illness was measured by APACHE II and SAPS II scoring systems, and organ dysfunctions by SOFA scores. These scoring systems are internationally used and allow comparison between different ICUs. Intensity of treatment was measured by TISS-76 scores, and these are also internationally comparable. However, severity-of-illness

scores were developed by specifically excluding obstetric patients, and therefore they overestimate mortality in the obstetric population (Rojas-Suarez et al. 2014). In addition, intervention scores (TISS-76) only describe interventions delivered in ICU and ignore previous interventions that may have occurred in the delivery room or operating theatre (Reis Miranda et al. 1996).

ICU-admitted obstetric patients' HRQoL was measured using the EQ-5D tool, which is an appropriate instrument for measuring QOL in critically ill patients (Angus & Carlet 2002). This tool is well validated (Coons et al. 2000; Angus & Carlet 2002) and has population norms in the literature (Ohinmaa & Sintonen 1995). This study utilized the population norms defined by Ohinmaa and Sintonen (1995), which are the latest available values (despite the publication date). This study met the quality criteria of HRQoL measures: assessment of HRQoL at baseline, no major exclusion criteria in the study population, description of the non-respondent group versus respondent group, and comparison with the age- and sex-matched normal population (Oeyen et al. 2010).

It is known that EQ-5D is primarily intended to describe the state of health that people are experiencing now. However, at the onset of intensive care admission, patients are usually in a life-threatening condition and often unable to communicate. Thus, it is not considered sensible to describe the state of health at that moment. Instead, it is necessary to record a description of the state of health that preceded the critical illness in order to get a baseline that can be compared with the state of health at follow-up. This issue is relevant, because it is good to know whether patients are going to recover from intensive care over the next months or whether HRQoL is poor. EQ-5D questionnaires completed during the intensive care period apply to the time just before the serious illness.

In this study, the EQ-5D measurement's loss to follow-up was considerable. This might be because we analysed data from clinical information systems, so-called secondary data. The data had initially been collected for other purposes, for example administrative purposes. Thus, the accumulation of data could not be effected during the study period. However, maternal and neonate demographics were compared between the subgroups (normal QOL, impaired QOL and lost to follow-up), and the demographics did not differ statistically between the three subgroups.

### 6.3 Ethical considerations

The General Data Protection Regulation (GDPR) of the European Union (EU) came into force on 25 May 2018. The purpose of GDPR is to regulate the processing of personal data in all EU member states. GDPR aims to strengthen the rights of data subjects and to increase transparency in the use of personal data. The key changes effected by GDPR include the following: 1) according to controller accountability, a controller has an obligation to demonstrate that it adheres to the data processing requirements set forth in GDPR; 2) the rights of the data subject are broader, and the obligations of the controller have increased;



3) data security breach notification has become mandatory; 4) legal methods and legal consequences have become more rigorous; 5) controllers and processors may have an obligation to appoint a data protection officer (Office of the Data Protection Ombudsman 2018). In Finland, GDPR will be supplemented by a new Data Protection Act, which will replace the Personal Data Act (523/1999) currently in force.

The main principles concerning the processing of personal data remain unchanged for the most part, as do the rights of data subjects. In future, however, a person will have a right to inspect the data concerning him or her and to submit a request for rectification of incorrect data and for erasure of unnecessary data. The entity responsible for processing personal data has an obligation to correct inaccurate personal data and to erase unnecessary or obsolete personal data without delay within one month of receipt of the request for data rectification or erasure (Office of the Data Protection Ombudsman 2018).

A controller has to be able to provide written proof that the controller is abiding by the data protection legislation and the principles of processing personal data, and that the controller is ensuring the rights of data subjects as required by legislation. The controller must also be prepared for possible data security breaches. A data security breach is an incident due to which personal data is destroyed, erased, changed, forwarded without permission or attained by an entity that has no right to process that data. A notification of a personal data security breach that threatens individuals' rights or freedoms must be submitted to the Data Protection Ombudsman within 72 hours of the discovery of the breach. In some cases, a notification of the data security breach must also be given to the data subject (Office of the Data Protection Ombudsman 2018).

According to the Finnish Personal Data Act (523/1999), personal data can be processed on other grounds than those laid down in Section 8, Subsection 1, for the purposes of scientific research, provided that specific conditions are met. In this study of the intensive care of obstetric patients, only data from patient registers and patient documents was used, and this was done retrospectively. It was not possible to conduct the study of the intensive care of obstetric patients without the patients' identification data, because the combination of data from national registers and patient documents was based on the identification of patients. Data obtained from different registers and patient documents was compatible with regard to the use of this data (see research questions), and no separately collected research material was used. Also, there was no contact with the study subjects in any way during the study. Furthermore, due to the age of the data and the large amount of information used in the study, the study was exempt from the principle of informed consent. The collected data comprised a study register; authorization to establish and maintain this register was granted by THL.

To ensure protection of privacy during the study, special care was taken to avoid any combination of anonymous data from different registers that would enable the identification of individuals. Patients' identification data was used only to combine data from national registers and patient documents in order to establish research material.

Patients' identification data was saved in the study register, the user rights to which belonged to the designated study group. The analysis of research material was performed without patients' identification data, and the study results have been reported in a manner that does not make it possible to identify individual persons.

In this study, the privacy of the research subjects was safeguarded according to the Constitution of Finland (731/1999), the Personal Data Act (532/1999), the Act on the Openness of Government Activities (621/1999), the Statistics Act (361/2013) and the Act on National Personal Records Kept Under the Health Care System (556/1989). The Ethics Committee of Pirkanmaa Hospital District gave an ethical statement on the conduct of the study on 25 February 2014 (ETL code R12050H). Because sensitive personal data was saved on the study register, appropriate notification about the maintenance of this register was given to the Data Protection Ombudsman. The compiled study register will be discarded when the study subjects' personal data is no longer required for conducting the study or for ensuring the relevance of the study results.

## 6.4 Discussion of the main findings

In this study, the ICU admitted obstetric patients' episode of care has been approached from three different perspectives: the course of pregnancy and delivery, intensive care processes, and the HRQoL. The perspectives were seen to partially overlap, but each aspect tells a specific story about episode of care or a part of it. This study examined these perspectives simultaneously, and not as separate, so as to provide a comprehensive understanding of the episode of care. The intensive care process of these patients' has not been described to this extent in previous research.

Previous studies have reported obstetric risk factors that lead to an increased risk of non-optimal outcomes (Pallasmaa et al. 2016; Lal & Hibbard 2015; Macharey et al. 2015; Trilla et al. 2014). Obstetric patient ICU admissions have been well described in previous literature (Chantry et al. 2015; Pollock et al. 2010; Zwart et al. 2010; Cartin-Caba et al. 2008). The results of this study mainly confirm previous findings of the risk factors for pregnant women and the intensive care processes of obstetric patients. However, there have been few previous studies on ICU admitted mothers and their HRQoL. From this point of view, the scientific value of the study is significant.

It should be taken into account that the health care system produced the data used in this study. The data produced from these registers requires research questions that can be specifically answered by the available data. This may detract from the theoretical base of the study, especially in regard to ICU admitted obstetric patient HRQoL. In the future it is important to deepen the understanding of episodes of care by increasing an awareness of the experience of the ICU admitted mother and the whole family. Methodologically it is possible to study these experiences, for example by the use of qualitative methods.

This study has made following main findings. First, advanced maternal age and nulliparous and multiple pregnancies were associated with obstetric ICU admission. Furthermore, infants born to these mothers were more frequently born preterm, had lower birthweight and were more likely to need treatment in NICU or an observation unit (Article I).

According to perinatal statistics from THL (2016), the average age of parturients has increased in Finland in recent years. The mean age of parturients is higher than ever before: in 2016 the mean age of all parturients was 30.7 years, and the mean age of all nulliparous was 29 years. This study has shown that advanced maternal age is a contributing factor for obstetric ICU admission. Previous studies reported that advanced maternal age increased the risk of LBW infants and preterm births (Goisis et al. 2017). Herstad et al. (2014) found an association between advanced maternal age and emergency caesarean section.

The findings of this study have shown that ICU-admitted obstetric patients had adverse birth outcomes such as preterm delivery (59.6%), the need for NICU treatment (56.1%) and infant respiration care (19%). Additionally, 4.6% of ICU-admitted mothers experienced the loss of their infant (reference population 0.6%). The type of delivery was mainly caesarean section (68.9%). In a study by Fredriksen et al. (2018), advanced maternal age, use of assisted reproductive technology, nulliparity, smoking during pregnancy, and obesity increased the risk of an adverse pregnancy outcome. Additionally, nulliparity at very advanced maternal age ( $\geq 45$  years) is a significant risk for adverse pregnancy and birth outcomes (Alon et al. 2016).

This study did not collect data on the number of births in each hospital. However, there are statistics on live births in different hospital districts in Finland. This data is freely available on the Statistics Finland website. This data was used to determine the incidence of obstetric ICU admissions among all deliveries. During the study period there were 94,642 births in four hospital districts and a total of 291 obstetric ICU admissions. The incidence was 0.3% of all maternities and varied from 0.02 to 0.5% (Table 10.). Previous studies have described a low incidence of obstetric ICU admission among all deliveries (Vasquez et al. 2015; Ng et al. 2014; Aldawood 2011; Crozier & Wallace 2011; Leung et al. 2010), which are consistent with findings of this study. However, it is possible that university hospital administrative practice may vary and that some obstetric patients were treated somewhere other than ICU – for example, in a recovery ward after caesarean section. Table 10 describes the statistics for live births in different hospital districts in Finland and the incidence of ICU admission during the study period.

Table 10. Live births in different hospital districts in Finland and incidence of ICU admission

	Hospital district I	Hospital district II	Hospital district III	Hospital district IV	Incidence
	Live births (ICU admissions)				%
2007	5691 (27)	5645 (25)	4798 (-)	2356 (3)	0.3
2008	5855 (39)	5695 (23)	4877 (2)	2434 (10)	0.4
2009	5932 (39)	5788 (20)	4932 (1)	2479 (16)	0.4
2010	5857 (25)	5819 (13)	5116 (-)	2497 (11)	0.3
2011	5844 (13)	5678 (10)	4895 (2)	2454 (12)	0.2
Total	29 179 (143)	28 625 (91)	24 618 (5)	12 220 (52)	0.3
%	0.5	0.3	0.02	0.4	-

The second finding of this study was that severity-of-illness and organ failure scores suggested ICU-admitted obstetric patients' good probability of recovery and a short LOS. Nonetheless, the reasons for admission and mode of delivery were associated increasingly with both the severity-of-illness scores and the level of intervention required (Article II). However, in previous studies little is reported about severity of illness scores, intervention scores and common interventions (see Table 7).

Consistent with previous studies, the commonest reason for admission was hypertensive complications, followed by obstetric haemorrhage (Pollock et al. 2010). This study found an association between hypertensive complications and preterm birth. Moreover, eclampsia was more common in ICU-admitted patients compared with the reference value (5.7% versus 0.05%). Patients admitted for obstetric haemorrhage mainly delivered at term (74.7%). It might that adverse birth events appear during delivery, leading to a need for obstetric intensive care. In this study, 8.6% of patients were admitted for non-obstetric reasons, which were related to disease-specific and organ dysfunction-specific reasons. It may be that these patients had chronic diseases that worsened during pregnancy or delivery, and which in turn affected their severity of illness. Alon et al. (2016) found that nulliparous women of very advanced maternal age were more likely have chronic health conditions.

In the literature, ICU-admitted obstetric patients' TISS-76 scores are rarely reported. However, study Vasquez et al. (2014) reported such patients' TISS-76 score as 22.5, which is in line in our findings (median 21.5). In study Reinikainen et al. (2007) reported all patients treated in ICU mean daily TISS-76 scores in age group 0-39 years was 20.2 points. Usually, the TISS-76 score obtained by intensive care patients is 10-30 (Reis Miranda et al. 1996). However, it is notable that TISS-76 scores only describe interventions delivered in ICU and disregard any previous interventions and treatments, such as those which may have occurred in the delivery room or operating theatre. Therefore TISS-76 scoring may underestimate the amount of treatment these patients require (Reis Miranda et al. 1996).

The last main finding of this study was that ICU-admitted obstetric patients' HRQoL was below that of the reference population at baseline but improved over time. However, one fifth of patients had below-reference values at follow-up (Article III, Article IV).

It is possible that the intensive care period had no impact on reduced HRQoL, and pregnancy itself may represent a physical or mental burden. In cases where HRQoL was lower than reference values, we do not have detailed data regarding what other factors might have influenced the poorer HRQoL, e.g. infant death (following seven days), infant severity of illness or changes in family situation. In addition, multiparous obstetric patients experienced impaired HRQoL in the follow-up; Stern et al. (2014) also reported that multiparous women score worse on the mental scale than nulliparous women. However, it is likewise possible that the intensive care period had no impact on reduced HRQoL in multiparous patients.

However, it is notable that some of the patients' still had a reduced quality of life after six months. This study discloses a question of need for mental support after an intensive care admission. This fact may not have adequately been taken into account in current practice.

Nurses in ICU rarely encounter obstetric patients, but when necessary they must be conversant with this population's characteristics as well as possessing the competence to respond to their nursing needs. Hypertensive disorders and obstetric haemorrhage are the main indicators for intensive care treatment, and nurses must be aware of the complications of these disorders, such as convulsions and massive obstetric haemorrhage. Other indications such as heart diseases and organ dysfunctions can indicate the need for obstetric intensive care, either during pregnancy or after childbirth.

Even when the newborn is doing well, if the mother requires treatment in ICU, family cohesion should be supported, for example by allowing visits to the newborn in ICU. When this patient group is compared with the non-obstetric population in ICU, their circumstances are always associated with changed family dynamics because of the child.

## 6.5 Recommendations for practice

Based on the findings of this study, the following recommendations for practice are made:

1. Results of the episode of care may be used to evaluate and develop the health care system both within an organization and between organizations.
2. In practice, it necessary to pay higher attention to the obstetric condition, special characteristics and needs of the mother during pregnancy and birth.
3. Infants can be critically ill, or the family may experience the loss of a child. Therefore care should be focused on the whole family and their psychological support, not just the mother in ICU.
4. After an obstetric ICU admission, some patients continued to experience an impaired HRQoL. In the future, efforts should be made to identify those mothers who have a decreased quality of life, and to ensure they are most intensively monitored after birth.
5. The results of this research could be implemented in healthcare education for nurses and midwives.

## 6.6 Recommendations for future research

Based on the findings of this study, the following recommendations for future research are made:

1. It would have been appropriate to compare HRQoL with other parturients (i.e. those who did not experience complicated pregnancy or delivery), but there was no data available. In further studies it would be meaningful to examine this population and compare it with the ICU-admitted obstetric population.
2. Further studies should consider multidimensional measurements to describe ICU-admitted obstetric patients' physical, cognitive and psychological components in the long term. Furthermore, the follow-up period should be longer.
3. Further studies should consider employing qualitative methods to research the experience of the mother and the family.
4. A register-based follow-up study should be considered to examine the future reproductive health and general health indicators of these mothers, and their comparison to the reference population.
5. Nordic countries have similar national reporting systems to collect data on parturients, deliveries and newborns. Future studies should consider research cooperation with other Nordic countries. The MBRs in Nordic countries enable research on healthcare and the evaluation of the quality of care and procedures in ICU-admitted obstetric patient.

## 7 Conclusions

Based on the findings of this study, the following conclusions can be drawn: advanced maternal age, nulliparity and multiple pregnancies are contributing factors for obstetric ICU admission. The majority of ICU-admitted mothers delivered by unscheduled caesarean section. The main indicators for admission are hypertensive complications and obstetric haemorrhage. Severity-of-illness and organ failure scores suggest a good probability of recovery and short LOS. Nonetheless, the reasons for admission and mode of delivery are associated increasingly with both the severity-of-illness scores and the level of intervention required.

Infants born to these mothers are more frequently born preterm and are more likely to need treatment in NICU or an observation unit. Mothers admitted for hypertensive complications and non-obstetric reasons more likely to deliver preterm. However, obstetric haemorrhage was associated with full-term birth. Of mothers who needed intensive care, 4.6% lost their infant before the age of one week.

ICU-admitted obstetric patients' HRQoL is below the reference population before ICU stay, but improves six months after discharge and was similar to reference values. Nonetheless, one fifth of patients have below-reference values at follow-up.

In conclusion: ICU-admitted obstetric patients have a good probability of recovery, and their HRQoL remains good after discharge. However, these patients' situation is often complicated by the fact that the newborn is seriously ill and needs treatment in NICU or an observation unit.



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## 10 Appendices



## Appendix 1. Characteristics of studies of ICU-admitted obstetric patients

Study	Country	Data collection, yrs	N	Design	Setting
Yuqi et al. (2017)	China	8	487	Descriptive	Second Clinical Hospital of Fujian Medical University of China (SC2)
Chantry et al. (2015)	France	4	11 824	Descriptive	All ICUs in France (MC1)
Vasquez et al. (2015)	Argentina	1	362	Prospective	20 ICUs in Argentina (8 public, 12 private) (MC1)
Bandeira et al. (2014)	Brazil	1	298	Prospective	1 tertiary referral ICU in Belo Brazil (SC2)
Ng et al. (2014)	Hong Kong	5	67	Retrospective	1 regional hospital in Hong Kong (SC2)
Paxton et al. (2014)	Australia	2.5	249	Retrospective	1 centre in Brisbane (SC2)
Rojas-Suarez et al. (2014)	Colombia	6	726	Retrospective	1 large teaching hospital in Cartagena (SC2)
Vasquez et al. (2014)	Argentina	3.5	151	Prospective	1 public-sector ICU (uninsured) vs 1 private-sector ICU (insured) in Argentina (MC1)
Wanderer et al. (2013)	USA	10	2927	Descriptive	All hospitals within the state of Maryland (MC1)
Donati et al. (2012)	Italy	2	1259	Retrospective	6 Italian regions (MC1)
Rios et al. (2012)	Argentina	2	242	Retrospective	4 medical-surgical ICUs in 4 Buenos Aires hospitals (MC1)
Aldawood (2011)	Saudi Arabia	10	75	Retrospective	King Abdulaziz Medical City (SC2)
Crozier & Wallace (2011)	Australia	2	60	Retrospective	1 centre in Melbourne (SC2)
Leung et al. (2010)	Hong Kong	10	50	Retrospective	1 regional hospital in Hong Kong (SC2)
Togal et al. (2010)	Turkey	3.5	73	Retrospective	Tertiary referral hospital in Malatya province (SC2)
Zwart et al. (2010)	Netherlands	2	847	Prospective	10 tertiary care centres, 33 non-academic teaching hospitals and 55 general hospitals (MS1)
Madan et al. (2009)	USA	9	15 447	Case-control	All infants born in New Jersey (MC1)
Cartin-Ceba et al. (2008)	USA	11	153	Retrospective	4 ICUs at Mayo Clinic in Rochester (MC1)

<sup>1</sup> MC: multicentre study

<sup>2</sup> SC: single-centre study

## Appendix 2. The selected studies of HRQoL during pregnancy and after obstetric complications

Study	Country	Participants and data collection	Instrument(s)	Main results
Moura et al. (2017)	Brazil	Mothers of premature infants born with gestational age $\leq$ 34 weeks and birthweight $\leq$ 1500 g N=133 5 time-points (maternal discharge, 6, 12, 24 and 36 months after delivery)	WHOQOL-BREF	Mothers of VLBW infants exhibited transient improvements in physical well-being during the first year after delivery. The presence of depressive symptoms in mothers and diagnosis of post-haemorrhagic hydrocephalus or bronchopulmonary dysplasia were negatively associated with QOL.
Prick et al. (2015)	Netherlands	Women after obstetric complications N=1392 6 weeks post-partum	SF-36	IUGR and hypertensive disorders led to lower HRQoL scores than post-partum haemorrhage. Delivery by caesarean section had a negative impact on physical HRQoL.
Stern et al. (2014)	Austria	Women suffering from preeclampsia N=95 About 6 weeks after delivery	SF-12	Women who had suffered from severe pre-eclampsia were substantially reduced in their mental QOL. Multiparous women scored worse on the mental scale than primiparous women, and pregnant women scored worse than non-pregnant women on the physical level.
Lau (2013)	Macao	Mothers of premature and LBW infants N=581 Second trimester	SF-12 Perceived Stress Scale	Participants with past adverse obstetric complications and higher perceived stress levels were more likely to have premature infants. Participants with higher perceived stress levels and poorer HRQoL in the physical health domain were more likely to have LBW infants.
Lee & Hsu (2012)	USA	Mothers with an LBW and preterm infant in NICU at early post-partum N=55 Second week of post-partum	SF-36 version 2 Perceived Stress Scale Impact of Events Scale Lee's Fatigue Scale Edinburgh Postnatal Depression Scale	The majority of the study participants were stressed, depressed, fatigued and at risk for poor physical and mental health. Poor sleep quality as perceived by mothers was significantly associated with stress, fatigue and poor mental and physical HRQoL.
Witt et al. (2012)	USA	Mothers with VLBW and NBW infants N=297 VLBW infants N=290 NBW infants Children approximately 4–5 years of age	SF-12 version 2	Mothers of VLBW infants experienced worse physical and mental HRQoL than mothers of NBW infants. Among mothers of VLBW infants, stress significantly contributed to adverse HRQoL outcomes when children were aged 5. Child behaviour problems at the age of 2 were also associated with worse subsequent maternal mental HRQoL
Bijlenga et al (2011a)	Netherlands	Women with complicated with gestation hypertension or mild pre-eclampsia N=491 randomized N=220 non-randomized Baseline, 6 weeks post-partum and 6 months post-partum	SF-36 EuroQol. 6D3D Hospital Anxiety and Depression Scale Symptom Checklist SOL-90	Comparison of induction of labour with expectant monitoring in women with gestation hypertension or pre-eclampsia after 36 weeks. This study did not find treatment effects on long-term HRQoL. The physical component score improved over time and was better in non-randomized patients.

Biljenga et al. (2011b)	Netherlands	Women with singleton pregnancy, 36+0–41+0 gestational age with suspected IUGR N=361 randomized N=198 non-randomized At baseline before and after inclusion/randomization, 6 weeks post-partum and 6 months post-partum	Short-Form-36 (SF-36) EuroQol. 6D3D Hospital Anxiety and Depression Scale Symptom Checklist SCL-90	The physical and mental components were below norm values at inclusion. The physical component improved over time, but stayed below norm values at 6 months, while the mental component did not improve. In pregnancies complicated by intrauterine growth retardation beyond 36 weeks, induction of labour did not affect long-term maternal QoL.
Hoedjes et al. (2011)	Netherlands	Woman who had pre-eclampsia, IUGR and/or gestational diabetes N=174 6 and 12 weeks post-partum	SF-36	Women who experienced severe pre-eclampsia had a lower post-partum HRQoL than those who had mild pre-eclampsia. QoL improved on almost all SF-36 scales from 6 to 12 weeks post-partum. NICU admission and perinatal death were contributing factors for poorer mental QoL.
Leung et al. (2010)	Hong Kong	Obstetric patients admitted to ICU N=50 Mean time following discharge from ICU: 2 years 7 months	SF-36	All 8 domains were lower than the norms of Hong Kong females aged 18–40 years. In domains of physical functioning, bodily pain and social functioning, the scores were significantly lower than population norms. The greatest difference was in bodily pain (64 vs 85).
Mautner et al. (2009)	Austria	Groups: Hypertensive disorders (N=18) Gestational diabetes (N=11) Preterm delivery (N=32) Controls (N=29) 24th–37th week of gestation, 2–5 days post-partum, 3–4 months post-partum	WHOOOL-BREF Edinburgh Postnatal Depression Scale	Women in the preterm group had higher depression scores and lower HRQoL scores on physical domains during pregnancy than those without complications. Women with hypertensive disorders showed the second most depressive symptoms. Physical and global HRQoL improved and depressive symptoms decreased from late pregnancy and early post-partum period to late post-partum. Pregnancy-specific problems, especially risk of preterm delivery, was associated with more depressive symptoms and decreased HRQoL in pregnancy.
Donohue et al. (2008)	USA	Primary caregivers of VLBW survivors N=83 VLBW N=84 NBW Infants 12–18 months old	QOLI Family Resource Scale	Caregivers' QoL did not differ between the two groups. Both groups of infants reported substantial mental and physical health problems, but perceived good QoL. However, VLBW infants had poorer health and required more healthcare resources.



## 11 Original Publications I–IV





# PUBLICATION

I

## **Maternal and neonatal characteristics in obstetric intensive care unit admissions**

Seppänen P, Sund R, Uotila J, Helminen M, Suominen T

**Submitted**



# PUBLICATION

## II

### **Obstetric admissions to ICUs in Finland: a multicentre study**

Seppänen P, Sund R, Roos M, Unkila R, Meriläinen M, Helminen M,  
Ala-Kokko T, Suominen T.

*Intensive and Critical Care Nursing* 2016; 35: 38–44

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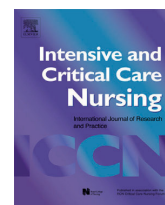




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ORIGINAL ARTICLE

# Obstetric admissions to ICUs in Finland: A multicentre study



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## KEYWORDS

Adverse event;  
Interventions;  
Obstetric patient;  
Outcome;  
Severity of illness

**Summary** In this study, the objective was to describe and analyse reasons for obstetric admissions to the ICU, severity of illness, level and types of interventions, adverse events and patient outcomes. In a retrospective database study, we identified 291 obstetric patients during pregnancy and puerperium from four Finnish university hospitals. Most were admitted in the post-partum period and hypertensive disorders were the main indications for admissions, followed by obstetric haemorrhage. The median length of stay was 21 hours. The most common intervention was blood transfusion and mechanical ventilation was required in nearly one fifth of the patients. Three patients had a prolonged stay and nine had re-admissions. One maternal death was recorded. This study found that severity of illness and organ failure scores describe the obstetric patient as having a good probability of recovery and a short length of stay. However, the obstetric patients reason for admission and their type of delivery were associated with both the severity of illness scores and level of intervention required. Those admitted for non-obstetric reasons and having had a vaginal delivery demonstrated higher severity of illness scores, organ failure scores, and levels of intervention when compared to those admitted for obstetric reasons or those who had delivered by caesarean section. In conclusion, care of these patients can be improved by understanding the severity of illness scores, common ICU interventions and patient outcomes.

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### Implications for Clinical Practice

- With the low number of obstetric patients admitted to ICU, a register-based study provides a large study population and long observation period.
- Care of obstetric patients can be improved by understanding the severity of illness scores, common ICU interventions and patient outcomes.

## Introduction

In developed countries, maternal mortality is low ([World Health Organisation, 2014](#)) but sometimes complications associated with pregnancy and childbirth require intensive care. Previous studies have shown that the most frequent reasons for intensive care unit (ICU) admission during pregnancy or post-partum are: hypertensive disorders, obstetric haemorrhage ([Crozier and Wallace, 2011](#); [Pollock et al., 2010](#); [Wanderer et al., 2013](#)), non-obstetric sepsis ([Zwart et al., 2010](#)), respiratory failure ([Selo-Ojeme et al., 2005](#)) and cardiac problems ([Mirghani et al., 2004](#)). Although obstetric admissions to ICU are infrequent ([Pollock et al., 2010](#)), care of these patients can be improved by understanding the severity of illness scores, common ICU interventions and patient outcomes.

Register-based studies are an appropriate method to search unreported phenomena from all admissions and collect data from retrospectively. Routinely recorded databases (as a source of secondary data) can provide a large study population of obstetric patients and a long retrospective observational period ([Motheral et al., 2003](#)). In addition considering the low frequency of obstetric intensive care admissions register-based studies are a justifiable method, because small samples might yield random outcomes ([Räisänen et al., 2013](#); [Sund et al., 2013](#)).

In this study, the objective was to retrospectively describe and analyse reasons for obstetric admissions to the ICU, severity of illness, level and types of interventions, adverse events and patient outcomes.

## Methods

### Study design

The study used a retrospective audit design. Data were retrospectively collected from the clinical information systems of four university hospitals in Finland between 2007 and 2011.

Data from all obstetric patients aged 18–50 admitted to intensive care during pregnancy and post-partum (up to 42 days) were included in the study.

### Data collection

Patients were identified using the APACHE III diagnosis-group, which is compulsory information for all ICU admitted patients in Finland. All women aged 18–50 in the APACHE III diagnosis category “other gynaecological disease” were

considered. The total number of patients identified in the four hospitals was 328, of which 291 were accepted for final inclusion in the study ([Fig. 1](#)).

For data collection, three clinical information systems (CIS) were used: Intensium (Finnish Intensive Care Quality Consortium), Clinisoft and Miranda. All ICUs participating in this study use these clinical information systems to record patient data. Each unit identified contact people who collected defined variables from the clinical information systems, using a research strategy provided by the researchers. Data obtained from these information systems was based on the patient’s social security number. Five variables required manual searches by the contact people in each unit, and included parity, ante or post-partum treatment, gestational age, type of delivery and the need for embolisation. One nominated contact person integrated all of the data and recorded it into the study register.

Obstetric patient data collected over the five-year period included: (1) maternal demographics from the Miranda information system, (2) intensive care severity of illness scores, Therapeutic Intervention Scoring System 76 (TISS-76) scores and intensive care complications from Intensium information system and (3) the type of ICU interventions required, length of stay (LOS), prolonged stay (defined as  $\geq 144$  hours) and patient outcome obtained from the Clinisoft information system (see [Fig. 1](#)).

### Data analysis

The reasons leading to intensive care treatment were re-categorised as obstetric and non-obstetric by using ICD-10 diagnosis codes. Obstetric reasons included: hypertensive disorder, obstetric haemorrhage and pregnancy or delivery related complications. Hypertensive complications included pre-eclampsia, eclampsia and hypertension. Obstetric haemorrhage included ante, intra or postpartum haemorrhage. Pregnancy or delivery related complications included diagnoses associated with uterine function such as rupture, uterine atony, placental abruption or placenta praevia and types of delivery related complications. Non-obstetric reasons were categorised as heart diseases, respiratory failure, infection, liver or kidney dysfunction and miscellaneous. Types of delivery were categorised as vaginal delivery, planned section, planned immediate section and emergency section. In the Clinisoft information system, complications in intensive care treatment were categorised as listed above.

The retrieved data was inserted into a Microsoft Excel spreadsheet and exported to SPSS 20.0 software for descriptive and statistical analysis. Categorical data were analysed using frequency counts and percentages and continuous

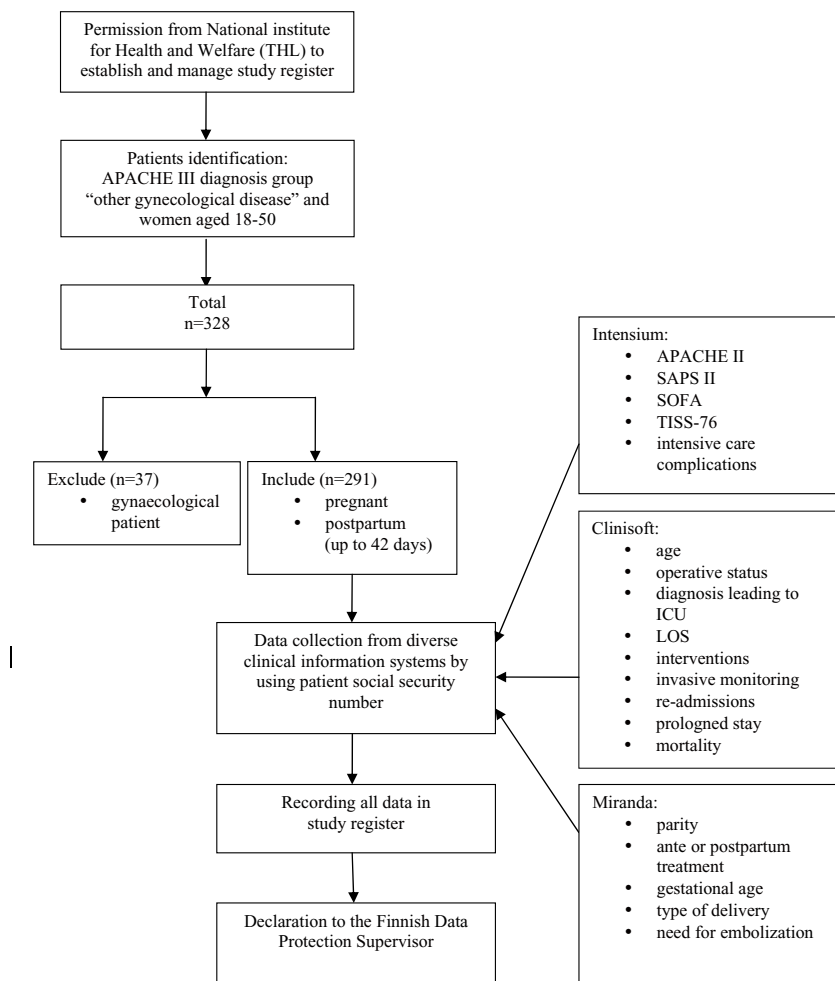


Figure 1 Process of register-based data collection, used clinical information systems and defined variables.

data as median and interquartile ranges (Q1–Q3). Statistical analysis were performed using the Mann–Whitney  $U$  test ( $U$ ), Kruskal–Wallis test ( $\chi^2$ ) and Fisher Exact test (FET). Difference was considered to be statistically significant at  $p \leq 0.05$ .

### Ethical considerations

The study was approved by the Tampere university hospital ethics committee (R12050H) and approval was obtained from all four university hospitals where the data were collected. Permission to maintain the study register was granted by the National Institute for Health and Welfare (THL) in June 2012 and a declaration from the Finnish Data Protection Supervisor was received in August 2012. As the collected audit data and patient data were anonymised, no informed consent was required.

## Results

### Maternal demographics

During the 5-year study period a total of 328 patients were identified from the clinical information systems. The study analysed the data of 291 pregnant or postpartum patients. Of this group 264 (90.7%) were admitted for obstetric reasons and 27 (9.3%) were admitted for non-obstetric reasons. The most common obstetric reasons leading to ICU admission were hypertensive disorders ( $n = 166$ , 57%), followed by obstetric haemorrhage ( $n = 74$ , 25.4%). Twenty-four patients (8.2%) had either pregnancy or delivery related complications. Non-obstetric reasons leading to ICU admission were heart diseases ( $n = 4$ , 1.4%); respiratory failure ( $n = 4$ , 1.4%); infection ( $n = 3$ , 1%); liver ( $n = 3$ , 1%) or kidney ( $n = 2$ , 0.7%) dysfunction; and miscellaneous ( $n = 11$ , 3.8%). The maternal demographics are displayed in Table 1.

**Table 1** Maternal demographics.

Variables	Obstetric (n=264)	(%)	Non-obstetric (n=27)	(%)
Age (years)				
<20	4	1.5	1	3.7
20–34	188	71.2	19	70.4
35–39	60	22.7	6	22.2
≥40	12	4.5	1	3.7
Parity				
Primiparous	167	63.3	12	44.4
Multiparous	87	33.0	14	55.6
Missing	10	3.8	–	–
ICU stay				
Postpartum	254	96.2	26	96.3
Antepartum	3	1.1	1	3.7
Missing	7	2.7	–	–
Gestational age				
Weeks ≥ 22	248	93.9	26	96.3
Weeks < 22	–	–	1	3.7
Missing	16	6.1	–	–
Operative status				
Operated	232	87.9	20	74.1
Non-operated	32	12.1	7	25.9
Type of delivery				
Vaginal delivery	48	18.2	3	11.1
Planned section	28	10.6	3	11.1
Planned immediate section	151	57.2	15	55.6
Emergency section	27	10.2	5	18.5
Missing	10	3.8	1	3.7
Need for embolisation	38	14.4	3	11.1

### Severity of illness, level of interventions and length of stay

The median severity of illness scores for APACHE II were 9.0 (interquartile range 7.0–12.0), for SAPS II 14.0 (10.0–20.3) and for SOFA 2.0 (1.0–4.0). The intensity of treatment scores TISS-76 were on a daily median of 21.5 (18.0–25.5). The APACHE II- ( $U=2218$ ,  $p=0.003$ ), SAPS II- ( $U=2719$ ,  $p=0.044$ ) and SOFA- ( $U=1521.5$ ,  $p=0.013$ ) scores were higher in patients admitted to the ICU for non-obstetric reasons when compared to obstetric reasons. In addition, the daily TISS-76 scores were seen as higher in patients who were admitted for non-obstetric reasons ( $U=2046$ ,  $p<0.001$ ). The SAPS II ( $\chi^2=17.306$ ,  $p<0.001$ ), SOFA ( $\chi^2=8.485$ ,  $p=0.037$ ) and TISS-76 ( $\chi^2=8.331$ ,  $p=0.040$ ) scores were highest in patients who gave birth vaginally when compared to planned section, planned immediate section or emergency section. On median, patients were treated for 21.0 (16.0–27.0) hours in ICU and 92.8% ( $n=273$ ) of patients had a LOS shorter than 48 hours (range 3–281 hours) (Table 2).

### Types of interventions

The most common intervention during ICU stay was blood transfusion ( $n=77$ , 26.5%), which was more common in patients who gave birth vaginally when compared to planned section, planned immediate section or emergency section (FET=12.476,  $p=0.003$ ). Assisted ventilation was needed

in 22.7% ( $n=66$ ) of cases and included mechanical ventilation 18.2% ( $n=53$ ) and non-invasive ventilation, such as continuous positive airway pressure (CPAP) or bi-level positive airway pressure (BiPap) ( $n=13$ ). The requirement for mechanical ventilation was significantly increased in post-operative patients when compared to non-operative patients (FET 7.404,  $p=0.003$ ) and in those who had delivered by emergency section (FET 25.524,  $p<0.001$ ).

Haemodialysis was needed by two patients and was a more common intervention in patients who were admitted to the intensive care unit (ICU) for non-obstetric reasons (FET=19.691,  $p=0.008$ ). The majority of women received invasive arterial pressure monitoring ( $n=285$ , 97.9%). A central line was inserted in 28.5% ( $n=83$ ) of patients and a pulmonary artery catheter in 3.4% ( $n=10$ ). Central line (FET=21.240,  $p<0.001$ ) and pulmonary artery catheter (FET 31.651,  $p<0.001$ ) insertion were significantly increased for patients who were admitted to the ICU for non-obstetric reasons (Table 3).

### Adverse events

During the study period there were three (1%) patients who had a prolonged stay in ICU (159 hours, 194 hours and 281 hours). Intensive complications arose in five cases (1.7%) and included septic shock ( $n=2$ , 0.7%) and disseminated intravascular coagulation (DIC) ( $n=3$ , 1.0%).



**Table 2** Severity of illness, intervention scores and length of stay.

	APACHE II ( <i>n</i> = 288) Median (Q <sub>1</sub> –Q <sub>3</sub> )	SAPS II ( <i>n</i> = 290) Median (Q <sub>1</sub> –Q <sub>3</sub> )	SOFA ( <i>n</i> = 247) Median (Q <sub>1</sub> –Q <sub>3</sub> )	TISS-76 ( <i>n</i> = 291) Median (Q <sub>1</sub> –Q <sub>3</sub> )	LOS (h) ( <i>n</i> = 291) Median (Q <sub>1</sub> –Q <sub>3</sub> )
Reason for admission					
Obstetric	9.0 (7.0–11.0)	14.0 (10.0–19.0)	2.0 (1.0–4.0)	21.0 (18.0–25.0)	21.0 (16.0–26.0)
Non-obstetric	12.5 (7.8–17.0)	18.0 (11.0–29.0)	4.0 (2.0–6.8)	26.0 (22.0–33.0)	24.0 (17.0–41.0)
<i>p</i> -Value	0.003 <sup>a</sup>	0.044 <sup>a</sup>	0.013 <sup>a</sup>	<0.001 <sup>a</sup>	0.157
Type of delivery					
Vaginal	9.0 (7.0–11.5)	19.0 (11.0–24.3)	3.5 (2.0–5.3)	24.0 (18.0–26.0)	19.0 (13.0–25.0)
Section					
Planned	7.0 (6.0–11.0)	11.0 (10.0–15.0)	3.0 (2.0–5.0)	20.3 (18.5–26.0)	24.0 (17.0–37.0)
Immediate	9.5 (7.0–12.0)	13.0 (10.0–19.0)	2.0 (1.0–4.0)	21.0 (18.0–24.5)	21.0 (15.0–27.0)
Emergency	9.0 (7.0–14.0)	18.5 (11.3–23.3)	2.0 (1.0–3.3)	23.5 (19.2–29.9)	21.5 (18.5–33.5)
<i>p</i> -Value	0.240	0.001 <sup>b</sup>	0.037 <sup>b</sup>	0.040 <sup>b</sup>	0.056

<sup>a</sup> Mann–Whitney *U* test, significance level *p* < 0.05.

<sup>b</sup> Kruskal–Wallis test, significance level *p* < 0.05.

**Table 3** Common interventions to ICU obstetric patients.

Variables	All ( <i>n</i> = 291) %	Obstetric reason ( <i>n</i> = 264) %	Non-obstetric reason ( <i>n</i> = 27) %	<i>p</i> -Value <sup>a</sup>
Interventions				
Blood transfusion	26.5	26.1	29.6	0.654
Mechanical ventilation	18.2	18.9	11.1	0.435
CPAP/BiPap	4.5	4.5	3.7	1.000
Hemodialysis	0.7	0.0	7.4	0.008
Invasive monitoring				
Arterial pressure	97.9	100	97.7	1.000
Central line	28.5	24.6	66.7	<0.001
Pulmonary artery catheter	3.4	1.5	22.2	<0.001

<sup>a</sup> Fisher exact test, significance level *p* < 0.05.

## Patient outcome

Almost all (*n* = 287, 98.6%) of the patients recovered and were transferred to a medical department. Three (1%) patients were transferred to another ICU facility. During the study period, only one (0.3%) maternal death was recorded. The patient was a primipara and had delivered by caesarean section. The patient had high severity of illness scores; the APACHE, SAPS II and SOFA were 34, 84 and 18 respectively. The TISS-76 score was 45.

## Discussion

In this study, it was found that all obstetric patients had low APACHE II, SAPS II and SOFA scoring during their ICU stay, which indicated a good probability of recovery.

Previous studies also reported low APACHE II (Cheng and Raman, 2003; Cohen et al., 2000) and SAPS II (Gilbert et al., 2003) scores and this indicates that obstetric patients generally have a good outcome. However we found that those patients who were admitted for non-obstetric reasons had higher severity of illness and organ failure scores when compared to those admitted for obstetric reasons. This may

be related to these patients having chronic diseases that worsened during pregnancy or delivery, and which in-turn affected their severity of illness. The non-obstetric reasons for admission found in the study included heart diseases, liver and kidney dysfunctions, multiple organ failure (MOF), respiratory failure and stroke, all of which contributed to the patients being admitted to ICU.

Our study found that the type of delivery affected the severity of illness. Those patients who had a vaginal delivery demonstrated higher severity of illness scores, organ failure scores and levels of intervention when compared to those who had delivered by caesarean section. However severity of illness scores such as APACHE II and SAPS II have been developed in the non-pregnant population and therefore these scoring systems tend to overestimate mortality in the obstetric population (Gilbert et al., 2003; Hazelgrove et al., 2001; Vasquez et al., 2007). Therefore it is necessary to also use other measurements to estimate the findings of intensive care treatment, for example quality of life.

In this study, the median daily TISS-76 scores were 21.5, which is also representative of the average points of all ICU patients in an earlier Scandinavian study (Reinikainen et al., 2005). Our findings also reflect the findings of previous studies indicating obstetric patients require an intensive level

of treatment (Vasquez et al., 2007; Cohen et al., 2000). In addition we found that the reasons leading to the ICU stay and the type of delivery were associated with the level of intervention. Those patients who were admitted for non-obstetric reasons and had a vaginal delivery, had higher TISS-76 scores compared to those admitted for obstetric reasons or who had delivered by caesarean section. As TISS-76 scores describe interventions only delivered in the ICU and disregard any previous interventions that may have occurred in the delivery room or operating theatre (Miranda et al., 1996), the TISS-76 scoring may have underestimated the number of interventions that these patients received.

The average obstetric patient length of stay in ICU was 21 hours and over 90% had an admission shorter than two days, which contrast to the findings of previous studies (Zeeman, 2006). Although some studies reported parallel results (Crozier and Wallace, 2011; Zeeman et al., 2003), most reported a longer LOS (Heinonen et al., 2002; Keizer et al., 2006; Murphy and Charlett, 2002). Our findings may be related to changes in anaesthetic, ICU and ward practices that have resulted in shorter lengths of stay in more recent years.

Our findings demonstrate that over the last decade there have been no significant changes in the need for obstetric intensive care. Obstetric haemorrhage and hypertensive disorders are still the most common reasons for admissions and the severity of illness scores indicate a good probability of recovery. Our findings are parallel to previous study findings, and we considered that the need for intensive care treatment and monitoring was intensive and the level of interventions was the same as is seen in other intensive care patients. The TISS-76 scores support this finding in our study.

### Study limitations

It is acknowledged that this study is limited by the patient identification method, used in regard to seeking obstetric patient information from the clinical information system. Although the APACHE III diagnosis group is a compulsory element of recorded information, obstetric patients could not be located if they were recorded under a diagnosis code other than "other gynaecological disease". With this in mind, it is possible that obstetric patient information relating to the pregnancy and postpartum phases was missed in the research material. This might have influenced the minor number of antepartum ICU admissions that were found in this study. It should also be considered that register-based studies may include the possibility of incorrectly recorded information and missing data within the original sources. Therefore future studies are required to further validate these findings and to determine how much of the targeted research population was unable to be examined using a set search strategy.

### Conclusion

This study found that severity of illness and organ failure scores describe the obstetric patient as having a good probability of recovery and a short length of stay. However, the obstetric patient's reason for admission and their type of delivery were associated with both the severity of illness

scores and level of intervention required. Those admitted for non-obstetric reasons and having had a vaginal delivery demonstrated higher severity of illness scores, organ failure scores and levels of intervention when compared to those admitted for obstetric reasons or those who had delivered by caesarean section. Further studies are required to analyse the need for other medical and nursing services which are required during pregnancy and childbirth as this would provide further information about prospective risk factors that might increase possibility for intensive care admissions.

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### Conflict of Interest

The authors have no conflict of interest to declare.

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# PUBLICATION III

**Obstetric patients' health-related quality of life before and after intensive care.**

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Research paper

## Obstetric patients' health-related quality of life before and after intensive care



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## ABSTRACT

**Background:** Intensive care admissions during pregnancy, childbirth, and postpartum period are relatively well investigated. However, very little is known about these obstetric patients' health-related quality of life (HRQoL) before and after critical care.

**Objective:** The objective of this study was to assess obstetric patients' HRQoL before intensive care admission (baseline) and at 6 months after discharge (follow-up)

**Design:** This was a retrospective database study. In a 5-year period, the data of all women admitted to the intensive care unit (ICU) during pregnancy, delivery, or up to 42 days postpartum were analysed.

**Methods:** Four multidisciplinary ICUs of Finnish University hospitals participated. The HRQoL was assessed using the EuroQol-5D (EQ-5D) instrument with utility score (EQsum) and visual analogue scale (EQ-VAS).

**Results:** A total of 283 obstetric patients were identified from the clinical information system. Of these, 99 (35%) completed the EQ-5D questionnaires both at baseline and follow-up, and 65 of them (23%) completed EQ-VAS. The comparison of patients' EQsum scores before intensive care admission and after discharge showed that patients' HRQoL remained good (0.970 vs 0.972) (max 1.0) or increased (0.788 vs 0.982) in 80.8% of the patients. Patients reported improved overall health on the EQ-VAS at 6 months follow-up (EQ-VAS mean, 71.86 vs 88.20;  $p \leq 0.001$ ) (max 100). However, 19.2% of the patients had lower HRQoL (EQsum mean 0.987 vs 0.798) at follow-up. Following intensive care, 15% of the patients had more pain/discomfort, and 11% expressed more depression/anxiety. Multiparous patients were more likely to suffer from worsened depression/anxiety ( $p = 0.024$ ).

**Conclusion:** In the majority of the obstetric patients, HRQoL at 6 months follow-up remained good or had increased from baseline. However, nearly one-fifth of the patients had impaired HRQoL after discharge. Thus, intensive care management should take in to consideration follow-up program after intensive care of ICU-admitted obstetric patients.

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## 1. Introduction

Intensive care admissions during pregnancy, childbirth, and postpartum period are relatively well investigated, and studies have been conducted in developing as well as in developed countries.<sup>1</sup> The main reasons for the admissions include obstetric haemorrhage and hypertensive complications, regardless of the countries where studies have been conducted.<sup>2–5</sup> However, a considerable difference between countries can be found regarding mortality; in high resource countries, intensive care unit (ICU) mortality is very low.<sup>6,7</sup> In comparison, the number of non-survivors in developing countries is notably high.<sup>8,9</sup> Despite previous studies of ICU-admitted obstetric patients, very little is known about their health-related quality of life (HRQoL) before and after critical care.

To determine the HRQoL of an ICU-admitted obstetric population, a retrospective database study in four multidisciplinary ICUs in Finland was performed. The objective of the present study was to assess obstetric patients' HRQoL before intensive care admission (baseline) and at 6 months after discharge from ICU (follow-up). This study provides information that could be useful for development of maternity care, childbirth, and obstetric intensive care.

## 2. Methods

### 2.1. Study design and settings

A retrospective database study in four multidisciplinary ICUs of Finnish university hospitals was carried out. Permission to maintain a study register and approval for data collection were granted by the National Institute for Health and Welfare and participating university hospitals. Data were derived from hospital databases (Clinisoft, Intensium) and the Medical Birth Register (BR) database. The protocol of this study was approved by our hospital Ethics Committee (R12050H). As only anonymised data were used, no informed consent was required.

During a 5-year period from January 2007 to December 2011, the data of all obstetric patients admitted to the ICU in any trimester of pregnancy, during delivery, or up to 42 days postpartum were analysed. Obstetric intensive care admissions were searched retrospectively from the clinical information system (Clinisoft) using the Acute Physiology and Chronic Health Evaluation (APACHE) III classification, which is compulsory recorded data for all ICU-admitted patients. The classification system consists of two options: an APACHE III score, which can provide initial risk stratification for severely ill patients and predictive equation, which uses APACHE III scores and reference data on disease categories to provide risk estimates for hospital mortality for ICU-admitted patients.<sup>10</sup> In this study, patient selection was based on the disease category "other gynaecological disease," which included diagnoses related to pregnancy, delivery, and postpartum period. Disease category was used only for patient selection. The data of all women aged 18–50 years were considered. The data relating to the same person in different registers were identified by the person's social security number and could be combined for research purposes. Gynaecological patients (non-pregnant), those with missing BR data, and those who died were excluded. The actual study population consisted of those patients who completed the EuroQol-5D (EQ-5D) questionnaires both at baseline and follow-up.

Data concerning maternal and neonate characteristics were collected. These included age, causes of admission (i.e., hypertensive complications, obstetric haemorrhage, other obstetric causes, and non-obstetric causes), APACHE II (a version preceding APACHE III, applied during the initial data collection), Simplified Acute Physiology Score II, Sequential Organ Failure Assessment,

Therapeutic Intervention Scoring System 76 data, and ICU length of stay (LOS), which were retrieved from the hospital database. Additionally, previous deliveries, number of fetuses, type of delivery (i.e., vaginal, vacuum extraction, planned section, urgent section, and emergency section), hospital LOS, gestational age, birth weight, situation of the child at the age of 1 week (i.e., home, postnatal ward, neonate ward, or other hospital), and perinatal mortality were retrieved from the BR database.

### 2.2. Health-related quality of life measurement

Obstetric patients' HRQoL was assessed using the short EQ-5D instrument. It is a non-disease-specific instrument developed by EuroQol Group. There is a literature to support the validity and reliability of the EQ-5D instrument and its adequacy to use in HRQoL measures.<sup>11</sup> In addition, the EQ-5D is an appropriate instrument for measuring quality of life in critically ill patients and is extensively used in intensive care research.<sup>12,13</sup> EQ-5D is available in many languages in a standardised format and has population reference data for a specific country or international region.<sup>14</sup> The EQ-5D is a licensed product by the EuroQol Group.<sup>15</sup>

The EQ-5D instrument consists of two parts; a descriptive system and the visual analogue scale (EQ-VAS). The descriptive system comprises five domains: (i) mobility; (ii) self-care; (iii) usual activities; (iv) pain/discomfort; and (v) anxiety/depression. Each of these five domains has three levels: no problems, moderate problems, and severe problems. A person completing the EQ-5D indicates the level that best describes his or her experience of problems in each domain. Together the individual domains constitute a utility score, which facilitates classification of patients into various health states. Answers to questions in all five domains can be converted into one single summary index (EQsum), with a score of 1.00 indicating full health and 0 standing for death. The EQ-VAS records respondent's self-rated health state on a scale of 0–100; 100 represents "best imaginable state" and 0 "worst imaginable health state".<sup>16</sup>

With the EQ-5D instrument, the data were collected continuously of critically ill patients in all the ICUs that participated in this study on behalf of the organisations. The data were initially collected for administrative purposes, and researchers have received permission to use the data. The HRQoL before ICU admission (baseline) was estimated retrospectively, and the evaluations were performed during the ICU stay. Respondents were asked to estimate their health status at the time that preceded intensive care admission by choosing the most suitable option from the three-level EQ-5D domains and to indicate their present health state by the EQ-VAS. The interviews were conducted by intensive care nurses or physicians. The follow-up period was 6 months after discharge from the ICU. The data pertaining to this period were collected by a telephone interview or by mailing questions to the respondents to fill and return to a nominated person in each ICU that participated in the study. The EQ-VAS was included in both baseline and follow-up questionnaires. All EQ-5D questionnaires (baseline and follow-up) were recorded in the Clinisoft by the interviewer or by the nominated person. Obstetric patients' utility scores (EQsums) were calculated by one of the authors.

### 2.3. Statistical analysis

All identified patients were divided into four subgroups on the basis of the EQ-5D questionnaires they had responded to: (1) baseline and follow-up (2) only baseline (3) only follow-up, and (4) missing. Maternal and neonate demographics were compared between the subgroups to identify any statistically significant differences between these groups. Maternal and neonatal basic

characteristics were compared using the Kruskal–Wallis test, the Fisher exact test and the Mann–Whitney U test. The maternal characteristics data comprised a total of 283 obstetric patients and the neonatal data a total of 305 newborns. The results are expressed as percentages or median with interquartile range (IQR). For the actual study population that responded to the baseline and follow-up questionnaires, the EQ-5D domains were analysed separately using the McNemar test. During the follow-up period patients demonstrated some direction of change in each EQ-5D domain, labelled as worsened, same, or improved. The EQsum and EQ-VAS scores were compared between baseline and follow-up using the Wilcoxon test. Statistical significance was defined as *P* value of less than 0.05; however, in demographic data comparisons between patient groups, Bonferroni-adjusted *P* value of 0.0083 was used. Changes in the EQsum and EQ-VAS between baseline and follow-up were reported as worsened, same, or improved. In this study, a minimum difference of 0.074 in the EQsum and 7 points in the EQ-VAS was considered clinically important,<sup>17,18</sup> in keeping with the mean minimum difference value found in a review of the tool used in a variety of patient population.<sup>19</sup> All statistical analyses were performed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA).

### 3. Results

#### 3.1. Obstetric patients and neonates demographic

In total, 328 patients were identified from clinical information systems over a 5-year period (2007–2011). Of these patients, 45 were excluded (37 gynaecological patients, seven patients with missing BR information, and one maternal death that occurred in ICU); thus, 283 patients were eligible for analysis and comprised the actual study population (Fig. 1). The EQ-VAS was completed by 65 (23%) of those patients who responded at baseline and during follow-up. The leading cause of ICU admission among the 99 study

patients was hypertensive complications (62.6%), followed by obstetric haemorrhage (20.2%). The majority of the deliveries were caesarean sections (CSs); 62.6% were urgent CSs, 12.1% were planned CSs, and 4% were emergency CSs. Preterm birth (<37 weeks of gestational age) was recorded in 57.4% of the deliveries. Low birth weight (LBW) (<2500 g) was recorded in 52.8% of the neonates, and 44.4% of the neonates needed treatment in neonate ward or other hospital at the age of 1 week. Perinatal mortality was 3.7%. *P* values ranged from 0.010 for “Child at the age of one week” between subgroup “Home care,” “Postnatal ward,” Neonate ward,” and “Other hospital” to 0.997 for the Therapeutic Intervention Scoring System 76. However, the differences in maternal or neonate demographics between the four subgroups, i.e., baseline and follow-up, only baseline, only follow-up, and missing, have no significant differences while Bonferroni-adjusted *P* value of 0.0083 was used (Table 1).

#### 3.2. Health-related quality of life

There were no statistically significant differences in the domains of pain/discomfort, depression/anxiety, or self-care and usual activities before and after admission to intensive care (Table 2). Only mobility showed a statistically significant improvement (McNemar's test; *p* = 0.021). However, during the follow-up, 15 patients (15.5%) had worsened pain/discomfort and 11 patients (11.1%) had worsened depression/anxiety compared to baseline (Table 3). Patients with worsened depression/anxiety at 6 months follow-up had a higher rate of emergency CSs than other types of delivery (9.5% [*n* = 1] vaginal deliveries, 8.3% planned CSs [*n* = 1], 8.1% [*n* = 1] urgent CSs, 75% [*n* = 8] emergency CSs). Multiparous patients were more likely to suffer from worsened depression/anxiety (Fisher's exact test; *p* = 0.024). Patients reported improved overall health on the EQ-VAS at 6 months follow-up (Wilcoxon test; *p* ≤ 0.001). Table 4 presents the EQsum and EQ-VAS scores at baseline and

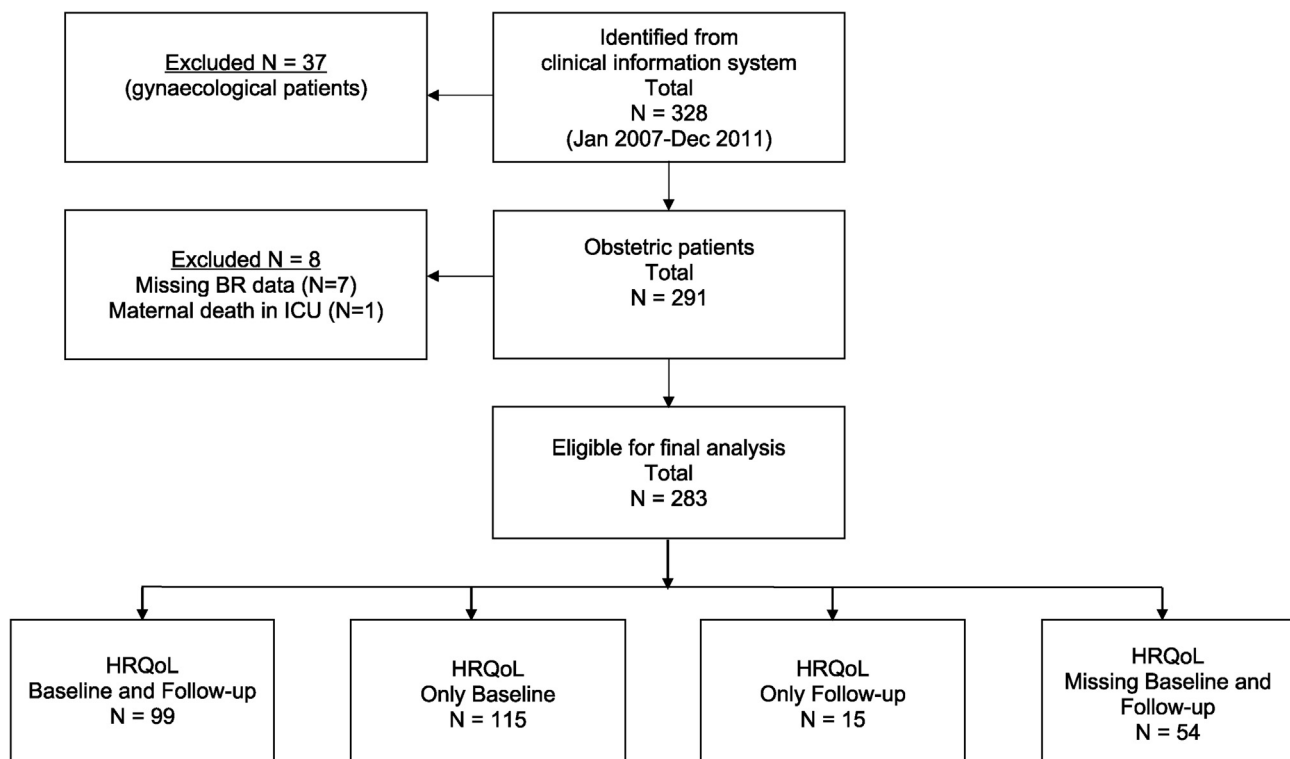


Fig. 1. Patient flowchart. ICU = intensive care unit; BR = birth register, HRQoL = health-related quality of life.



**Table 1**  
Demographic data of obstetric patients and neonatal.

Demographic data	Baseline and follow-up (n = 99)	Only baseline (n = 115)	Only follow-up (n = 15)	Missing (n = 54)
	N (%)	N (%)	N (%)	N (%)
Age, years				
<20	0 (–)	1 (0.9)	0 (–)	4 (7.4)
20–35	76 (76.8)	81 (70.4)	14 (93.3)	38 (70.4)
>35	23 (23.2)	33 (28.7)	1 (6.7)	12 (22.2)
Previous deliveries				
0	64 (64.4)	68 (59.1)	7 (46.7)	40 (74.1)
1–2	29 (29.3)	37 (32.2)	7 (46.7)	11 (20.4)
≥3	6 (6.1)	10 (8.7)	1 (6.7)	3 (5.6)
Number of fetuses				
1	90 (90.1)	107 (93.0)	12 (80.0)	52 (96.3)
2	9 (9.1)	8 (7.0)	3 (20.0)	2 (3.7)
Type of delivery				
Vaginal	18 (18.2)	13 (11.3)	3 (20.0)	9 (16.7)
Vacuum extraction	3 (3.0)	7 (6.1)	1 (6.7)	0 (–)
Planned CS <sup>a</sup>	12 (12.1)	13 (11.3)	1 (6.7)	9 (16.7)
Urgent CS <sup>a</sup>	62 (62.6)	68 (59.1)	7 (46.7)	30 (55.6)
Emergency CS <sup>a</sup>	4 (4.0)	14 (12.2)	3 (20.0)	6 (11.1)
Cause of admission				
Hypertensive complications <sup>b</sup>	62 (62.6)	61 (53.0)	7 (46.7)	35 (64.8)
Haemorrhage <sup>c</sup>	20 (20.2)	23 (23.0)	6 (40.0)	9 (16.7)
Other obstetric causes <sup>d</sup>	12 (12.1)	20 (17.4)	1 (6.7)	3 (5.6)
Non-obstetric causes <sup>e</sup>	5 (5.1)	11 (9.6)	1 (6.7)	7 (13.0)
ICU scores median (IQR)				
APACHE II	9.0 (6.0–12.0)	9.5 (7.0–12.0)	9.0 (7.0–16.0)	9.0 (7.0–12.0)
SAPS II	15.0 (10.0–21.0)	14.0 (10.0–21.0)	14.0 (10.0–19.0)	11.5 (10.0–19.0)
SOFA	3.0 (2.0–5.0)	2.0 (1.0–4.0)	3.0 (1.0–6.0)	2.0 (1.0–4.0)
TISS-76 (daily)	20.5 (18.5–25.0)	21.5 (17.5–26.0)	22.5 (20.0–25.5)	21.0 (19.0–24.0)
ICU LOS, hours, median (IQR)	22.0 (16.0–27.0)	21.0 (15.0–28.0)	17.0 (9.0–23.0)	21.0 (17.0–26.0)
Hospital LOS, days, median (IQR)	9.0 (6.0–11.0)	9.0 (6.0–13.0)	7.0 (5.0–13.0)	9.0 (7.25–11.7)
Number of neonatal	N = 108 (%)	N = 123 (%)	N = 18 (%)	N = 56 (%)
Gestational age < 37 weeks	62 (57.4)	72 (58.5)	9 (50.0)	37 (66.1)
Birth weight, g				
≥2500	52 (47.2)	53 (42.3)	10 (50.0)	23 (41.1)
<2500	33 (25.0)	39 (32.5)	6 (38.9)	11 (19.6)
<1500	16 (21.3)	14 (11.4)	2 (11.1)	14 (25.0)
<1000	7 (6.5)	17 (13.8)	0 (–)	8 (14.3)
Child at the age of one week				
Home care	45 (41.7)	42 (34.1)	2 (11.1)	19 (33.9)
Post-natal ward	10 (9.3)	11 (8.9)	0 (–)	3 (5.4)
Neonate ward	44 (40.7)	60 (48.8)	16 (88.9)	26 (46.4)
Other hospital	4 (3.7)	5 (4.1)	0 (–)	5 (8.9)
Perinatal mortality <sup>f</sup>	4 (3.7)	5 (4.1)	0 (–)	3 (5.4)

APACHE, Acute Physiology and Chronic Health Evaluation; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment; TISS, Therapeutic Intervention Scoring System.

<sup>a</sup> Caesarean section.

<sup>b</sup> Pre-eclampsia, eclampsia, and hypertension.

<sup>c</sup> Intrapartum or postpartum haemorrhage.

<sup>d</sup> Uterine dysfunctions, rupture, and atony, placental abruption, placenta previa, and delivery-related complications.

<sup>e</sup> Heart diseases, respiratory failure, infection, liver or kidney dysfunctions, and miscellaneous.

<sup>f</sup> Stillbirth or died before the age of one week (0–6 days from delivery or age under 7 days).

during follow-up. Patients with worsened pain/discomfort and patients with worsened anxiety/depression had better HRQoL before ICU admission than at 6 months follow-up (EQsum mean 0.947 vs 0.797 and EQsum mean 0.967 vs 0.756, respectively).

#### 4. Discussion

The present study found that in the majority of the obstetric patients HRQoL was good at baseline and remained so or improved 6 months after intensive care discharge. In addition, more than half of the patients had an increased EQ-VAS score at follow-up, indicating improvement in self-rated health status. However, nearly one-fifth of the patients had impaired HRQoL after discharge. Following intensive care, 15% of the patients indicated having worsened pain/discomfort than before, and 11% had worsened depression/anxiety compared to baseline. Multiparity was a contributing factor to depression/anxiety.

In a heterogeneous obstetric population, pregnancy and child-birth involve factors that may impair physical, mental, and social health status. It is known that sleep disturbance is common in women during pregnancy and has a significant impact on maternal HRQoL.<sup>20–22</sup> Moreover, pregnancy-specific health problems, such as hypertensive disorders or risk for preterm delivery, are associated with decreased HRQoL in pregnancy and postpartum. In previous studies, women who had hypertensive complications experienced more depressive symptoms during pregnancy,<sup>23,24</sup> and in women who suffered from severe preeclampsia, mental health quality of life postpartum was reduced.<sup>25</sup> In addition, caring for an infant with very low birth weight is related to poorer HRQoL among mothers,<sup>25</sup> and neonatal ICU admission and perinatal death are predictive factors for reduced HRQoL.<sup>26</sup>

Impaired HRQoL could be explained by different factors, such as hypertensive complications, delivery emergencies, or care of an infant with LBW. Prick et al.<sup>27</sup> investigated postpartum HRQoL after

**Table 2**  
Number of patients reporting problem levels in EQ-5D domains at baseline and follow-up.

EQ-5D domain	Problems	Baseline	Follow-up	<i>p</i>
		<i>N</i> (%)	<i>N</i> (%)	
Mobility	No	87 (87.9)	95 (96)	0.021 <sup>a</sup>
	Moderate	12 (12.1)	4 (4)	
	Severe	0 (–)	0 (–)	
Self-care	No	97 (98)	98 (99)	1.000
	Moderate	2 (2)	1 (1)	
	Severe	0 (–)	0 (–)	
Usual activities	No	96 (97)	93 (93.9)	0.453
	Moderate	3 (3)	6 (6.1)	
	Severe	0 (–)	0 (–)	
Pain/discomfort	No	75 (75.8)	76 (76.8)	0.801
	Moderate	22 (22.2)	22 (22.2)	
	Severe	2 (2)	1 (1)	
Depression/anxiety	No	88 (88.9)	86 (86.9)	0.824
	Moderate	11 (11.1)	13 (13.1)	
	Severe	0 (–)	0 (–)	

EQ-5D, EuroQoL-5D.

<sup>a</sup> McNemar test <0.05.

**Table 3**  
Direction of change in each EQ-5D domain during follow-up (*n* = 99).

EQ-5D domain	Worsened	Same	Improved
	<i>N</i> (%)	<i>N</i> (%)	<i>N</i> (%)
Mobility	1 (1)	89 (89.9)	9 (9.1)
Self-care	1 (1)	96 (97)	2 (2)
Usual activities	5 (5)	92 (93)	2 (2)
Pain/discomfort	15 (15.5)	68 (68.6)	16 (16.1)
Anxiety/depression	11 (11.1)	79 (79.8)	9 (9.1)

EQ-5D, EuroQoL-5D.

**Table 4**  
Summary index (EQsum) and self-rated health state (EQ-VAS) scores at baseline and during follow-up.

Direction of change	EQsum		EQ-VAS			
	<i>N</i> (%)	Baseline	Follow-up	<i>N</i> (%)	Baseline	Follow-up
All	99 (100)	0.936	0.940	65 (100)	71.86	88.2 <sup>a</sup>
Worsened <sup>b</sup>	19 (19.2)	0.987	0.798	7 (10.7)	87.33	76.85
Same	60 (60.6)	0.970	0.972	21 (32.3)	89.16	87.23
Improved <sup>b</sup>	20 (20.2)	0.788	0.982	37 (57)	56.46	90.89

EQsum, EuroQoL-5D instrument with utility score; EQ-VAS, EuroQoL-5D instrument with visual analogue scale.

<sup>a</sup> Wilcoxon test <0.001.

<sup>b</sup> A minimum difference of 0.074 in the EQsum, 7 points in the EQ-VAS was considered clinically important.

obstetric complications and found that hypertensive disorders led to lower HRQoL in postpartum women and that CS had the greatest negative impact on postpartum HRQoL. A study by Mautner et al.<sup>23</sup> showed that women who were diagnosed and treated for hypertensive complications and had the risk of preterm delivery experienced more symptoms of depression in pregnancy. In addition, the mode of delivery has been associated with differences in HRQoL after birth. Women who had a vaginal delivery or underwent CS on maternal request were more likely to report better HRQoL than women who had undergone an emergency section.<sup>28</sup> In a study by Turkstra et al.,<sup>29</sup> women who had a highly distressed childbirth had lower HRQoL after 12 months of follow-up. Additionally, these women had more general practitioner visits in their first year after childbirth and were more likely to receive health services, such as referrals to psychological treatment. Mothers of infants with very low birth weight experienced worse physical and mental HRQoL

than mothers of infants with normal birth weight; this might be explained by maternal symptoms of stress.<sup>25</sup>

It is notable that the present study reported several hypertensive complications, delivery emergencies, and cases of LBW in neonates, all of which potentially have a negative impact on obstetric patients' HRQoL in the long term, yet multiparity was the only factor that significantly contributed to the experiences of increased depression/anxiety. To deepen the knowledge of the factors associated with poor maternal HRQoL, further studies should compare different populations of pregnant women, including those without critical illness.

In this study, the obstetric patients had a low level of physiological impairment and low severity scores. The patients also had short LOS in ICU. It is possible that for obstetric patients such as these, who do not demonstrate great severity of illness, ICU care may not be the optimum choice and another level of care with appropriate patient monitoring could be considered. In addition, it is assumed that pregnancy in itself may reduce HRQoL. Research has shown that women who are treated, for example, for hypertensive complications or has a risk of preterm delivery have symptoms of depression at the baseline measurement.<sup>23</sup>

Some limitations of this study should be noted. First, 99 patients (35%) of the entire study cohort completed the baseline and follow-up EQ-5D questionnaires, which is a considerably low proportion of all identified patients. This might be due to the fact that the analysed data were retrieved from clinical information systems and secondary data were initially collected for other purposes. Thus, the accumulation of data could not be influenced during the study period. The low response has potentially biased the results for some measures.

Second, baseline measurement was performed during the ICU stay when the patient was already affected by a decline in health, and some of the patients may have been in the antenatal ward because of a complication before admission to ICU. Furthermore, the end of pregnancy may be associated with mobility changes that are unrelated to acute illness and need for recovery in ICU. It should be also noted that the EQ-5D is not intended to be used retrospectively. These factors may have had an effect on how the patient estimated her baseline health status, and these points create uncertainty in the baseline results. However, the EQ-5D instrument has been developed further to include five levels instead of three to make the health measurement more sensitive. We suggest that in future studies the five-level scales should be used.

Finally, in this study, we were not able to control for confounders and no comparison with non-ICU-admitted pregnant population was performed. Therefore, it was unable to draw any conclusion. In future studies, it is important to extend the investigation to confounders and comparisons for women of child-bearing age. However, the advantages of using secondary data were that it was already available; the data provided a long observational period and covered the whole study population. In addition, register-based studies make it feasible to study rare phenomena, such as ICU-admitted patient.

## 5. Conclusion

In the majority of the obstetric patients who had good HRQoL before intensive care, HRQoL was similarly good or had increased at 6 months' follow-up after intensive care. However, nearly one-fifth of the patients had impaired HRQoL after discharge. Further study is needed to better understand the impact of ICU admission associated with childbirth on HRQoL. However, it would appear that intensive care management should take into consideration a follow-up program after intensive care of ICU-admitted obstetric patients.

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# PUBLICATION IV

**Health-related quality of life after obstetric intensive care admission:  
comparison with the general population**

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## Health-related quality of life after obstetric intensive care admission: Comparison with the general population



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### ABSTRACT

**Purpose:** To examine health-related quality of life (HRQoL) in obstetric patients after intensive care discharge, with comparison to age-appropriate reference values from the general Finnish female population.

**Material and methods:** Retrospective register-based study. Four multidisciplinary intensive care units at Finnish university hospitals participated.

**Results:** A total of 291 obstetric patient were admitted to the ICU, of whom 114 (39%) completed follow-up measurements. At baseline (pre-intensive care admission), patients showed lower physical (mobility, self-care, pain/discomfort) and social (usual activities) dimensions compared to reference values. Baseline overall health status (EQsum) was lower than reference values. However EQsum increased over six months (mean, 0.907 to 0.946) such that follow-up values were similar to reference values. At follow-up, 18.4% of patients showed poorer HRQoL (mean, 0.764; range, 0.638–0.885) compared to reference values. Multiparous patients showed lower scores than primiparous patients. EQ VAS scores were lower at baseline, but increased over six months (72.12 to 87.5) such that follow-up values were similar to reference values.

**Conclusions:** The baseline HRQoL of study population was lower than that of the general population, but after six months, the mean values were comparable to reference value. However, one in five patients still experienced impaired QoL at follow-up.

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### 1. Introduction

In developed countries, maternal mortality has decreased to very low rates [1]. However, pregnancy and childbirth are still potentially associated with severe maternal morbidity, sometimes requiring maternal intensive care. Leading causes of pregnancy-related admissions to the intensive care unit (ICU) are hypertensive complications and obstetric hemorrhage [2–8]. In addition, non-obstetrical indications, such as exacerbation of chronic disease, can necessitate ICU admission [9].

Even in cases of critical illness, obstetric patients commonly show good short-term outcomes in developed countries [10]. However, pregnancy and delivery are still potentially life-threatening

situations. Moreover, when women require obstetric postpartum intensive care, the newborn may also be in bad condition and receiving intensive care [9,11]. Such pregnancy- and delivery-related complications can influence an obstetric patient's physical, mental, and social well-being, exacerbating reductions of health-related quality of life (HRQoL) over a longer period [12]. Despite increasingly awareness of the long-term effects of critical illness in the general population, obstetric patients are an often neglected group in research.

The aim of our present study was to examine HRQoL in obstetric patients after intensive care discharge, with comparison of our results to age-appropriate reference values from the general Finnish female population. Our hypothesis was that at six months following ICU discharge, the patients' health status would have returned to normal with no remaining physical, social, or mental problems. HRQoL was measured using the EuroQoL-5D (EQ-5D) tool, including a summary index (EQsum) and visual analogue scale (EQ VAS).

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## 2. Materials and methods

### 2.1. Study design and population

This retrospective register-based study included data on obstetric patients treated in the intensive care units of four Finnish university hospitals, during pregnancy and up to 42 days post-partum, over a five-year study period. The study protocol received ethics committee approval (R12050H), and the National Institute for Health and Welfare (THL) granted permission for data collection and to maintain the study register. Data were collected from the Medical Birth Register (MBR), which is maintained by THL and includes maternal sociodemographic and obstetric information for all mothers who have given birth in Finland, as well as perinatal outcomes for up to seven days for all live-born or stillborn infants born after 22 weeks of gestation or weighing  $\geq 500$  g. Data were also retrieved from the following clinical information systems (CIS): Clinisoft, the Finnish Intensive Care Quality Consortium (Intensium, Kuopio, Finland), and the Miranda database.

### 2.2. Data collection

From the Intensium hospital database, we identified obstetric patients of 18–50 years of age, who were treated in the ICU during pregnancy and postpartum, with discharge dates from January 1, 2007 to December 31, 2011. Searches were performed using the APACHE III classification “other gynecological disease”. Exclusion criteria were not being an obstetric patient, maternal death in the ICU, missing MBR data, or missing EQ-5D measurement (baseline and follow-up).

Data from the hospital database were linked with the MBR using the patients’ personal identification numbers. The database included the following information on maternal and neonatal characteristics: age; previous deliveries; number of fetuses; gestational age, i.e., normal, late preterm, moderately preterm, or extreme preterm; delivery type, i.e., vaginal, planned caesarean section (CS), urgent CS, or emergency CS; admission cause, including obstetric reasons (e.g., hypertensive complications, obstetric hemorrhage, or other pregnancy- or delivery-related complications) and non-obstetric reasons (e.g., heart disease,

respiratory failure, infection, liver or kidney dysfunction, or miscellaneous); ICU interventions, such as mechanical ventilation, CPAP/BiPap, hemodialysis, arterial pressure, central line, and pulmonary artery catheter; ICU scores, i.e., APACHE II, SAPS II, SOFA, and TISS-76 daily and total; length of stay; treatment administered to newborn children, i.e., intensive care or observation unit; and perinatal mortality.

### 2.3. Health-related quality of life measurement

Health-related quality of life (HRQoL) was measured using the generic EuroQol 5D (EQ-5D) instrument. The EQ-5D includes two parts, the first of which measures health in five dimensions: the physical dimensions of mobility, self-care, and pain or discomfort; the mental dimension of depression or anxiety; and the social dimension of usual activities (work, study, homework, family, or leisure activities). Respondents asked to choose the most suitable option from three alternatives—no problem (1), moderate problems (2), of severe problems (3)—making it possible to define various health states as a digital number series. These preference-based measures are used to calculate a single summary index score (EQsum) based on the different aspects of health, which ranges from 0 to 1.0. The second part of the EQ-5D is a self-rated visual analogue scale (EQ VAS), used to rank health from 0 (worst imaginable health state) to 100 (best imaginable health state) [13].

EQ-5D measurement was a standard part of case management in the intensive care process in the units from which data was collected for our present study. For the baseline measurement, an intensive care nurse or physician asked the patient the EQ-5D questions referred to the time preceding the acute hospitalization. The collected data were recorded in the CIS (Clinisoft). Since the data were routinely collected and retrospectively analyzed data, the data collection was consistent throughout the study period. Follow-up measurements were collected via telephone interview or letter at six months after ICU discharge. Follow-up data were collected and recorded by nominated persons in each unit. The obstetric patients’ HRQoL measurements included information from the of EQ-5D dimensions and EQ VAS. The EQsum was calculated by one of the authors [15].

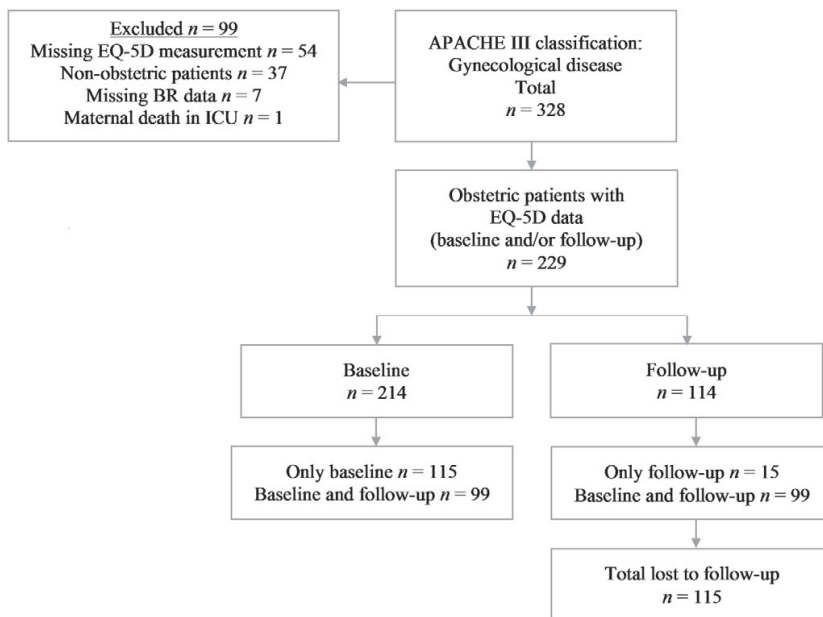


Fig. 1. Flow chart of EQ-5D measurements at baseline and follow-up.



## 2.4. Statistical analysis

Data analyses were performed using SPSS 15.0 software (SPSS, Chicago, IL). Categorical data are presented as percentages. Continuous data showed a non-normal distribution and are reported as median and interquartile range (IQR 25th–75th percentiles). EQ-5D population norms are reported in the literature [14], including defined reference values for the general Finnish population, including for both genders and multiple age groups [15]. Reference values were obtained from the general Finnish population of females aged 17–44 years. Finnish population mean reference scores (EQsum) were relatively stable from 17 to 44 years (from 0.96 to 0.93), as well as EQ-VAS (around 86) [15]. Impaired QOL at follow-up was defined as measurements lower than the reference population values minus the clinically important difference, which was 0.074 for EQsum [16]. Comparisons were performed using the Mann-Whitney *U* test and Fisher's exact test. A *p* value of <0.05 was considered significant in all tests.

## 3. Results

### 3.1. Characteristics

During the study period, 328 admissions were recorded as “other gynecological disease” according to the APACHE III classification. Of these admissions, 99 were excluded: 54 were missing EQ-5D measurement (baseline and follow-up), 37 were non-obstetric patients, 7 were missing BR data, and 1 admission resulted in maternal death. Thus, a total of 229 obstetric patients were eligible for analysis, with available data from CIS, MBR, and EQ-5D measurements (baseline and/or follow-up). We analyzed a total of 214 baseline EQ-5D measurements (from before the ICU stay) and 114 follow-up EQ-5D measurements (from six months after pregnancy and ICU discharge). A total of 115 patients were lost to follow-up (Fig. 1). Table 1 presents the follow-up characteristics of the patients with normal QOL (*n* = 93), patients with impaired QOL (*n* = 21), and those lost to follow-up (*n* = 115).

### 3.2. EQ-5D dimensions

Compared to reference values, the patients showed impaired baseline EQ-5D results in the physical dimensions (mobility, self-care, pain or discomfort) and the social dimension (usual activities) (Fig. 2). These values were increased at six months after ICU discharge, such that the follow-up values did not significantly differ from the reference values. The EQ-5D results for mental quality of life at baseline and follow-up in patients did not differ from the reference values.

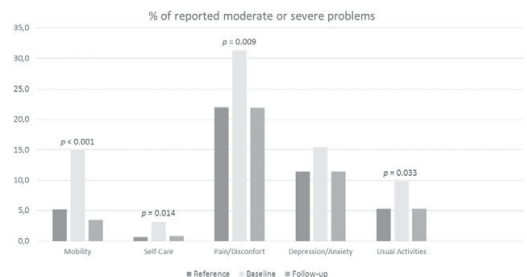
### 3.3. EQsum and EQ VAS

The baseline mean EQsum score was 0.907, which was lower than reference values (Table 2). Moreover, the reference values were also higher than the baseline EQsum scores in the age groups 18–24 years and 25–34 years. For 93 patients (81.6%), health status had returned to normal at six months after ICU discharge (mean EQsum, 0.987; range, 0.885–1) relative to the reference values. On the other hand, 21 patients (18.4%) reported decreased HRQoL at follow-up (mean, 0.764; range, 0.638–0.885) compared to the reference values (Table 3). Of these patients, 14 (66%) had decreased HRQoL compared to baseline (0.982 to 0.766), five (24%) had HRQoL similar to baseline (0.742 to 0.746), one (5%) had HRQoL increased from baseline (0.559 to 0.745), and one (5%) had a missing baseline measurement. Multiparous women scored worse on their HRQoL compared to primiparous women. At the follow-up 70 patients had ICU LOS <24 h and 44 had LOS ≥24 h. Statistically, ICU LOS and HRQoL at follow-up did not differ between the groups (*p* = 0.866). The baseline mean EQ VAS score was 72.12, which was lower than the reference value. Six months

**Table 1**  
Follow-up characteristics of intensive care unit admitted obstetric patients.

Maternal Characteristics	Normal QOL <sup>a</sup> ( <i>n</i> = 93)	Impaired QOL ( <i>n</i> = 21)	Lost to follow up ( <i>n</i> = 115)	<i>p</i>
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
Age in years, median (IQR)	30.0 (27.0–34.0)	32.0 (30.5–38.0)	31.7 (27.1–36.0)	0.139
Previous deliveries				
0	62 (66.7)	9 (42.9)	68 (59.1)	
1–2	29 (31.2)	7 (33.3)	37 (32.2)	0.003
≥3	2 (2.2)	5 (23.8)	10 (8.7)	
Gestational age <sup>b</sup>				
Normal	45 (48.4)	7 (35.0)	50 (43.5)	
Late preterm	25 (26.9)	4 (20.0)	22 (19.1)	0.299
Moderately preterm	20 (21.5)	8 (40.0)	30 (26.1)	
Extremely preterm	3 (3.2)	1 (5.0)	13 (11.3)	
Delivery type				
Vaginal	22 (23.7)	3 (14.3)	20 (17.4)	
Planned section	11 (11.8)	2 (9.5)	13 (11.3)	0.081
Urgent section	57 (61.3)	12 (57.1)	68 (59.1)	
Emergency section	3 (3.2)	4 (19.0)	14 (12.2)	
Admission cause				
Hypertensive complications <sup>c</sup>	57 (61.3)	12 (57.1)	61 (53.0)	
Hemorrhage	21 (22.6)	5 (23.8)	22 (19.1)	0.947
Pregnancy or delivery related complications	10 (10.8)	3 (14.3)	21 (18.3)	
Non-obstetric	5 (5.4)	1 (4.8)	11 (9.6)	
Interventions				
Mechanical ventilation	19 (20.4)	4 (19.0)	23 (20.0)	1.000
CPAP/BiPAP	6 (6.5)	–	5 (4.3)	0.591
Hemodialysis	–	–	2 (1.7)	–
Arterial pressure	91 (97.8)	20 (95.2)	112 (97.4)	0.460
Central line	30 (32.3)	5 (23.8)	29 (25.2)	0.602
Pulmonary artery catheter	2 (2.2)	2 (9.5)	3 (2.6)	0.154
ICU scores, median (IQR)				
APACHE II	9.0 (7.0–12.0)	10.0 (6.5–12.5)	9.5 (7.0–12.0)	0.560
SAPS II	15.0 (10.0–21.0)	14.0 (10.0–19.0)	14.0 (10.0–21.0)	0.856
SOFA	3.0 (2.0–5.0)	2.0 (1.0–5.5)	2.0 (1.0–4.0)	0.934
TISS-76, daily	20.5 (18.5–24.5)	24.5 (18.8–27.9)	21.5 (17.5–26.0)	0.129
TISS-76, total	41.0 (35.5–50.5)	44.0 (32.0–72.5)	41.0 (32.0–53.0)	0.456
Length of ICU stay (hours), median (IQR)	21.0 (16.0–27.0)	20.0 (12.5–33.0)	21.0 (15.0–28.0)	0.709
Number of newborns	<i>n</i> = 104 (%)	<i>n</i> = 22 (%)	<i>n</i> = 123 (%)	
Treatment to newborn in NICU or observation unit	54 (51.9)	15 (68.2)	64 (52.0)	0.238
Perinatal mortality <sup>d</sup>	3 (2.9)	2 (9.1)	5 (4.1)	0.209

<sup>a</sup> Compared to age-appropriate reference values from the Finnish female population.  
<sup>b</sup> Gestational age in weeks: normal, ≥37; late preterm, 34<sup>+</sup>0–36<sup>+</sup>6; moderately preterm, 28<sup>+</sup>0–33<sup>+</sup>6; extremely preterm, <28.  
<sup>c</sup> Pre-eclampsia, eclampsia and hypertension.  
<sup>d</sup> Stillborn or died before seven days of age.



**Fig. 2.** Reported moderate or severe problems.

**Table 2**

Summary index (EQsum) and visual analogue scale (EQ-VAS) scores from patients compared with the general Finnish female population (GP) by age groups.

EuroQol-5D Measurement	Age, years			Age, years			Age, years			All		
	18–24	n	p	25–34	n	p	35–44	n	p	n	n	p
EQsum												
GP	0.96	166		0.95	213		0.93	170		0.946	549	
Baseline	0.894	28	<0.05	0.912	126	<0.01	0.903	60	ns	0.907	214	<0.001
Follow-up	0.940	13	ns	0.954	73	ns	0.926	28	ns	0.946	114	ns
EQ-VAS												
GP	87	166		87	213		85	170		86.38	549	
Baseline	72.19	21	<0.05	68.71	77	<0.001	75.48	33	<0.05	72.12	131	<0.001
Follow-up	89.16	12	ns	87.16	61	ns	87.52	25	ns	87.5	98	ns

ns = nonsignificant.

after discharge, self-rated health status had returned to normal compared to the reference values (Table 3).

#### 4. Discussion

In our present study, we examined HRQoL in obstetric patients treated in intensive care units and compared the results to age-appropriate reference values from the general Finnish female population. During the study period there were 94,642 births in four hospital districts and 291 obstetric ICU admissions (0.3% of all maternities; varied 0.02 to 0.5%). Our findings demonstrated that obstetric patient health status was lower than reference values prior to ICU admission, and had returned to reference value levels by six months following ICU discharge. However, nearly one-fifth of patients still had below-reference value HRQoL at follow-up.

In the current study, we found that physical QOL values at the end of pregnancy were lower than reference values. Prior studies show that pregnant women experience poor physical and mental HRQoL. Tsai et al. (2016) reported impaired physical and mental HRQoL that persisted throughout the entire pregnancy. Compared to controls, Sut et al. (2016) found pregnant women had worse EQ-5D scores, with decreases in the second and third trimesters. In particular, scores on the physical dimension reportedly decrease from early to late pregnancy [19,20]. Prior studies report that sleep disturbances are a contributing factor to the poor QOL experienced pregnant women [17,18], and that delivery by elective or emergency CS negatively impacts physical [21] and perceived HRQoL [22]. Interestingly, our present results showed that scores on the depression or anxiety dimension among patients were similar to reference values, indicating that pregnancy or delivery did not affect mental HRQoL.

Our present findings partly support the hypothesis that health status returned to reference values by six months after ICU discharge. However, nearly one-fifth of the study patients still had lower HRQoL at 6 months after discharge. In this study given the low severity of illness and the very short length of ICU stay, it seems unlikely that the ICU admission itself would have any major long-term impact on HRQoL. Van der Woude et al. [23] found in their review that incontinence and being HIV-positive seemed to be associated with impaired QOL in postpartum women. In addition, postpartum depression and a caesarean section seemed to be associated with impaired health status.

**Table 3**

Summary index (EQsum) at baseline and follow-up in patients with impaired health related quality of life.

EQsum	n	Baseline		Follow-up	
		Mean	Min–max	Mean	Min–max
All	21	0.901	0.559–1	0.764	0.638–0.885
Increased	1	0.559		0.745	
Similar	5	0.742	0.62–0.885	0.746	0.693–0.824
Decreased	14	0.982	0.833–1	0.766	0.638–0.885
Missing baseline	1			0.833	

In their study of women admitted to the ICU for non-obstetric reasons, Cartin-Ceba et al. (2008) found that maternal critical illness and specific ICU interventions significantly affected fetal outcomes. Although our present study included a low number of non-obstetric admissions, over half of the neonates in such cases were preterm and required treatment in the NICU or observation unit. Notably, the emergency section rate was also higher in this group, although this difference was not statistically significant. Previous studies of general obstetric population care have reported mothers of very low birthweight infants experienced worse physical and mental HRQoL than mothers of normal birthweight infants [24]. Although our present results showed no significant association between long-term HRQoL and these neonate outcomes, others have reported that NICU admission and perinatal death are associated with decreased long-term QOL [25].

When evaluating the present study results and the data available in the literature, it is important to realize that impaired HRQoL after follow-up is not necessarily caused by the intensive care treatment. This present results demonstrate considerably better HRQoL than found in the general ICU population [26]. It is likely that HRQoL is largely predicted by a combination of obstetric complications, such as hypertensive disorders, obstetric hemorrhage, delivery-related complications, and neonatal outcomes, rather than critical care admission alone. The therapeutic needs of obstetric patients differ from the needs of other populations admitted to the ICU. The duration of ICU stay in our present series was lower than reported by others [2,4,8], as was the need for assisted ventilation [7,8]. However, similar to previously reported findings, hypertensive disorders and hemorrhage were the leading causes of obstetric ICU admissions in our present population [10]. Saravanakumar et al. [27] reported a large sample of patients who received high dependency unit care in obstetric settings, and reported that hypertensive disorders and obstetric hemorrhage were the most frequent reasons for admission. Furthermore, length of stay was typically less than a day, and the need for intervention was minor.

After intensive care discharge HRQoL improves over time, with obstetric ICU patients showing good long-term outcomes. However, in our present study population of obstetric patients, at six months after discharge, 21.9% still experienced pain or discomfort and 11.4% still experienced depression or anxiety. It is essential to identify the patients who are more likely to require physical or mental support after intensive care discharge. Our results indicated that impaired QOL at follow-up was particularly common among multiparous patients. However, this may be related to factors associated with being multiparous, and possibly has nothing at all to do with the ICU admission. In further studies multidimensional measurements to describe ICU admitted obstetric patient physical, cognitive and psychological components in long-term period should be considered.

Our present study has several limitations. First, the addition of more time-points beyond six months after discharge could have provided additional information about long-term HRQoL in this population. However, a six-month follow-up is considered adequate [28]. Second, it would have been more informative to make comparisons with a pregnant non-ICU patient population and a maternity ward population. Alternatively,

it can be hypothesized that complete recovery from intensive care is more likely in an obstetric population than a non-pregnant population. Finally, although our sample size was reasonable compared to previous studies [26], a considerable number of patients were lost to follow-up. A risk of bias is caused by the majority of patients being lost to follow-up. Strengths of this study include the multicenter design, and the observation of all obstetric ICU admissions during the five-year study period with standard assessment of HRQoL at baseline.

## 5. Conclusions

Obstetric patient health status at baseline was lower than that of the reference population, but was similar to reference values at six months after pregnancy and intensive care discharge. However, one in five patients still experienced impaired QOL at follow-up.

## Conflict of interest

The authors have disclosed that they do not have any potential conflict of interest.

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