Obstetric Emergency Triage

A new mindset in obstetric emergency care in Sweden

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ABSTRACT

Introduction Obstetric emergency triage, facilitating prioritization according to urgency of obstetric patients seeking emergency care, is a relatively new form of triage. Adaptations to physiological changes during pregnancy and pregnancy specific conditions enable assessment of the patient, fetus, and labor status, essential to achieve equality in emergency care for the obstetric patient. Introducing obstetric emergency triage constitutes a profound alteration in management that may challenge preconceived notions on how to provide best care. Further, implementation of obstetric emergency care must be supported by a reliable and valid triage system. With triage being contextual and lacking a definition of true urgency in triage, validation of triage systems is challenging.

Aim The overall aim of this thesis is to reduce maternal mortality and morbidity by introducing a new working method within obstetric emergency care.

Methods *Paper I* presents the development and implementation of the Gothenburg obstetric triage system (GOTS), including a literature review on obstetric triage. In *paper II*, 13 registered nurses and midwifes rated 30 paper-case scenarios, assessing interrater reliability by the intraclass coefficient. In *paper III*, 13 in-depth interviews with obstetric staff underwent inductive qualitative content analysis according to Graneheim and Lundman. *Paper IV* and *V* assessed the validity of GOTS by developing a set of construct outcome measures in a consensus based, modified Delphi-process followed by consecutive medical chart reviews of 1280 patient visits at an obstetric emergency department. Dichotomized triage levels enabled sensitivity and specificity calculations.

Results I) GOTS was developed as a five-level triage system based on pregnancy-adapted vital signs and chief complaints. II) GOTS has a good interrater reliability when used by non-obstetric and obstetric staff. III) Staff experiences that triage facilitates prioritization of patients according to level of acuity, directs attention towards aberrations, and promotes reflection and action, enhancing teamwork by improved communication. IV and V) Acknowledging the challenges in validating triage systems, GOTS has a good contextual validity, assessed by using a set of 31 weighted outcome measures reflecting urgency at the time of triage, with a sensitivity and specificity of

0.62 (CI 0.50 – 0.73) and 0.98 (CI 0.97 – 0.99), respectively. A two-phased validation process is suggested for validating triage systems.
Conclusion GOTS is the first OTS developed for, implemented in and validated in a Swedish context. Obstetric triage based on e.g. GOTS should be introduced into Swedish obstetric emergency care.

Keywords Acuity, Delphi method, Emergency medicine, Experiences, Implementation, Obstetrics, Patient safety, Quality improvement, Qualitative research, Reliability, Triage, Validity, Working conditions

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SAMMANFATTNING PÅ SVENSKA

Vid ett besök på en akutmottagning görs alltid en första bedömning för att avgöra om den vårdsökande personen har ett tillstånd som kräver akutsjukvård och, om så är fallet, hur snabbt fortsatt handläggning behövs. Bedömningen kallas ***triage*** och utförs oftast av en erfaren sjuksköterska som till stöd för sin bedömning använder ett ***triagesystem***. Triagesystem tar hänsyn till patientens symtom och vitalparametrar såsom puls, blodtryck, syremättnad, andningsfrekvens, kroppstemperatur och vakenhetsgrad och prioriterar utifrån dessa patienten till en av fyra till fem akuta handläggningsnivåer. Triagesjuksköterskan, vars beslut kan få stora konsekvenser för patienten, har en utsatt position på akutmottagningen. Därför är det nödvändigt att bedömningen stöds av säkra och tillförlitliga triagesystem.

Gravida och nyförlösta patienter, s.k. obstetriska patienter kan i Sverige söka akutsjukvård på akutmottagningar, på gynekologiska akutmottagningar eller, efter att graviditeten kommit ca halvvägs, på förlossningsavdelningar. Det är sedan tidigare känt att gravida och nyförlösta kvinnor har en högre risk för felbehandling på akutmottagningar, vilket lett till både ökad sjuklighet och dödsfall. I vissa fall beror felbehandlingen på att triageringen inte kunnat identifiera den svårt sjuka obstetriska patienten. En orsak är att traditionella triagesystem inte tar hänsyn till de stora fysiologiska förändringar som uppstår i samband med graviditet. Normalgränserna för vitalparametrarna är därför inte applicerbara för bedöminng av gravida. Gravida kan också drabbas både av graviditets-relaterade sjukdomar och av sjukdomar som annars är ovanliga hos icke-gravida i deras ålder. Dessutom skall även barnets mående bedömas. På förlossningsavdelningar används inte triage. Patienterna tas istället omhand i turordning, baserat på när de kom till avdelningen snarare än hur sjuka de är.

Denna avhandling syftar till att utveckla, implementera och utvärdera ett nytt triagesystem som tar hänsyn till de fysiologiska förändringarna som sker i samband med graviditet samt att studera triagesystemet som ett verktyg i det dagliga arbetet. Triagesystemet skall kunna användas både inom obstetrisk och icke-obstetrisk akutsjukvård.

I ***delstudie I*****,** beskrivs utvecklingen och implementeringen av Gothenburg Obstetric Triage System (GOTS) på Sveriges största förlossningsenhet.

Utvecklingen inledes som ett led i ett stort patientsäkerhetsarbete och studien omfattar bl.a. en litteraturgenomgång.

Delstudie II God mellanbedömmarreliabilitet, dvs ett triagesystems förmåga att stötta barnmorskor och akutsjuksköterskor till att göra samma bedömning av samma patient vid samma söktillfälle, är en förutsättning för ett säkert triagesystem. I delstudie II bedömer 13 barnmorskor och sjuksköterskor 30 patientfall hämtade från den kliniska vardagen, omvandlade till pappersfall.

Delstudie III Implementering av triage i akutomhändertagandet av obstetriska patienter innebär en stor förändring jämfört med tidigare handläggning och kan upplevas som ett ifrågasättande av det tidigare förfarandet. Därav är det av stor vikt att undersöka hur personalen upplever arbetsmetoden. I delstudie III djupintervjuas 13 barnmorskor, förlossningsläkare och undersköterskor kring deras upplevelser av att använda obstetriskt akuttriage efter att ha arbetat med GOTS i sex månader.

Delstudie IV-V Validering av triagesystem är en komplex utmaning. I delstudie IV utvecklas standardiserade utfallsmått för validering av obstetriska triagesystem. Dessa används sedan för validering av GOTS i delstudie V, där 1280 patientbesök granskas för att undersöka om triageringsnivån de fick vid akutbesöket motsvaras av given handläggning.

Sammanfattningsvis visar avhandlingen att införandet av obstetriskt triage som arbetsmetod ger en förbättrad arbetsstruktur. Efter implementering, prioriteras patienterna till vård baserat på behov istället för tidpunkt för ankomst till avdelningen. Personalen beskriver upplevelser av ökad patientsäkerhet samt en förbättrad arbetssituation via förbättrad kommunikation och minskad stress.

GOTS har en god mellanbedömmarreliabilitet och validitet i de undersökta miljöerna och är ett säkert triageringssystem som stöttar den triagerande barnmorskan eller sjuksköterskan till adekvata bedömningar av patienten. Både barriärer och framgångsfaktorer för implementering har identifieras och kontextuella överväganden vid införande av triagesystem är viktiga.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Lindroos L, Korsoski R, Ohman MO, Elden H, Karlsson O, Sengpiel V. *Improving assessment of acute obstetric patients - introducing a Swedish obstetric triage system.* BMC Health Serv Res. 2021;21(1):1207.

II. Lindroos L, Elden H, Karlsson O, Sengpiel V. *An interrater reliability study on the Gothenburg obstetric triage system- a new obstetric triage system.* BMC Pregnancy Childbirth. 2021;21(1):668.

III. Lindroos L, Sengpiel V, Elden H. *A new mindset in Swedish obstetric emergency care – a qualitative study describing midwives, auxiliary nurses, and obstetricians' experiences of working with obstetric emergency triage.* Under review.

IV. Lindroos L, Ernstad E, Sengpiel V. *Validating obstetric triage systems – what are we really measuring? A modified Delphi process introducing outcome measures for obstetric triage systems.* Submitted for publication.

V. Lindroos L, Ernstad E, Nilsson S, Sengpiel V. *Validation of the Gothenburg Obstetric Triage System (GOTS).* Submitted for publication.

CONTENTS

ABBREVIATIONS

ATS	Australasian Triage Scale
BSOTS	Birmingham Symptom specific Obstetric Triage System
CCA	Chief complaint algorithm
CI	Confidence Interval
CTAS	Canadian Triage and Acuity Scale
CTG	Cardiotocography
EMTALA	Emergency Medical Treatment and Active Labor Act
ED	Emergency department
ESI	Emergency Severity Index
GOTS	Gothenburg obstetric triage system
ICC	Intraclass correlation coefficient
ICU	Intensive care unit
IRR	Interrater reliability
LOS	Length of stay
MEOWS	Modified early obstetric warning system
MFTI	Maternal Fetal Triage Index
MBRRACE	Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries
MTS	Manchester Triage System

OTDA	Obstetric Triage Decision AID
O-NEWS	Obstetric National Early Warning Score
OTS	Obstetric triage system
QI	Quality improvement
RETTS	Rapid Emergency Triage and Treatment System
RN	Registered nurse
SATS	South African Triage System
SETS	Swiss Emergency Triage Scale
SU	Sahlgrenska University Hospital
SWOT	Strength, Weakness, Opportunities and Threats
TMF	Theories, models and frameworks

INTRODUCTION

This doctoral thesis will introduce the concept of obstetric emergency triage in a Swedish setting. It presents the development of Sweden's first obstetric triage system (OTS) – The Gothenburg Obstetric Triage System (GOTS) – and its implementation at the Department of Obstetrics at Sahlgrenska University Hospital (SU). The thesis also presents an evaluation of reliability and validity of GOTS, including a discussion on overall triage validation. Additionally, an evaluation of staff experience in working with obstetric emergency triage is presented. Even though emergency triage is essential for effectively managing emergency departments (EDs), enabling provision of safe and efficient care as well as ensuring clinical justice for patients, obstetric emergency triage is yet to be implemented on a national level in Sweden.

Failure to promptly identify and treat urgent or critically ill obstetric patients seeking general emergency care departments (EDs), obstetric emergency care departments or labor wards, has repeatedly led to maternal morbidity and mortality (1-3). To improve identification of obstetric patients in need of immediate care, obstetric emergency triage can be applied. Emergency triage is most often defined as the initial management process within emergency care, aiming to identify patients with urgent and time-dependent conditions. By identification, patients can be prioritized for further assessment and management in accordance with medical urgency. Triage aims to improve the patient's clinical outcome and/or prevent deterioration and is successful if the patient receives needed interventions in a timely manner.

Emergency triage is a complex process and in addition to its' primary aim, triage is often also used to regulate inflow of patients to EDs, to optimize organizational planning, and to plan for example resource utilization and predict outcomes such as mortality. Adding to the complexity, triage can be

defined as a structured system, a working method, or a location. Defining the purpose of triage is imperative for evaluation and development of emergency triage. In this doctoral thesis, if not otherwise noted, the concept of emergency triage is equivalent to *the prioritization of patients in accordance with medical urgency, based on urgency in the moment of triage.*

EMERGENCY TRIAGE

The concept stems from the military, prioritizing human casualties into three severity levels, thus focusing recourses where most needed and best applied. Like military care, emergency care has limited control over inflow of patients and in the 1950's, emergency care in the United States adopted the concept of triage into the medical field (4, 5). Simultaneously, the responsibility of triage was assigned to dedicated triage nurses (6). After development of structured triage systems, the concept was implemented into prehospital emergency care and emergency care internationally in the early 1990's (5). Today, triage is deemed imperative for emergency care, both nationally and internationally. Triage is essential to manage an everlasting challenge of overcrowding in EDs and facilitates allocation of limited recourses (7-9). With unlimited resources, triage would be redundant as no queue would arise (10). Nevertheless, there is a vast contrast between the use of triage systems in clinical practice and research evaluating their performance, with limited scientific support and an elusive actual effect on patient outcome (11-13).

THE TRIAGE PROCESS

Triage is performed at first contact with medically trained staff at the ED, with an initial assessment most often performed by a registered nurse (RN) or by a triage physician. The patient is assessed by a combination of symptom presentation and vital sign parameters and the following prioritization into an acuity level reflects the acceptable length of time that the patient may wait for further physician assessment or intervention, *figure 1*. More severe symptom presentation or deviating vital sign parameters result in a more urgent acuity level, leading to shorter time for further assessment by a physician. Physician led triage has been shown to reduce mortality and unscheduled return to the ED as well as a reduction in waiting time to further assessment by a physician

(12), yet nurse-led triage is more common, amongst other factors related to cost-effectiveness (14).

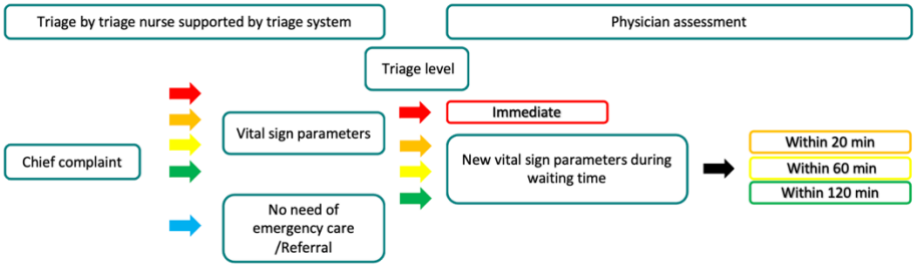

Figure 1 *Example of a triage process. Colors represent different triage levels, with falling urgency levels from red to blue. Patients triaged into red or orange levels are urgent. Time-definitions are benchmarks for maximum waiting time from triage to further assessment by physician.*

TRIAGE SYSTEMS

Triage systems support the triage nurse/physician in the initial medical evaluation of a patient seeking emergency care by providing a structure for initial assessment. Since the 1990's multiple triage systems have been developed worldwide and five-level triage systems have been shown to be superior to the original, military 3-level systems (15, 16). Many systems stem from the internationally prevailing Emergency Severity Index (ESI), Australasian Triage Scale (ATS), Manchester Triage System (MTS), Canadian Triage and Acuity Scale (CTAS), and South African Triage System (SATS). All of these are five-level triage systems combining assessment of symptoms and vital sign parameters, and in one case (ESI) the expected resource utilization (17-22). With development of existing as well as new triage systems, many triage systems have become increasingly specified, focusing both on specific diagnoses and patient groups while also incorporating adaptations to local prerequisites such as accessibility to radiology and operating accessibility (6, 23). The majority of such specifications and

adaptations have been applied to clinical practice based on clinical expertise, but lack scientific support (6, 10-12), consequently impairing comparison and validity studies (12, 15, 24).

Acuity levels are referred to as 1 to 5 and/or a combination of colours, representing each acuity level (25). Many systems include time limits, benchmarking waiting time to further assessment by a physician ranging from "immediate/resuscitation" to "referral to planned visits/no need of emergency care". The systems, however, differ in their approaches. For example, ESI is an algorithm that for each falling acuity level excludes need of life-saving interventions and high-risk situations, not specifying these two concepts further. Such a system relies on experience, knowledge, and clinical judgment of the triage nurse to make adequate assessments. In contrast, for example CTAS specifies conditions or presenting complaints within each acuity level thus, leaving less room for and requiring less subjective judgement by the triage nurse (17, 25).

The most used triage system in Sweden is the Rapid Emergency Triage and Treatment System (RETTS) (26, 27). RETTS is a five-level triage system, combining chief complaint/symptoms and vital sign parameters to assess patients. The system also incorporates recommendations on initial management such as laboratory investigations. Chief complaint/symptoms and vital sign parameters are assessed separately by the triage nurse and may result in two different acuity levels. If so, the highest acuity level constitutes the final triage level. RETTS is available for adult, paediatric, prehospital, psychiatric and – based on the work in this thesis - obstetric emergency care patients. It is highly specified in its symptom descriptions but allows for the triage nurse subjective evaluation to affect the final triage level, enabling the triage nurse

to decide on a higher acuity level due to subjective medical concern for the patient.

Triage has been recognized to be the most error-prone area of the ED and the triage nurse has an exposed position in the ED, who's decisions may have life-altering consequences for the patient (7, 12, 28). Triage systems support triage, but do not constitute the complete triage process. This process is dependent on both external and internal factors, such as work environment and individual traits of the triage nurse. Traits like knowledge, confidence, having the ability to multitask, and capacity to cope with a high workload are important to cope with the frequently stressful environment of triage (24, 29, 30). Supportive, reliable, and valid triage systems are crucial to avoid individual variation in assessments, consequently decrease the risk of unequal care and of missing severely ill patients (13, 31).

Vital sign parameters

Vital sign parameters are the patient's blood pressure, heart rate, breathing frequency, oxygen saturation, temperature, and consciousness. These parameters have well-defined cut-off levels in the non-obstetric adult population, enabling identification of deviation from normality. As a patient falls ill, physiological changes such as increased breathing frequency and pulse will usually occur. Thus, abnormalities in these measurements may indicate illness and strengthen the ability of a triage system to identify medical urgency and thus adequately triage patients (23, 32, 33). However, a patient may present with an urgent condition while still having normal vital sign parameters and hence, the triage assessment should include both symptoms and vital signs (10, 34).

Vital sign parameters in the obstetric patient

Most organs and bodily functions are affected by pregnancy. Due to pregnancy-related physiological changes, non-obstetric reference values for normal vital sign parameters are inapt for assessment of the obstetric population (35). These physiological changes enable pregnant and newly delivered women to maintain normal vital sign parameters further into the development of severe illness (36). For example, blood can be relocated from the uteroplacental unit and centralized, maintaining a normal blood pressure in haemorrhagic compilations or sepsis. Vital sign parameters must therefore be adapted and deviation from normality taken even more seriously in the obstetric patient as they may reflect progressed severe illness (37).

Modified early obstetric warning system - MEOWS

Research on normal vital signs parameters in the obstetric population is scarce (38). As preeclampsia, a hypertensive disorder, is one of the most serious complications in pregnancy, research has focused on safe blood pressure levels (36, 38). In addition, temperature has a traditionally strong clinical significance, because of risk of infection in association with for example premature rupture of the membranes and fever during delivery, with possible severe maternal and fetal consequences.

The use of early warning scores i.e., measuring vital sign parameters on hospitalised patients repeatedly during a hospital visit to facilitate an early recognition of deterioration, has been recommended internationally for both the non-obstetric and obstetric population (39-41). In Sweden, the introduction of MEOWS started in the early 2010's and a national recommendation including the O-NEWS2 system was issued in 2018 (41).

Studies aiming to establish Early Warning Score systems for obstetric patients have identified cut-off levels for normal vital sign parameters in obstetric

patients mainly by either measuring vital sign parameters in a relatively small, selected population or by retrospectively calculating cut-off levels for increased risk of admission to an intensive care unit (ICU) (33, 42, 43). Thus, different obstetric early warning systems use different cut-off levels to define deviation from normality (37, 44). Studies have found such scales reliable for predicting death (33, 45), however, evidence on failure to identify sepsis in the obstetric population has also been presented (46).

Table 1 *Vital sign parameters, normal levels in three non-OTSs (darker teal) and three systems with adapted vital sign parameters to the obstetric patient's altered physiology (lighter teal)*

	ESI *	**SATS ****	**RETTS**	**MEOWS** *Carle et al*	***Green et al*** **Gestation week 40*****	**GOTS**
s-BP (mmHg)	.	101 – 199	> 90	90 – 139	102 – 144	90 – 139
d-BP (mmHg)	.	.	.	< 90	62 – 95	< 95
Heart rate (/min)	< 100	51 – 100	50 – 110	60 – 110	89 – 114	60 – 110
Breathing frequency (/min)	< 20	9 – 14	8 – 25	10 – 17	9 – 23	10 – 20
Saturation (%)	> 92	.	> 95	> 95	93 – 99	> 94
Temperature (°C)	.	35 – 38.4	35 – 38.5	35.1 – 37.9	35.4 – 37.4	35.1 – 37.9
Consciousness (AVPU / RLS)	.	A	A / 1	A	.	A / 1

AVPU – Alert, Verbally Responsive, Painfully Responsive, Unresponsive, *d-BP* – diastolic blood pressure, *ESI* – Emergency Severity Index, *GOTS* – Gothenburg Obstetric Triage System, *MEOWS* – modified early obstetric warning system, *RETTS* – Rapid Emergency Triage and Treatment System, *RLS* – reaction level scale, *SATS* – South African Triage System, *s-BP* – systolic blood pressure

* Only in ESI-level 3, assessing vital sign parameters not indicated in other levels

** Measuring vital signs should not obstruct critical management

*** 3rd – 97th centile

Carle et al (33), Green et al (36)

A significant contribution to the field has been made by Green et al, assessing 1041 women without significant comorbidities and their vital sign parameters, screened at 4-6 weekly intervals throughout pregnancy (36). The study does not exclude patients developing pregnancy related illness such as preeclampsia. With population characteristics being representative for the

Swedish population, the study presents reference values for normal vital sign parameters at several time points during pregnancy applicable in a Swedish context, *table 1*.

OBSTETRIC EMERGENCY TRIAGE

As within other areas of emergency care, the obstetric medical field has seen a rise in patient inflow and faces the same challenges with managing overcrowding and caring for patients in a safe, structured, and cost-effective way. The obstetric population has a growing complexity, with an increasing age and rising number of patients with intercurrent diseases such as obesity, in turn increasing risk of complications during pregnancy and labour (47, 48).

Despite the large number of emergency triage systems that has been developed, the absolute majority are lacking specifications for triaging obstetric patients and are thus inapt for the obstetric population. To adequately triage the obstetric patient, the system needs to assess both woman and fetus, as well as labour status (49, 50). The alterations in vital sign parameters must be considered and potentially life-threatening disorders, only occurring during pregnancy such as preeclampsia, ablatio, or imminent preterm delivery are not assessed in non-obstetric triage systems (non-OTS). A slightly increased blood pressure in the non-obstetric patient may be a severe and urgent condition in the preeclamptic obstetric patient. Moreover, obstetric patients may present with either pregnancy-related conditions or with disorders unrelated to pregnancy. An adequate OTS must therefore include symptom descriptions that may identify a wider diversity in illness.

The obstetric emergency triage process differs from the general triage process by the fact that two different triage levels may emerge when the woman and the fetus are assessed, *figure 2*.

In general emergency care, no adequate assessment of the fetus is usually possible, therefore triage is limited to the woman and only uses the initial triage level.

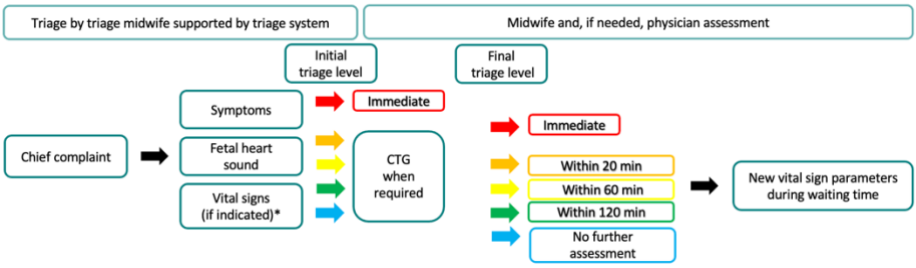

Figure 2 *Triage process of obstetric triage*
CTG – cardiotocography
*Vital signs are mandatory when the patient is triaged as green – red.

HISTORY OF OBSTETRIC TRIAGE SYSTEMS

The Emergency Medical Treatment and Active Labor Act (EMTALA)

As with the development of emergency triage into a medical tool, the development of obstetric emergency triage was initiated in the US, accelerated by legal changes occurring with the introduction of the EMTALA in 1986 (51, 52). By this, obstetric units were mandated to perform a structured assessment of patients seeking emergency care, assessing if a severe illness was present or if the patient was in active labour. The organized steps in triage were to be identical regardless of the location or size of the perinatal service and regardless of a patient's ability to pay. Violating this regulation could led to major financial consequences for the unit (51, 53).

Identifying the need for obstetric emergency triage

During the early 2000s, obstetric emergency triage was a fast-growing area of obstetric care internationally. Even so, it was not until 2011 that Paisley et al.

concluded that the obstetric medical field faces the same challenges as non-obstetric emergency care, with overcrowding leading to several problems (49). Lacking a structured triage system, the initial assessment of patients is based on a quick visual evaluation. Additionally, nurses assess the patients based on time of arrival and with inconsistency in their assessments of patients presenting with similar symptoms (49). The same pattern was found in paper I of this thesis (54), potentially resulting in unequal and biased care as well as inappropriate prioritization as patients do not always appear ill at first glance. Paisley et al. presented the first structured, five-level OTS, the Florida Hospital OB Triage Acuity Tool (49). The system was part of a quality improvement (QI) project, and no structured validation was performed. However, the project highlighted important aspects, such as the need for continuous education and the fact that without a triage system in place, urgent and semi-urgent patients were not seen quickly enough while less urgent patients were seen prior to what they required.

Following the identification of risks associated with not using a structured OTS, a Best Practice for obstetric emergency triage was established through a systematic review in 2014 (52). The need for a validated and reliable OTS in combination with the importance of teamwork was emphasized, recommending that the obstetric triage process should consist of a 10-20-minute initial assessment of both mother and fetus by a nurse or midwife (52). The need for obstetric triage was further stressed when the American College of Obstetricians and Gynaecologists issued a committee opinion, urging hospital-based obstetric units to collaborate with EDs to establish guidelines for triage of pregnant women (55).

The importance of a structured obstetric triage process has since become increasingly evident, with several, mainly Anglo-Saxon, countries following

the development of recommendations and OTSs (54, 56-60). In the yearly presented Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries (MBRRACE)-report, assessing all maternal mortality cases in the United Kingdom, the necessity of vital sign parameters assessment has repeatedly been stressed (3, 61). A peer-reviewed recommendation on obstetric emergency triage is currently (2023) being developed by the Royal College of Obstetricians and Gynaecologists (62). So far, no equivalent recommendation for Sweden has been presented and before the work for this thesis started, obstetric emergency triage was not practiced in Sweden.

Development of different OTSs

Since the development of the Florida Hospital OB Triage Acuity Tool other OTSs have been developed, *table 2* (54, 56-59, 63-66). As with non-OTS, OTSs are contextual with adaptations to local prerequisites such as medical guidelines, language, and pre-existing non-OTS. These adaptations are imperative to achieve a safe and adequate prioritization as both tradition in care, differences in area of responsibilities within staff categories, and the obstetric population differ in different contexts.

Table 2 *OTSs in developed countries*

System	Paper *Author*	Year Country	Modelled on	Levels	VP	Including initial management	Method			Key message
							Reliability	Validity	Staff experience	
ATS+ - Australasian Triage System										
	Triage of pregnant women in the emergency department: evaluation of a triage decision aid *McCarthy et al*	2013 Australia	ATS	5	Y	N	.	.	.	Implementing two algorithms can improve documentation and assessment for women triaged with two pregnancy-related symptoms.
OTAS – Obstetric Triage Acuity Scale										
	Implementing an obstetric triage acuity scale: interrater reliability and patient flow analysis. *Smithson et al*	2013 Canada	CTAS	5	Y	N	*IRR* Vignettes of ob/gyn cases	*Construct* LOS, Admission	.	OTAS has substantial IRR. Acuity level correlates to admissions to the antenatal and birthing units. 2/3 of visits were of lower acuity.
	Acuity Assessment in Obstetrical Triage *Gratton et al*	2016 Canada					*IRR* and *ITR* Written clinical scenarios	*Construct* Resource utilization	.	Overall substantial IRR with comparable IRR in one tertiary care and two community hospitals.
	The Impact of Standardized Acuity Assessment and a Fast-Track on Length of Stay in Obstetric Triage: A Quality Improvement Study *Smithson et al*	2016 Canada						*Construct* LOS		Reduction in overall LOS but poor correlation between LOS and level of acuity. Fast-track reduced LOS. OTAS enables improvements in patient flow.

System	Paper *Author*	Year Country	Modelled on	Levels	VP	Including initial management	Method			Key message
							Reliability	Validity	Staff experience	
MFTI – Maternal Fetal Triage Index										
	Content Validity Testing of the Maternal Fetal Triage Index *Ruhl et al*	2015 USA	ESI	5	Y	N	.	*Content* I-CVI	.	MFTI is a tool that can be introduced for use in clinical settings to improve patient and process outcomes
	Interrater Reliability Testing of the Maternal Fetal Triage Index *Ruhl et al*	2015 USA					*IRR* Comparing assessments by research- and triage nurse	.	.	IRR = 0.65
	Implementing an Obstetrics-Specific Triage Acuity Tool to Increase Nurses' Knowledge and Improve Timeliness of Care *Quaile*	2018 USA					.	.	Pre- and post-implementation testing with questionnaire	Improved nurse knowledge post implementation and education as well as improved timeliness of care with reduction in time to triage. Education about and use of OB triage should be part of obstetric nursing training
SETS – Swiss Emergency Triage Scale										
	Validation of an emergency triage scale for obstetrics and gynecology: a prospective study *Veit-Rubin et al*	2017 Switzerland	SETS	4	Y	N	*IRR* and *ITR* Vignettes of ob/gyn cases	*Criterion* Over- and undertriage	.	IRR = 0.75 and ITR = 0.81 The four-level SETS is a valid and reliable emergency triage tool

System	Paper *Author*	Year Country	Modelled on	Levels	VP	Including initial management	Method			Key message
							Reliability	Validity	Staff experience	
BSOTS – Birmingham Symptom specific Obstetric Triage System										
	The design and implementation of an obstetric triage system for unscheduled pregnancy related attendances: a mixed methods evaluation *Kenyon et al*	2017 UK	MTS	4	Y	N	*IRR* Vignettes of ob/gyn cases	*Construct* Several maternal and fetal outcome measures	Qualitative focus group interviews	Improved time to triage <15 min IRR = 0.96 High degree of satisfaction among midwives with improved knowledge
	Evaluating the implementation of the Birmingham Symptom-specific Obstetric Triage System (BSOTS) in Australia *Vasilevski et al*	2022 Australia						*Construct* TTT Timeliness of care	Qualitative focus group interviews	BSOTS is applicable to the Australian maternity context and supports the timely triage and care of women. The structured framework helped midwives to triage effectively
Iranian Ob triage index										
	The development and validation of an obstetric triage acuity index: a mixed-method study *Moudi et al*	2020 Iran	OTAS	5	Y	N	*IRR* Doubled real-life assessments	*Face* *Content* I-CVI *Construct* Admission, resource utilization, LOS *Criterion* Over- and undertriage	.	Good validity and reliability in a tertiary teaching hospital Multi-professional teams should be involved in triage system development

System	Paper *Author*	Year Country	Modelled on	Levels	VP	Including initial management	Method			Key message
							Reliability	Validity	Staff experience	
OTDA – Obstetric Triage Decision Aid										
	Validity of the Obstetric Decision Aid *McCarthy et al*	2018 Australia	ATS	5	Ukn	N	.	*Construct* Admission, recourse utilization		A higher triage category was significantly associated with admission to hospital
	Implementation of an obstetric triage decision aid into a maternity assessment unit and emergency department *McCarthy et al*	2021 Australia						*Construct* Actual implemen-tation in ED and MAU Timeliness of care	Self-ratings in confidence and competence	Implementation facilitated a streamlined process of care according to clinical urgency and the ability to prioritize workload Improvement in self-rated confidence and competence in Ob triage
GOTS – Gothenburg Obstetric Triage System										
	Improving Assessment of Acute Obstetric Patients – Introducing a Swedish Obstetric Triage System *Lindroos et al*	2021 Sweden	RETTS	5	Y	Y		*Construct* Admission, LOS	Unstructured verbal follow-ups	Implementation led to improved management with urgency-based prioritization. Both patients and staff express improved satisfaction with obstetric triage
	An interrater reliability study on the Gothenburg Obstetric Triage System – a new obstetric triage system *Lindroos et al*	2021 Sweden					*IRR* written clinical scenarios RNs and Midwives	*Criterion* Over- and undertriage	.	Overall IRR = 0.78 9 % overtriage and 21% undertriage

An overview of studies describing/evaluating OTSs developed in industrialized countries after the introduction of the Florida Hospital Triage Acuity Tool, according to publication year. *ATS* – Australasian Triage System, *CTAS* – Canadian Triage and Acuity System, *ED* – emergency department, *ESI* – Emergency Severity Index, I-CVI – item-level content validity index, *IRR* – interrater reliability, *ITR* – intrarater reliability, *LOS* – length of stay, *MAU* – Maternity assessment unit, *MTS* – Manchester Triage System, *N* – no, *RETTS* – Rapid Emergency Triage and Treatment System, *RN* – registered nurse, *TTT* – time to triage, *Ukn* – unknown, *USA* – United States of America, *VP* – Vital parameters, *Y* – yes

SWEDISH OBSTETRIC CARE

Sweden's delivery care is among the safest for both mother and child in the world, with a maternal mortality rate of 5-6/100.000 live births and a neonatal mortality rate, ranging from 1.3 – 1.8/1000 births since 2005 (67, 68). Since 2018, the intrauterine death rate has been around 3.2 permille, a very low rate from an international perspective (67). Nevertheless, patients still die due to avoidable causes and failure to identify severely ill patients cause avoidable morbidity.

Sweden has 47 delivery units with annual deliveries between 400 – 10.000 (median 2052; 2020) (69) and in 2022, 104.734 children were born (70). Apart from the Stockholm area, there is only one delivery unit for each geographic area and most pregnant women in the area give birth at this unit if not transferred due to medical complications, *figure 3*. Less than 1% of all births are home deliveries (71). The caesarean birth rate was 19.1% in 2022 including both planned and unplanned caesarean sections (72). Delivery care is free of charge, except for a symbolic sum for the partners that stay overnight at the postnatal ward.

The prenatal care system is standardized, free of charge and is provided primarily by midwives organized in antenatal care units. More than 99% of pregnant women attend their regular appointments, which in an uncomplicated pregnancy in a healthy mother is approximately eight planned visits (69). Most pregnant women attend routine prenatal ultrasound. Midwives are highly professionally autonomous and provide patient oriented care to healthy women with suspected uncomplicated pregnancies before, during, and after delivery (69, 71, 73). In case of intercurrent diseases or pregnancy complications obstetricians are consulted and/or responsible for the antenatal care. However,

obstetricians have a less dominant role in Swedish obstetrics compared to most other developed countries (71).

Patients can access medical counselling by telephone 24/7, either by contacting the national medical counselling phone 1177 (74) or by calling a consultant phone, provided by the different delivery units. In the latter, telephone triage by a senior midwife is applied, however, the triage is often subjective and without structured support.

The "unplanned emergency visits to overall birth volume ratio" is 1.2-1.5 (54, 75). In 2022 this was equal to approximately 126.000 – 157.000 obstetric emergency patient visits in Sweden (70). If need for emergency care arises, pregnant or newly delivered women are usually seen either in the delivery units, general ED, gynaecological ED, or obstetric outpatient department. Differences in location of provided care are related to gestational length, place of residence and thus proximity to a delivery unit as well as location of and organization within the different hospitals. Prior to gestational week 18-20, pregnant women are referred to either gynaecological or general EDs. Beyond gestational week 20, when the fetus approaches viability, care is predominately provided in either general EDs or delivery units.

These differences in place of management can result in unequal and potentially life-threatening care as staff in general EDs have vastly varying experience in managing obstetric patients and are not trained in the identification and management of obstetric emergencies (31, 76). Pregnant women are a known risk group of receiving deficient care due to the so called "obstetric delay"; patients do not receive care in a timely manner because of their pregnancy and the worry of harming the pregnancy by performing for example imaging diagnostics (1, 31, 77). Delivery units on the other hand are mainly focused on delivery care, and patients seeking emergency care are often cared for

alongside patients in active labour, without staff that are explicitly tasked or trained to handle emergency patients (78). This may result in inability to provide care in a timely manner. In addition, delivery units are staffed by midwives and obstetricians, highly trained in obstetric emergencies but often lacking updated knowledge on other critical illnesses. As pregnant women may present with both pregnancy related and unrelated conditions, risk of missing

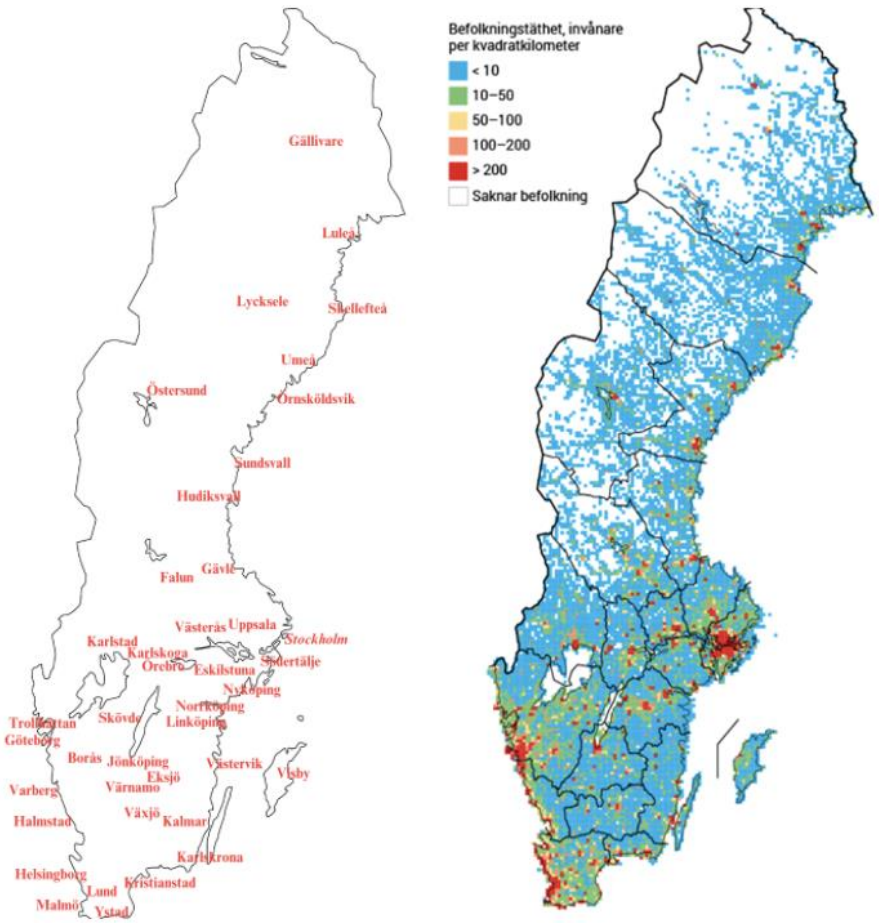

Figure 3 *Cities with delivery units (n=47) and population density in Sweden 2022. Stockholm has seven units (including Södertälje), other cities have one unit per city.*

urgent illness is present in all areas of obstetric emergency care.

When not applying obstetric emergency triage, obstetric patients are predominately assessed by time of arrival when managed in delivery units. In general EDs, obstetric patients may be allocated to an unnecessarily high acuity level due to lacking support for assessment and fear of the patient group itself. This may have severe consequences for other patients concurrently seeking care at the ED. At the same time, the obstetric patient may be allocated to a low level of acuity due to inability for non-OTSs and the inability of the triage nurse to identify a severe obstetric complication such as e.g. preeclampsia when much lower levels of blood pressure then in the general population need immediate assessment, *figure 4* (31, 60).

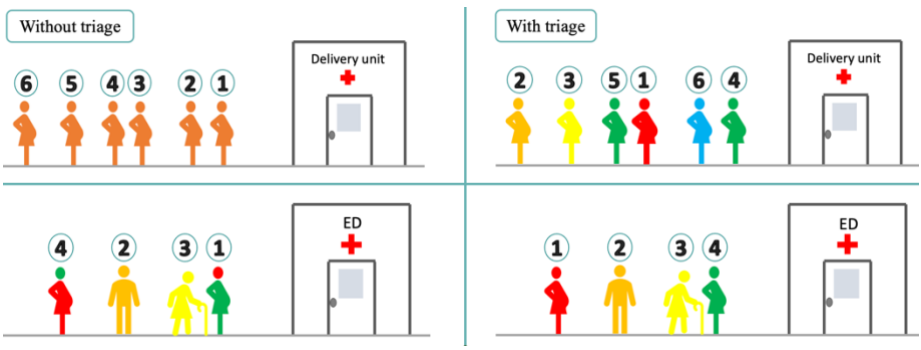

Figure 4 *Triage of obstetric patients in general EDs and delivery units. Color on body represents true acuity level, color on head represents applied triage level.*

GOTHENBURG OBSTETRIC TRIAGE SYSTEM (GOTS)

GOTS is Sweden's first OTS and was developed in 2016 as part of a quality improvement-project at the Department of Obstetrics/SU, Gothenburg. Due to patient safety concerns, the obstetric unit initiated a revision performed by a multidisciplinary team of obstetricians, midwives, auxiliary nurses, administrative personnel, healthcare developer, and managers, targeting management of obstetric patients seeking emergency care. A mapping process and repeated Strength, Weakness, Opportunities, and Threats (SWOT)-analysis (79) revealed similar deficiencies as concluded in previous research with an unstructured care process leading to implications for patient safety. Initial assessment differed depending on the current midwife working, and patients were assessed by time of arrival rather than by medical urgency (49, 54). A definition of an OTS was outlined, including both patient safety issues as well as organizational aspects (54).

The GOTS is a five-level triage scale with reference levels for vital sign parameters adapted to the physiological changes in pregnancy. Together with 14 chief complaint algorithms (CCAs) both symptom presentation and vital sign parameters constitute the basis for acuity level assessment, *figures 5* and *6* (54). The CCAs specify presentation of a specific symptom into five acuity levels and include a short overview on both possible obstetric and non-obstetric causes for the presenting symptoms. If different acuity levels are indicated by the chief complaint and vital signs, the higher level is assigned. Further, the algorithms incorporate recommendations on initial treatment and investigations, such as laboratory tests. The GOTS was intentionally structured to resemble the most frequently used non-OTS in Sweden, RETTS, to facilitate incorporation in both an obstetric and non-obstetric ED environment.

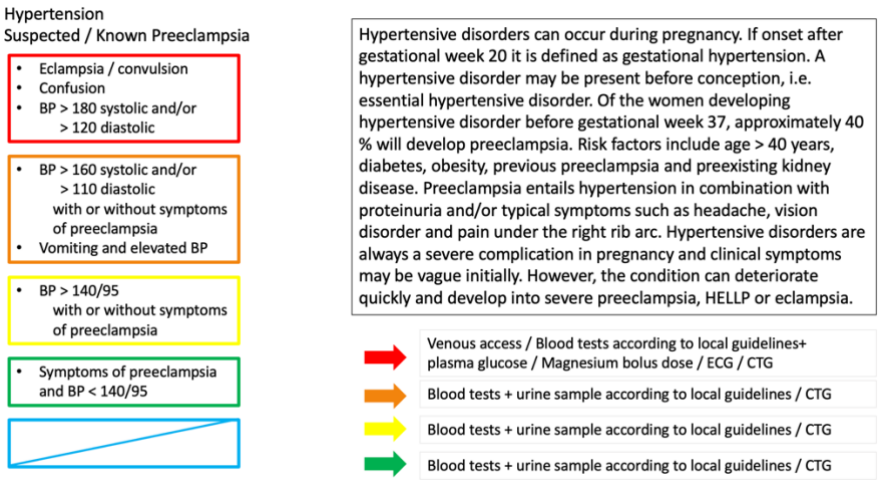

Figure 5 *Example of a chief-complaint algorithm in GOTS.*

When using GOTS for obstetric emergency triage, the patient is assessed by a midwife or RN in triage documenting the chief complaint and vital sign parameters on a supportive acuity form. One of five acuity levels, ranging from red (immediate) through orange (urgent) to yellow-green-blue (non-urgent), is assigned. Yellow to blue levels entail a low risk of critical illness and the patient can wait for further physician assessment, *figure 2*.

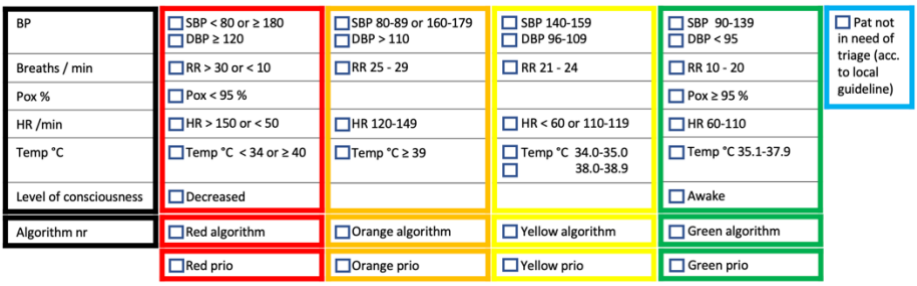

Figure 6 *Adapted vital sign parameters on the acuity chart used in GOTS.*
BP – blood pressure, *DBP* – diastolic blood pressure, *HR* – Heart rate, *POX* – pulse oximetry, *Prio* – prioritization, *RR* – respiratory rate, *SBP* – systolic blood pressure

EVALUATION OF OBSTETRIC EMERGENCY TRIAGE SYSTEMS

Validating emergency triage systems is essential to enable a safe prioritization of patients by adequately supporting triage nurses/midwives in their assessment of the patient. The system must be evaluated on two fundamental parameters; its' ability to correctly identify patients in different grades of medical urgency – the system's validity – and to which extent two or more assessors agree on triage level when using the system independently – the system's reliability (24, 80-82). The latter, reliability, has been the focus for previous research on OTS (83, 84).

Further, evaluation of the implementation process and staff experience is imperative to establish whether the system and its' subsequent working method are feasible and leads to improved care, maintained over time. Patient satisfaction should also be included in evaluation as this is of great importance in providing good and adequate care.

RELIABILITY

In the triage situation, various triage nurses/midwives/physicians should reach the same conclusion on triage level when applying the triage system for assessment on similar patients and under similar conditions (80). This consensus is called interrater reliability (IRR) and constitutes the foundation of validity in a triage system; if different users arrive at deviating conclusions it does not matter if the system is able to identify severely ill patients (80, 81), *figure 7*.

Reliability is not sufficient for establishing whether a triage system is a good and safe support system. Users may be highly coherent in their assessments,

but if the triage system fails to identify the correct patients, i.e, has low validity, it will still fail.

IRR-assessments are performed by several assessors at the same time. However, it is also possible to test for intrarater reliability, assessing the agreement of the same triage nurse/midwife/physician's assessments of a patient at different points in time. As reliability testing acquires similar circumstances at the different times of assessment, such studies are challenging. In addition, the tendency to remember previous patients or cases mandates enough time in between test-rounds.

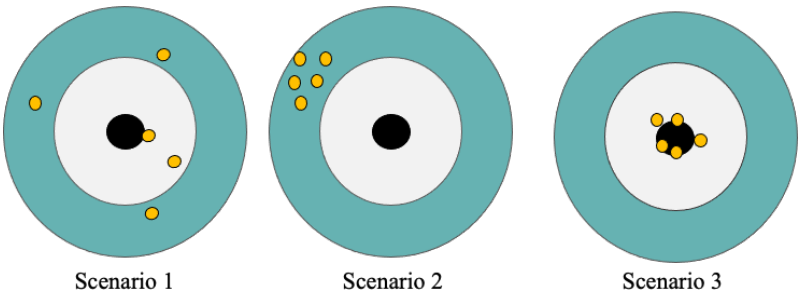

Figure 7 *Visualization of IRR and validity*
Five assessors are represented by yellow dots. In scenario 1, IRR is low; different raters come to varying conclusions. In scenario 2, IRR is good but assessments are still not near the true assessment (bullseye) hence, validity is low. In scenario 3, assessments are similar and close to the true assessment i.e., both IRR and validity are good.
(Inspired by Steiner, L and Norman G, - Precision and Accuracy: Two terms that are neither, 2006)

VALIDITY

Validity can be described as how closely an instrument approximates the truth. Within the field of triage, a generally accepted definition of validity is *"the degree to which the measured acuity level reflects the patient's true acuity at the time of triage"* (24). There are several types of validity, *table 3.*

Establishing validity in triage systems is challenging as no definition of true acuity exists. Continuing the "bullseye" analogy from *figure 7*, one could say that "the bullseye is missing". Thus, predictive construct validity is the most frequently used method of assessing triage systems. The surrogate outcome measures are often identified by expert consensus or chosen by convenience and face validity is usually high (15, 24, 82, 85).

Table 3 *Different types of validity*

Type of validity	Definition	Example in triage research
Criterion	Evaluates correlation of a system outcome to a true value or "gold standard"	- Comparing triage level attained by support of an OTS with a predefined true triage level - Over- and undertriage
Construct	Evaluates correlation of a system outcome to surrogate outcome measurements when true outcome or a "gold standard" does not exist	- Comparing triage level attained by support of an OTS with for example LOS, admission to hospital or mortality in ED
Predictive	A type of construct validity, assessing the degree to which a system can predict an outcome	
Content	Evaluates if a sample of items represents a certain construct	- Experts participates in consensus rounds establishing relevant items to include in a new instrument or tool - Quantified by calculating CVI
Face	Informal, subjective form of validity, established by the expertise of the experts developing a new system	- Discussion without structure, founded in expertise

CVI – content validity index (86, 87), *ED* – emergency department, *LOS* – length of stay, *OTS* – Obstetric triage system

It has been argued, that construct validity is the only assessable validity in triage research (85). Others claim that criterion validity, the most desirable type of validity, is equivalent to outcome measures established a priori by a group of experts, for example by letting experts assess patients and consensually decide on a true triage level (15).

Outcome measures

A variety of outcome measures have been used such as mortality in the ED or within different lengths of time, admission to ICU or hospital, length of stay (LOS) in the ED, resources utilization and costs (11). Good validity is often claimed by presenting a correlation between different triage levels and one or several of these outcomes, displayed by sensitivity and specificity or over- and undertriage.

However, such outcome measures do not necessarily reflect medical urgency at the time of triage assessment (11, 15, 24, 82, 88). The outcome measures are highly affected by local prerequisites such as ED organization, available resources as well as the situation in related in-house departments such as e.g., availability of hospital beds (89). Confounding variables such as variability in triage nurse/midwife experience and decisions, delayed and/or ineffective treatment and severity of illness are not accounted for (90). Additionally, the rationale for using such outcomes measures is rarely presented and reference standards or measures are yet to be established (15, 91). When applying the definition of validity within triage as *"the degree to which the measured acuity level reflects the patient's true urgency at the time of triage"* (24) these outcome measures have repeatedly been questioned (11, 15, 89, 92). The purpose of triage is not to predict outcomes, but to improve outcomes for the greatest number of patients (90).

To develop better suited outcome measures, *''a reference standard'',* for the urgency classification needs to be established (82). Not without facing critic of the method, it has repeatedly been proposed that a suitable method for establishing "a reference standard" could be the consensus focused Delphi method (24, 82, 93-96). The Delphi method is defined as "*a structured process that uses a series of questionnaires or "rounds" to gather information. Rounds*

are held until group consensus is reached" (94, 97). By letting experts within a field select relevant outcome measures through repeated rounds of consensus decisions, items concluded via a Delphi method have high face validity, which is an important prerequisite for further validity testing (94). In its original form, the Delphi method is strictly anonymous. However, different modified Delphi methods are often used instead, for example combining questionnaires and physical meetings (94, 96, 98).

There are extensive scientifical gaps in establishing validity in both non-OTSs and OTSs (11, 83, 84). A systematic review on non-OTSs established a wide range in sensitivity and specificity for different triage systems and outcome measures, without establishing neither reference values nor a recommendation on the preferred system to use (17). Adding to previous findings, a meta-analysis concluded a high risk of bias in several studies and with inconclusive definitions of outcome measures, results were incomparable (11).

Two reviews on OTS-validity have shown similar results. Apart from a study on content validity testing during the development of the Maternal Fetal Triage Index (MFTI), the reviews conclude that no sufficient testing for validity on any OTS has been presented (83, 84). More recently, several types of validity have been presented for the Iranian OB triage index. The methodology may be questioned as the previously criticised outcome measures are used for evaluation, and criterion validity is assessed by comparing the triage levels from the Iranian OB triage index with the triage levels of MFTI, a triage system deemed inapt for the Iranian context by the authors themselves. Hence, evaluation of the results is challenging. Nevertheless, it is the only study assessing sensitivity and specificity of an OTS, 75% and 77% respectively (59).

STAFF EXPERIENCE OF WORKING WITH OBSTETRIC EMERGENCY TRIAGE

As obstetric emergency triage is a relatively new working method and not yet as implemented as general emergency triage, research on staff experience in working with OTSs is limited. Within the non-obstetric context, triage is known to be the most error-prone activity at the ED (7, 12, 28), and traits such as courage, confidence, and rationality are important for triage nurses (29). In addition, performance of triage can depend on a variety of factors such as factual knowledge and triage experience (99, 100). Thus, differences in the perception of obstetric emergency triage among triage midwives are expected.

Within obstetric emergency care, the use of obstetric emergency triage can give rise to a perception of improved care, particularly highlighting the importance of communication and teamwork (35, 58, 101). However, challenges in implementing obstetric emergency triage have also been presented. Midwives lacking the extensive medical knowledge needed in triage as well as attitudes such as lacking willingness to change or a culture of "working like we always have done" have been identified (35, 102-104). For example, a tendency neglect abnormal vital sign parameters and thus assign an incorrect priority level has been found (64). These findings may, however, not be applicable in a Swedish setting as midwives in Sweden have a more autonomous profession compared to other developed countries, with the uncomplicated pregnancy and delivery independently managed without involvement of obstetricians or general practitioners.

As obstetric emergency patients may present in various areas of emergency care, the experience of general ED staff managing obstetric patients is important to assess. Previous findings show significant knowledge deficits when caring for patients with high-risk conditions associated with pregnancy,

putting obstetric patients at risk of medical errors or delay in medical interventions (31, 58, 65, 77). This may be a result of a centralization of pregnant patients to maternity units, reducing experience in managing them in other areas of medicine. Thus, it may be of even greater importance to facilitate safe and standardized triage in a non-obstetric environment.

PATIENT EXPERIENCE AND ANTICIPATIONS ON OBSTETRIC EMERGENCY TRIAGE

Even though an unanimous definition of patient satisfaction is lacking, it has become increasingly important within all aspects of medical care, including emergency care (105). In Sweden, health care providers are obligated by law to involve patients in their own care (106), and evaluation of care quality is no longer just focused on medical outcome measures but also on patient satisfaction. This is especially evident in countries with a high level of private care providers, where patient satisfaction is an important factor in a competitive health care market (78).

Research evaluating patient satisfaction in a health care unit using obstetric emergency triage as a working method is scares but show improved patient satisfaction when visiting a triage unit (78, 107, 108). However, not all units apply triage supported by an OTS as the term “triage unit” rather is used to define a unit managing obstetric patients seeking unplanned care without being in labour as opposed to assessing patients in a delivery ward.

Physician-patient interaction, information to patients, and waiting time are important factors for patient satisfaction in triage (105). Patients perceive that the real examination is initiated when triage is performed and the triage process creates experiences of respect and understanding from staff. Patients also tend to accept the priority rules associated with triage and trust that all necessary information is provided, feeling reassured and welcome (108, 109).

IMPLEMENTATION SCIENCE

Fulfilling an implementation of a new or altered working method or routine is usually accompanied by several challenges and insights. For example, when evaluating whether the implementation was successful or not it is of great importance to address whether a potential failure was due to the working method lacking essential components or due to a faulty implementation process.

Implementation science addresses and explores the so called "science-practice gap", constituted by the fact that only 14% of research reaches a patient (110). It offers systematic assistance and evaluation of planning, performing, and evaluating implementation endeavours, such as the implementation of GOTS in paper I. Defined by Bauer and Kirchner, implementation science is *the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practice into routine practice and, hence, to improve the quality and effectiveness of health services* (111). As opposed to controlling the context as done in efficacy studies (the ability to produce a desired or intended result) and effectiveness studies (the degree to which something is successful in producing a desired result), implementation science engages with the actual context and explores barriers and facilitators that may obstruct or enable successful implementation (111).

Implementation of a new, evidence-based practice is part of a "*diffusion – dissemination – implementation continuum*"; diffusion being defined as the passive, untargeted and unplanned spread of a new practice within a social system (112). Dissemination is the active spread of new practices, using planned strategies. Finally, implementation is the process of integrating new evidence-based practices within a specific setting (113).

Implementations science uses varying theoretical approaches, so called theories, models and frameworks (TMFs) with three overarching aims, *table 4* (113). Models tend to be narrower in scope compared to frameworks and theories (114). By applying one or a combination of several TMFs, an implementation of a new working method such as obstetric emergency triage can be evaluated regarding whether a failure of implementation is due to a failed innovation (i.e., the working method itself) or due to a failed implementation.

Table 4 *Aim and approach of theories, models, and framework*

Overall aim	Approach	Type of TMF	Mechanism
Theoretical approaches used in implementation science	Describing and/or guiding the process of translating research into practice	Process models	Specifies steps to describe and/or guide the process of transferring scientific knowledge into clinical practice. Provides practical guidance.
	Understanding and/or explaining what influences implementation outcome	Determinant frameworks	Specifies determinants, acting as barriers and/or facilitators and influence implementation outcomes. Aims to understand and/or explain such determinants influence on implementation outcome.
		Classic theories	Provides understanding of aspects of implementation from an external point of view. Theories originate from other scientific fields such as psychology and organizational theory.
		Implementation theories	Theories developed within the field of implementation science and knowledge of aspects of implementation.
	Evaluating implementation	Evaluation frameworks	Specific for evaluation of implementation success. Differentiating outcomes separates evaluation of the implementation effectiveness and the treatment effectiveness.

Table inspired by (Nilsen, P. Making sense of implementation theories, models, and frameworks, 2015) (113).

There are similarities between implementation science and QI however, the approaches differ on significant areas. QI often begins with a specific problem rather than the introduction of an evidence-based practice. Additionally, QI usually targets on an individual department or hospital and tends to not

contribute to generalizable knowledge. On the other hand, implementation science structurally evaluates strategies for increasing the uptake of an evidence-based practices into routine practice (111). TMFs enable a systematic research approach to study implementation and testing of interventions by providing a common language and a structure (114).

AIM

The ultimate aim of this doctoral thesis is to contribute to the reduction of maternal mortality and morbidity by the introduction of a new working method within obstetric emergency care. Aiming at this, the development and implementation of the GOTS is presented combined with evaluation of GOTS' reliability and validity. Obstetric staff experiences in working with obstetric emergency triage is explored, identifying factors affecting adoption of the working method.

SPECIFIC AIMS

Paper I

To present the development, implementation, and initial evaluation of an OTS.

Paper II

To determine the IRR of the GOTS in obstetric and non-obstetric emergency care staff as well as to assess the clinical accuracy and relevance of the IRR.

Paper III

To explore and describe midwives', auxiliary nurses' and obstetricians' experiences of working with obstetric emergency triage in a Swedish setting.

Paper IV

To develop a set of weighted surrogate outcome measures representing urgency at the timepoint of triage for construct validation of OTSs.

Paper V

To establish GOTS' validity according to outcome measures reflecting urgency in the moment of triage.

METHODS

The thesis applies both quantitative and qualitative approaches. This section provides an overview of the methodologies included, summarized in table 5.

Table 5 *Overview of papers included in thesis*

Variables	Paper I	Paper II	Paper III	Paper IV	Paper V
Setting	SU		Obstetric unit in eastern Sweden	SU	
Type of study	QI-implementation project	IRR	Qualitative	Modified Delphi method	Retrospective cross-sectional
Sampling	Cluster	Convenience	Purposive	Purposive	Cluster
Participants / patients (n)	Patient records (380)	Midwives and RNs (13)	Midwives, obstetricians and auxiliary nurses (13)	Midwives and obstetricians (10)	Patient records (1283)
Data collection period	2016 – 2020	2018 – 2019	Apr – June 2021	2021 – 2023	1st – 17th Jan 1st – 17th June 2021
Source of information	Systematic medical chart reviews SWOT-analyses Questionnaire Literature review	Ratings of 30 paper-case scenarios converted from real-life cases	In-depth interviews	Questionnaires Discussion rounds	Systematic medical chart reviews
Statistics / analysis	Descriptive	Kappa statistics (ICC) Descriptive	Qualitative content analysis *Graneheim and Lundman*	Descriptive Consensus	Descriptive Sensitivity / specificity
Outcomes	Description of development and implementation of GOTS Initial validation	Interrater reliability of GOTS Over- and undertriage compared to expert triage	Experience of working with OET in a Swedish setting	31 outcome measurements for construct validation of OTSs	Sensitivity and specificity of GOTS Over- and undertriage

ICC – intraclass correlation coefficient, *IRR* – interrater reliability, *OET* – Obstetric emergency triage, *OTS* – obstetric triage system, *QI* – Quality improvement, *RN* – registered nurse, *SU* - Sahlgrenska University Hospital, *SWOT* – strength, weakness, opportunity, threat
(n)=number of participants

SETTING

Paper I, II, IV, V

The Department of Obstetrics/SU is a tertiary care hospital with approximately 9.000 – 10.000 births yearly, *table 6*. It serves as a county hospital for slightly over 0.5 million inhabitants and is the referral hospital of three county hospitals, providing care for an additional 1.2 million inhabitants. The obstetric department handles all types of pregnancies, has 24/7 immediate operating accessibility and neonatal care from week 22+0. Aside from midwives and auxiliary nurses there are, at a minimum, two senior obstetricians and two residents on sight.

The unit has an obstetric ED, annually managing 14.000 emergency visits from gestation week 18+0 until 12 weeks postpartum. The obstetric ED uses GOTS for triage since April 2017 with triage performed by midwives experienced in antenatal care and delivery (54). Obstetric patients with severe respiratory, circulatory and/or neurological symptoms, are directed to the general ED. At the time of the studies, the obstetric ED was always manned by at least two midwives and one auxiliary nurse together with one of the above-mentioned physicians.

Paper III

The study was performed at an obstetric department in eastern Sweden, annually managing approximately 6.000 deliveries (≥ gestational week 32). Obstetric triage was implemented six months before data collection. The implementation was preceded by lectures on the working method and the triage system itself, in this case GOTS. At the time of the study, the staff allocated for emergency care of obstetric patients during daytime consisted of two midwives, one auxiliary nurse and one to two obstetricians. Alongside

Table 6 *Population demographics in the area of the Department of obstetrics/SU, 2022*

	(n)	(%)
Deliveries	8902	100
Primiparas	4240	47.6
Smokers, at booking for antenatal care in early pregnancy		
Yes	192	2.2
Missing	196	2.2
BMI		
• ≤ 18.5	152	1.8
• 18.5 – 24.9	4629	55.0
• 25 – 34.9	3267	38.8
• 35.0 – 39.9	267	3.2
• ≥ 40	106	1.3
Missing	481	5.4
Number of antenatal visits (standard programme: 9-10 visits)		
• ≤ 7	1407	15.9
• 8 – 12	6169	69.5
• ≥ 13	1300	14.6
Missing	26	0.3
Country of origin		
• Sweden	5483	69.1
• Other Nordic countries	62	0.8
• Other European countries	667	8.4
• Other countries	1727	21.8
Missing	963	10.8

Information from Swedish Pregnancy register (72).

managing obstetric emergency care patients, the midwives also manned a patient telephone and, together with the obstetrician, managed home inductions. During on-call hours, one to two midwives and one obstetrician staffed the unit alongside other units. Triage was performed by a midwife, though vital sign parameters were usually assessed by auxiliary nurses.

PARTICIPANTS AND SAMPLING

With sampling of participants for a study being imperative for the possibility to draw conclusions from the results, there are several approaches applicable.

Sampling and participants for papers I-V

For paper II, participants were sampled by voluntary response sampling, inviting all midwives and RNs, respectively, performing triage on a daily basis at the hospital's obstetric and general EDs. No other inclusion criteria were set to enable a sufficient number of participants. This was especially true for the midwife group, as no other unit in Sweden used obstetric emergency triage as a working method at the time of study II. Six midwives and seven RNs chose to participate.

For papers III and IV, participants were sampled by purposive sampling. In paper III the inclusion criteria for midwives, auxiliary nurse, or obstetrician was to have worked recurringly at the obstetric ED during the time period that obstetric emergency triage had been in use i.e., the last six months. Having an inductive, qualitative approach of exploring varieties in experiences of working with obstetric emergency triage, the thirteen included informants (of 47 eligible) constituted a sample with extensive diversity. In paper IV, a range of expertise in specific fields of maternal-fetal medicine and extensive experience in obstetric clinical care was sought in the participants in order to define relevant outcome measures. All participants had between five and thirty years of professional clinical experiences.

In paper I and V, cluster sampling was performed. In paper I, a random sample of 380 consecutive medical records were reviewed. This was deemed sufficient to assess the most common causes for seeking emergency care. For paper V, as there are no known differences in search patterns over the weeks of a month, two clusters of a total of 1280 medical charts on patients seeking emergency

care at the obstetric ED/SU during the time periods of 1st-17th January 2021 and 1st -17th June 2021 were reviewed. The periods were chosen to include differences in presentation of infectious diseases, which are known to vary with season.

Participation consent

For paper II, participants were verbally informed that participation was voluntary and could be terminated at any given time without explanation. Assurance on data confidentiality was given. In accordance with the ethical approval, participants gave verbal consent to participate. In papers III and IV all participants were given the same information both in writing and verbally and participants gave written consent to participate.

DATA COLLECTION

Paper I

Paper I was a QI-project conducted in five phases, outlined in *figure 8.* While including a literature review of obstetric triage, main emphasis was on the development and subsequent implementation as well as initial validation of a new OTS.

The Department of Obstetrics/SU has used a standardised but unvalidated questionnaire for patient satisfaction evaluation for more than ten years, *supplementary Paper 1*. Patient satisfaction in paper I was based on this local questionnaire, thus enabling comparison of patients' satisfaction before and after implementation of GOTS.

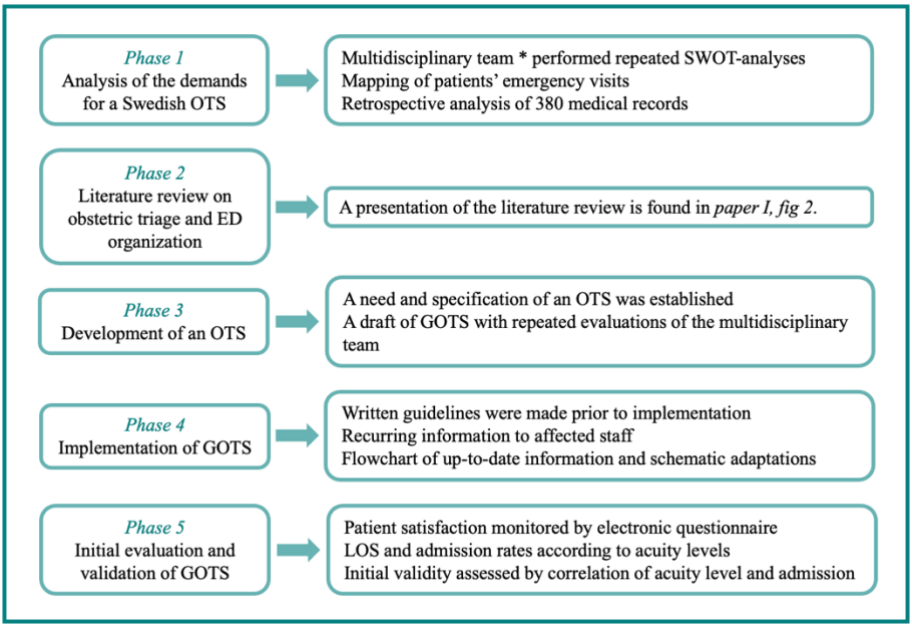

Figure 8 *The five phases of data collection and preparation of paper I.*
*Obstetricians, midwives, auxiliary nurses, administrative staff, healthcare developer and unit manager.
ED – emergency department, *GOTS* – Gothenburg Obstetric Triage System, *LOS* – length of stay, *OTS* – obstetric triage system, *SWOT* – strength, weaknesses, opportunities, threats

Paper II

IRR measures the consistency of two or more assessors assigning the same triage level when assessing the same patient individually, under similar conditions. Reliability is a precursor and foundation for validity in an OTS (80, 81).

Thirty real-life obstetric emergency cases were selected consecutively during two months. The cases were transferred into paper-cases, *appendix 1*. Prior to data retrieval, the cases were proofread to avoid risk of misinterpretation of available information. The midwives and RNs thereafter individually and anonymously triaged the 30 paper-case scenarios one-by-one. The scenarios represented all 14 GOTS CCAs and all five acuity levels. The cases were thus

not representative of the actual patient spectrum seeking care at the obstetric ED.

To enable evaluation of the clinical relevance of the assessments made by midwives and RNs, a reference group of two senior obstetricians and two senior midwives established a "true" triage level for each case by complete consensus. All participants, including members of the reference group, were unaware of the real-life triage level and outcome of the cases.

Paper III

In paper III, a qualitative study design was applied. Qualitative, semi-structured in-depth interviews were conducted by the PhD student. According to participants preferences, interviews took place either by zoom (115), telephone or face-to-face.

To avoid possible negative consequences of criticizing one's own workplace in front of colleagues, interviews were performed one-on-one with the exception of one case in which two participants were interviewed together at their own request (116). The open question: "What is your experience of obstetric triage as a working method?" initiated the interviews and was followed by questions such as "Can you explain a bit more?" and "Can you elaborate?" All interviews were audio-recorded, lasting 10 - 45 minutes (mean 33 minutes).

Paper IV

A four-round modified Delphi process was performed during 2021-2023, summarized in *figure 9*. Seven obstetricians and seven midwives were invited to participate. Due to the different responsibilities of professions in the obstetric ED, only obstetricians participated in rounds two to four. The four rounds were conducted by a combination of online anonymous questionnaires

and physical meetings. In round two and four, when physical meetings constituted the information retrieval process, a comfortable meeting atmosphere was created. The PhD student facilitated the meetings to assure that all participants were able to express thoughts and opinions.

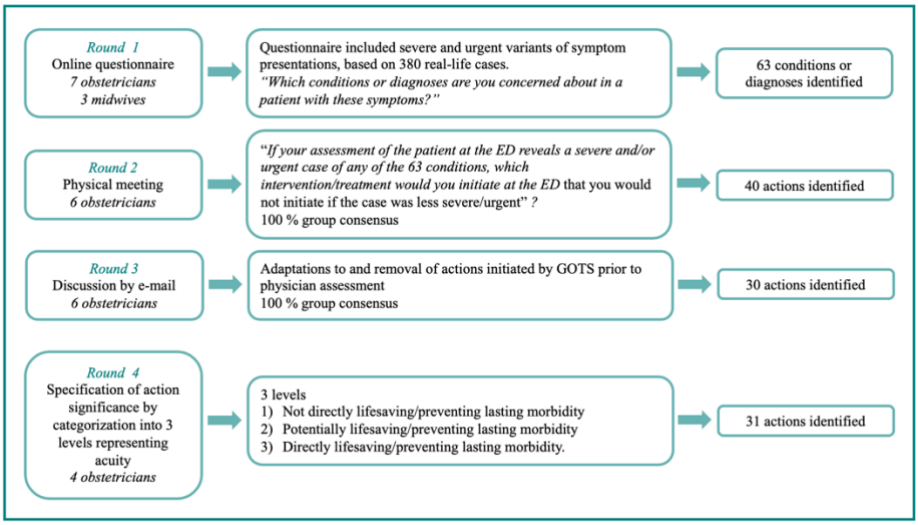

Figure 9 *A summary of the four round modified Delphi-process. Due to study aim, midwives did not participate beyond round one.*

Paper V

Data was retrieved by systematic patient records reviews and was collected from the electronic patient record systems Elvis, Obstetrix, Melior and E-arkiv. Information retrieval included demographics such as age, BMI, smoking, and parity as well as triage level at the current emergency visit, vital sign parameters, and assigned CCA. Additionally, all outcome measures defined in paper IV were registered.

To assure correctness of retrieved data, a quality audit was performed on 10% of the medical records. Reassessment of every 10th medical record revealed only 0.3% of deviating registrations, thus concluding data retrieval to be of high quality.

DATA ANALYSIS AND STATISTICS

Where applicable, 95% confidence intervals (CI) and two-sided calculations were applied. A summary of the statistical/analytical methods included in the thesis papers are presented in *table 7*.

Table 7 *The statistical/analytical methods included in the thesis papers I-V.*

Statistical/analytic method	Paper I	Paper II	Paper III	Paper IV	Paper V
Descriptive statistics	X	X			X
Measurement of agreement, Kappa-statistics		X			
Qualitative content analysis, Graneheim & Lundman			X		
Consensus discussion		X		X	
Sensitivity and specificity					X

Descriptive statistics

For descriptive categorial variables numbers and percentage was used. For continuous variables with skewed distribution, median and range were used. Should data have had a normal distribution, mean and standard deviation (SD) would have been used.

Measurement of agreement

Measurement of agreement, IRR, is assessed by using kappa statistics. This method is applicable when agreement between raters is of interest. There are several types of kappa statistic, however, the intra-class correlation coefficient (ICC) is to be used when data is measured on a continuous scale. ICC is a type of weighted kappa, assigning different weights to different levels. A wider deviation in assessments between assessors will weigh heavier than a narrower deviation i.e., if one assessor chooses the red triage level for a patient where most assessors choose the green level, the red triage level will lower the IRR more than if the participant had chosen a yellow triage level in the same

situation. The weighted kappa was chosen as it is clinically more relevant to choose a more deviating level.

In paper II, IRR is presented both as percentage level of absolute agreement and as a weighted Kappa value calculated by ICC with 95% CI, presenting both the magnitude of difference in assessments as well as adjusting for the possibility of participants guessing the same triage level (81).

Qualitative content analysis

Qualitative study design facilitates an exploratory approach to understand individuals' experiences with a phenomenon in their natural context and is used when knowledge on the study topic is limited (117). Following verbatim transcriptions, data in paper III were analyzed with inductive content analysis, as described by Graneheim & Lundman (118). Familiarization with the text was accomplished by several read-throughs and subsequently, meaning units were identified. The data were clustered into subcategories and categories through condensation and subsequent coding. All codes, subcategories, and categories were identified by dialogue and consensus among the authors, to strengthen credibility (118). The Consolidated Criteria for Reporting Qualitative Research (COREQ) was applied (119).

The Delphi method

The process of data analysis is comprehensively presented in supplement 1, paper III. Between each round the authors compiled the data and adapted them to local recommendations. For example, the intervention electrocardiogram was removed after the second round as it is part of the actions recommended by GOTS when patients present with certain symptoms. All suggested changes were consensually accepted or rejected.

Sensitivity and specificity

Assessing sensitivity and specificity is possible when there is a true or correct value for comparison (81). Sensitivity refers to a test's ability to correctly identify patients with an urgent condition and triage these into a red or orange triage level, the so-called true positives. Specificity refers to the test's ability to correctly identify patients without an urgent condition and triage these into a yellow, green or blue triage level, the so called true negatives (120). As there is no definition of true acuity within triage, sensitivity and specificity calculations require defined construct outcome measures as done in paper IV or a consensually determined correct triage level as done in paper II. These outcome measures can then be compared it to the actual triage level assigned in real-life. Calculations of sensitivity and specificity is performed as shown in *figure 10*.

	True acuity of condition	
Triage level	Urgent	Non-urgent
🔴/🟠	a	b
🟡/🟢/🔵	c	d

Sensitivity = a / (a+c)

Specificity = d / (b+d)

Figure 10 *Method for calculating sensitivity and specificity.*

The optimal triage system would prioritize all patients to a correct triage level compared to their urgency i.e., have a high sensitivity and specificity. However, as discussed later on, triage systems are merely supporting systems and prioritizations are influenced by both the knowledge and sometimes biases of the triage nurse/midwife as well as external factors such as other patients currently at the ED. Therefore, the optimal triage system cannot exist and as there are no reference values for sensitivity and specificity, rather a rationale for acceptable cut-off levels in the current context must be applied. The

sensitivity and specificity concepts are interrelated and most commonly cannot be optimized without affecting one another (120). Increasing sensitivity i.e., creating a system that is very likely to adequately identify and prioritize truly urgent patients into the red or orange triage levels will most likely decrease the ability to rule out urgency and prioritize patients into yellow, green or blue levels, hence reducing specificity.

When applicable, data were analyzed using SPSS Statistics, version 27 and 28.

ETHICS

All studies were approved by the Regional Ethical Review Board in Gothenburg and/or by the Swedish Ethical Review Authority, Dnr 783-18 (Oct 8th 2018), Dnr: 2020-04988 (Nov 10th, 2020), amendment 2022-05601-02 (Nov 4th, 2022)

RESULTS AND COMMENTS

This section provides a summary of results presented for each paper individually. A more comprehensive presentation can be found in each paper. The results are accompanied by elaborating comments.

Paper I

The aim of this study was to present the development, implementation, and initial evaluation of an OTS.

Phases 1 and 2 Analysis of the demands for a Swedish OTS and literature review

Mapping of the emergency care process revealed several areas requiring improvement such as the care process being unstructured, patients were placed in the waiting area together with booked patients without any medical assessment, and assessments were dependent on the midwives' experience. Patients were prioritized for care according to time of arrival rather than by medical need. In addition, the current working method did not allow for organizational evaluations, lacking predefined outcome measures and overview of patient flow.

The literature review on OTSs and studies on general emergency triage identified two key factors to address – triage and separating planned patients and patients seeking emergency care. A scares amount of previous research on obstetric emergency triage was found, unfortunately not providing any guidance to an applicable OTS. At the time, only three previous OTSs were identified, none of which were tested for external validity or adapted to the Swedish context. A compilation of the literature review can be found in paper I (54).

A retrospective medical chart review identified the predominant causes for seeking emergency care. These causes constituted the foundation for the development of the CCAs of GOTS.

Phase 3 Development of an OTS

A need for a new Swedish OTS was identified. It was to include both symptoms and pregnancy-adapted vital sign parameters. To ensure patient safety, it was to be aligned with national guidelines. To facilitate an easier implementation it should preferably resemble the predominately used non-OTS. Implementation should at the same time not affect patient- and staff satisfaction negatively, while also providing a structure for organizational evaluation. A first draft was produced and was repeatedly reassessed with input from the multidisciplinary team, allowing for changes to facilitate clinical appropriateness.

Phase 4 Implementation

To enable the implementation of GOTS and the consequential changes in working method and patient flow, several organizational, administrative, and facility changes were made. Among other adaptations, a new administrative time registration system was taken into use, and a triage room was equipped. Scheduled and emergency patients were separated into different waiting areas. To support implementation of GOTS, clear guidelines and information was distributed to both medical and administrative staff. A flowchart of the process provided up-to-date information, and someone from the multidisciplinary team was initially always on sight to take care of any potential complications or queries.

The implementation of GOTS enabled evaluation of effectiveness, such as changes in LOS, waiting time, and total obstetric triage volumes per hour. This enabled a more effective staff allocation and process planning.

Phase 5 Initial evaluation

Initial evaluation of the system showed a positive correlation between higher acuity levels and admissions, indicating good construct validity. Time to assessment by an obstetrician was proportional to the acuity level, *figure 11*. The blue category had a shorter waiting time as well as a slightly higher admission rate than the green category. The patient group triaged as blue include, amongst others, patients with suspected rupture of membranes and scheduled semi-acute patients that are seen at the obstetric ED. These patients are seen before the acute patients triaged as green and are to a higher degree admitted due to local guidelines such as induction of labor when amniotic water is stained.

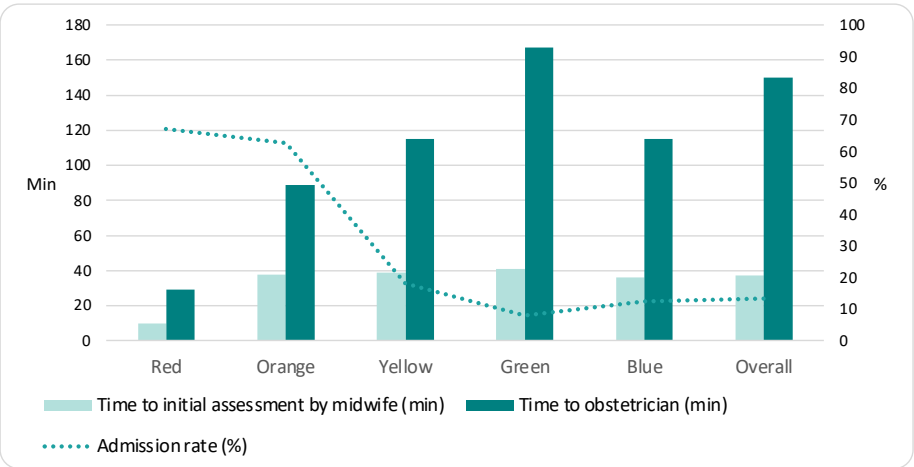

Figure 11 *Time (min) to initial assessment by midwife and obstetrician after triage and admission rate (%), stratified by triage level.*
Admission rates correlate to triage level, with a higher degree of admissions in the higher acuity levels (falling urgency from red to blue). Obstetric ED/SU, Feb-March 2020, 2 486 visits

Patient satisfaction, measured as a composite, weighted outcome of satisfaction with treatment, participation in decision-making, and accessibility of the unit according to a five-level Lickert scale, had been steady at 80% satisfaction since 2015. In 2019 the satisfaction increased to 86%. Causality between GOTS and patient satisfaction could not be established as other organizational changes occurred concurrently. Nevertheless, the findings were reassuring.

Initially, midwives and auxiliary nurse were skeptical of the working method. However, evaluation of the staffs' experience showed a sensation of increased security and structure embodied by the knowledge of "who is waiting in the waiting area" and in knowing in which order to assess the patients. The staff experienced less stress, and communication between professions was perceived as more objective and direct, aligning with previous research (30).

Comment

The study presents a successful implementation of a new working method that has provided the staff with an improved overview of patients seeking emergency care, and enabled the department to follow patient flow in a structured way. QI-projects of this character share several similarities with implementation research, which aims to introduce evidence based practices into clinical practice, and such an approach could have been applied (111). While the project started off as an QI-project, performing the literature review and identifying the need for a Swedish OTS made it increasingly evident that this was not a local problem. Rather, a national deficit in obstetric emergency care became evident and the study evolved more towards implementation research.

Applying a TMF

By applying a TMF to the project constituting paper I, a more transparent evaluation of implementation might have been achieved. A retrospective evaluation of the project using the Quality Implementation framework (QIF) (121), *table 8*, shows that several aspects of the QIF were indeed taken into account during the planning and executive phases of GOTS' implementation.

The QIF is a process model, specifying and describing steps of an implementation process. It is a synthesis of 25 implementation frameworks and has a pragmatic approach to step-by-step implementation, used to guide planning, monitoring, and evaluations of an implementation. It addresses four different phases of the implementation process with 14 associated action steps and emphasis is put on phase one and two i.e., planning and creating a structure for implementation (121).

GOTS was repeatedly evaluated and assessed by the multidisciplinary team, facilitating a dynamic process with high level of adaptation to context such as local circumstances, supporting participation in implementation from all involved categories of staff and reducing the sense of hierarchy between staff categories, otherwise often present in hospital settings. All major changes were documented by the PhD student leading the implementation.

Evaluation of patient satisfaction was performed using an unvalidated questionnaire. The questionnaire has been in use for more than a decade and no other assessment of patient satisfaction was available at the time of the study. The unvalidated questionnaire was therefore deemed adequate as it provided the ability to identify changes in patient satisfaction over time.

Table 8 *Summary of the four implementation phases and 14 critical steps in the Quality Implementation Framework (QIF) that are associated with quality implementation*

Implementation phases and critical steps in QIF	Corresponding action in implementation of GOTS	Outcome/Consequence
Phase One: Initial consideration regarding the host setting		
Assessment strategies		
1. Conducting a needs and resources assessment	Mapping patient pathway. SWOT-analysis. Medical record review.	Deficiencies in patient care and organization identified.
2. Conducting a fit assessment	Literature review. Mapping patient pathway. SWOT-analysis.	Separating planned and un-planned patients and applying triage was found to be feasible.
3. Conducting a capacity/readiness assessment		Not performing a readiness assessment may have led to increased initial resistance to changing working method.
Decisions about adaptation		
4. Possibility for adaptation	GOTS algorithms were repeatedly evaluated and prior to implementation it was decided that adaptations to facilitate clinical appropriateness could occur.	Midwives and auxiliary nurse were able to co-develop the system to achieve a clinically relevant system, supporting them in their clinical work.
Capacity-building strategies		
5. Obtaining explicit buy-in from critical stakeholders and fostering a supportive community/organizational climate	Management and stake-holder support was assured, elaborated further down.	Continuous support for implementation reduced queries and visualized the importance of the project.
6. Building general/organizational capacity		
7. Staff recruitment/maintenance	Staff allocations and schematic changes made staffing possible. Later new recruitments took place.	Staff got more variability in their work task.
8. Effective pre-innovation staff training	Information was given to both medical and administrative staff on regular workplace meetings. No training sessions took place.	Staff had an understanding of what the working method included.
Phase Two: Creating a structure for implementation		
Structural features for implementation		
9. Creating implementation teams	The multidisciplinary team also worked as implementors; members became leaders within their own staff category*.	A quick and direct pathway to address questions and queries, priming the deliverers (staff members) to the implementation process.

10. Developing an implementation plan	A clear implementation plan was created and a flowchart of the process provided up-to-date information.	Reduced questions and queries.
Phase Three: Ongoing structure once implementation begins		
Ongoing implementation support strategies		
11. Technical assistance/coaching/supervision	Organizational, administrative and facility changes. New time registration system. Equipping a triage room.	Enabled the working method and adequate evaluation of the unit which prior to implementation was not performed.
12. Process evaluation		
13. Supportive feedback mechanism		Lacking a supportive feedback mechanism was deemed a major deficit in the implementation process.
Phase Four: Improving future applications		
14. Learning from experience	Ongoing.	

Meyers DC, Katz J, Chien V, Wandersman A, Scaccia JP, Wright A: ***Practical implementation science: developing and piloting the quality implementation tool****. Am J Community Psychol 2012)*

*Each group member was responsible for their own area of expertise with a high-level of autonomy and trust between the implementation group members.

GOTS – Gothenburg Obstetric Triage System, *SWOT* – strength, weakness, opportunities and threats

Paper II

The aim of this study was to determine the IRR of the GOTS in obstetric and non-obstetric emergency care staff as well as to assess the clinical accuracy and relevance of the IRR.

Midwives and RNs completed 388 assessments from the 30 paper-case scenarios. Absolute agreement was seen in 69.6%. The overall ICC Kappa value for the final triage level was 0.78, establishing good IRR. Separate analyses of midwives' and RNs' final triage level revealed a somewhat higher Kappa value for the midwives (κ =0.82 vs. 0.76, *table 9*). Nevertheless, both groups had good IRR.

Table 9 *Kappa value presented by ICC for midwives, RNs and real-life assessments.*

	ICC	95 % CI
Midwives	0.82	0.73 – 0.90
RNs	0.76	0.65 – 0.86
Overall[(a)]	0.78	0.69 – 0.87
Real-life assessments [(b)]	0.93	0.86 – 0.97

Kappa values are interpreted as poor (< 0.5), moderate (0.5-0.75), good (0.75-0.9), and excellent (> 0.90).
[(a)] Assessments made by midwives and RNs as one group
[(b)] Real-life assessments, handled as performed by a separate assessor compared to reference triage level set by reference group i.e., hence IRR calculated for two groups
CI – Confidence interval, *GOTS* – Gothenburg Triage System, *ICC* – Intra-class correlation (2.1), *IRR* – intrarater reliability, *RN* – Registered Nurse

Over- and undertriage was seen in 9.3% and 21.1%, respectively. Sixty percent of the undertriaged cases was found in the two highest acuity levels and of these 55% (n=27) crossed the urgent/non-urgent barrier, see table 4 and figure 2 in paper II.

A sub analysis of the undertriaged cases showed that the main reason was not reacting to vital sign parameters, with RNs neglecting elevated blood pressure levels and midwifes neglecting respiratory rate as well as increased heart rate.

In addition, limitations due to paper case study design impaired triage of patients presenting with bleeding or pain, resulting in both over- and undertriage, *figure 2 paper II*.

Comment

Previous research on other OTSs shows similar results in IRR, however, as both study design and IRR-measures differ, comparison of IRR for different OTSs is vastly challenging (56, 58, 63, 64, 66). To the best of our knowledge no previous study assessing the IRR for staff with differing experience levels of the obstetric population has been performed. A good IRR is of outmost importance regardless of obstetric experience as obstetric patients may seek emergency care in different settings.

The malpractice of neglecting vital sign parameters was also identified in paper V. With previous research showing the importance of assessing vital sign parameters to assure safe care, this is concerning (32, 33). Assessing blood pressure has a strong tradition within obstetrics. Yet, adding assessment of all vital sign parameters might challenge preconceived notions on needed care. This could result in a lacking trust in the OTS and the working method, thus not applying it as intended. Whether assessment of all vital signs is important in the obstetric population is unknown, yet with the physiological changes occurring during pregnancy and their subsequent consequences on the patient's ability to maintain normal vital sign parameters despite severe illness, there is all the more reason to adequately assess them (37).

Over- and undertriage is further discussed under the discussion section.

Paper III

The aim of this study was to explore and describe midwives', auxiliary nurses' and obstetricians' experiences of working with obstetric emergency triage in a Swedish setting.

An overarching theme − *A new mindset* − emerged from the analysis, comprising the four categories: *Implications for the individual caregiver's own work* (four subcategories), *An improved organization* (two subcategories), *Improved patient care* (two subcategories), and *Barriers and facilitators for successful implementation* (two subcategories), presented in *figure 12*. To enable the reader to assess analysis credibility, quotes from the interviews can be found in paper III (122).

Figure 12 *Theme, categories and subcategories describing midwives', auxiliary nurses', and obstetricians' experiences of working with obstetric emergency triage in a Swedish setting.*

The study found that given adequate time for implementation, a new mindset within Swedish obstetric emergency care may develop. By applying obstetric emergency triage and hence assess patients promptly on arrival, the study participants perceived that they acquired an overview of patients, enabling transparent prioritization both between patients as well as between in-house and outpatient emergencies. Triage improved teamwork, with improved

communication between and within professions as well as reduced work-related stress in the obstetric ED. However, without complete implementation, mistrust and frustration might arise and there were both barriers to overcome and facilitators to utilize to enable successful implementation.

Amongst others, important barriers were lack of method instructions and an indicisiveness regarding implementation from the management. This led to an inconsistency in performing triage, which seemed to cease when it was needed the most. An suitable administrative system supporting the working method, clear routines and recurring training were some of the identified facilitators.

Despite the above-mentioned positively charged perceptions, a perception of inherent redundancy in triage, perceived as over-treating healthy patients was present. As previous research has identified the notion of "pregnancy being a natural aspect of life" as a barrier to implementing vital sign parameter controls, this was a somewhat anticipated finding (123). Other studies have revealed a sense of improved care but also of resistance to implement a system that may de-normalize or medicalize pregnancy and childbirth, as well as the feeling that the traditional way of assessing obstetric patients was being questioned (35, 58, 103, 104).

In this study, the feeling of redundancy was somewhat counteracted by the overall theme of creating an ED mindset.

Comment

An overall difference in the initial attitude towards obstetric triage was seen between the obstetricians and midwives/auxiliary nurses. Obstetricians felt that triage was a natural part of emergency medicine. Midwives and auxiliary nurses expressed an initial skepticism towards the working method, however, their perceptions changed during the implementation and study period.

Even though findings of experiences of redundancy and de-normalization or medicalization of obstetric care is understandable from a traditional point of view, they may have vast consequences for patient safety. With the growing complexity of today's pregnancies, with patients being older and more often presenting with severe and sometimes multiple intercurrent diseases, it is essential that notions as pregnancy being a natural part of life do not impede identification of severely ill patients. The results from paper III aligns with previous research, showing that obstetric triage provides a neutral and objective assessment and communication facilitator, allowing for old habits to be overcome (35, 101, 124).

To ensure trustworthiness during the data analysis, the different backgrounds and experiences of the three authors, contributed to a diversity of perspective while keeping the pivotal question *"What is your experience of working with obstetric triage?"* in focus. The different pre-understandings of the concept of obstetric triage counterbalanced each other (118, 125).

As a progression of attitudes towards triage was identified, further knowledge and understanding of the experience of triage as a working method may be found if a sequential evaluation is made after 12 and 18 months.

Paper IV

The aim of this study was to develop a set of weighted surrogate outcome measures representing urgency at the timepoint of triage for construct validation of OTSs.

A set of 31 outcome measures reflecting urgency at the time of triage was developed through a four-round, modified Delphi process, presented in *table 10*. The outcome measures may be used for construct validation of OTSs, used

in a similar context. Through round two - four, 100% consensus was deemed necessary, and achieved.

In the fourth round, the outcome measures were weighted into three levels, further specifying the interventions significance and thus correlate them to levels of acuity. Prioritization must sometimes occur also within the most urgent cases.

Comment

Ideally, outcome measures used for validation of triage systems reflect urgency at the time of triage. Nonetheless, for some conditions, evaluation of the patient is needed to assess whether the symptoms are in fact signs of an urgent condition. Interventions ordered or performed by the midwife/nurse or physician at the ED is the first objective action related to a condition and are therefore possible outcome measures.

Resource utilisation is frequently used as an outcome measure (15, 56, 59, 126), but one must be aware that resource utilisation may be affected by local prerequisites such as access to ultrasound competence or medical guidelines and thus, generalisability may be limited. The outcome measures in paper IV are inevitably affected by local circumstances such as the applied OTS and the ability to treat some conditions at the ED without admission. Ideally, a universal set of outcome measures could be used for all OTSs. Contextual effect is most likely unavoidable and evaluation of the suitability of outcome measures must therefore be assessed. Nevertheless, the outcome measures in paper IV may be used for comparative studies of OTSs implemented in a similar context.

Table 10 *Grading of outcome measures*

Type of intervention	**Severity**		
	Directly lifesaving / preventing lasting morbidity 3	**Potentially lifesaving / preventing lasting morbidity 2**	**Not directly lifesaving / preventing lasting morbidity 1**
Interventions performed at the ED or ordered from the ED and performed in direct connection to admission			
General	Cardiopulmonary resuscitation (CPR) Diagnosis of intrauterine fetal death (IUFD)[1]		
Surgery	Perimortem caesarean section Immediate caesarean section	Surgery within 30 min	
Other interventions		Radiology – computed tomography (CT) / magnetic resonance imaging (MRI) / ultrasound Thromboelastography (TEG) Blood gases Cardiac enzymes	Echocardiogram (ECG)*** Repeat laboratory tests within 6 hours
Admission to hospital *and* one or more of these *immediate* interventions:			
Failing vital functions	ICU* Continuous positive airway pressure (CPAP) Naloxone - suspected opioid overdose	CICU** Inhalation and/or oxygen Diuretics iv	

Venous thromboembolism	Thrombolysis	Low-molecular-weight heparin (LMWH), initiating treatment of suspected or verified venous thromboembolism	
Eclampsia/preeclampsia/ hypertension	Antihypertensive medication infusion Magnesium infusion - treatment for eclampsia	 Magnesium infusion - prophylaxis in severe preeclampsia	Surveillance of blood pressure and increased oral antihypertensive medication
Infection		Antibiotics infusion	
Allergic reaction	Adrenaline iv/im - treatment of severe allergic reaction		Oral steroids
Symptom relief			Analgesia with morphine and/or hyoscine butylbromide and/or non-steroidal anti-inflammatory drugs (NSAID) Blood transfusion
Fetal	Magnesium infusion - neuroprotection, threatened premature delivery	Continuous cardiotocogram (CTG) Atisoban iv Steroids im	

[1] *As detection of fetal distress before IUFD could potentially save the baby's life*
**ICU – intensive care unit – admission due to failing vital functions, possibly imminent need of intubation*
***CICU – cardiac intensive care unit – admission due to suspected or established heart failure. Enables immediate ECG*
****Ordered from the ED and performed within 24 hours*
ED – emergency department, im – intramuscular, iv – intravenous

Paper V

The aim of this study was to establish GOTS' validity according to outcome measures reflecting urgency in the moment of triage.

A total of 1.280 patient visits were included in the study and the appropriate initial triage level was found in 95.2%, evaluated by the standardized outcome measures developed in paper IV. Fifty-nine (4.6%) patients were initially triaged to the red or orange triage levels i.e., an urgent triage level. Distribution of initial triage level within each CCA is depicted in *figure 13*.

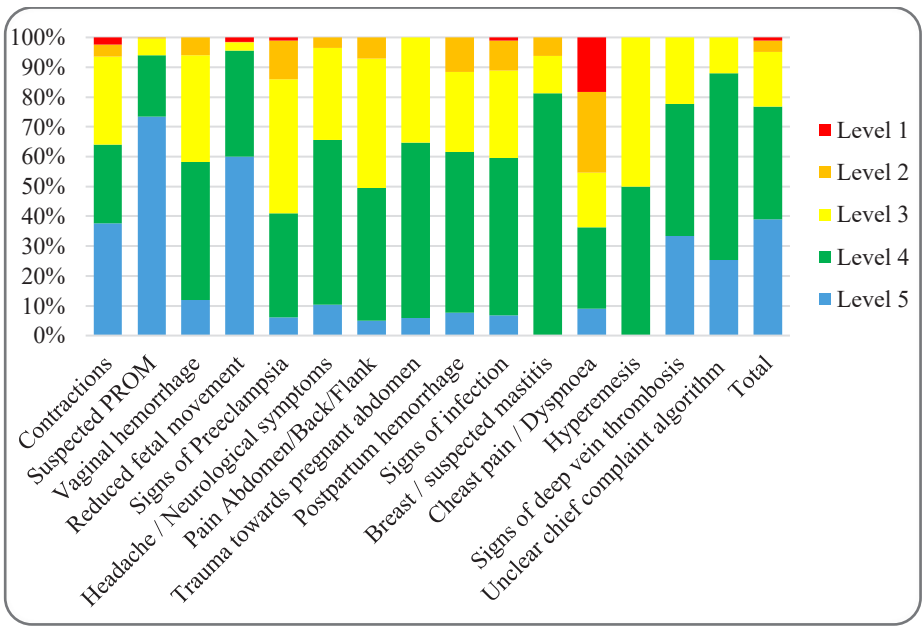

Figure 13 *Distribution of initial triage levels within each CCA and in total (n = 1.280). Level 1 and 2 are defined as urgent, Level 3,4, and 5 are defined as non-urgent.*

Over- and undertriage was found in 22 (1.7%) and 39 (3%) visits respectively, with CCAs based on subjective symptom descriptions such as pain, dyspnea, or contractions being prone to both over- and undertriage. When conducting more detailed chart reviews it became

evident that 10 of the undertriaged patients were clinically re-triaged due to changes in their symptom presentation and/or abnormal CTG. This resulted in a final triage level sensitivity and specificity of 0.62 (CI 0.50 – 0.73) and 0.98 (CI 0.97 – 0.99).

A time difference of nine minutes for median time to assessment by midwife was seen in patients with an outcome, triaged to either urgent (10 min ((00:00 – 01:14)) or non-urgent (19 min (00:00 – 00:39)) triage levels. This fact, in combination with none of the outcome measures being in the most severe level (directly lifesaving / preventing lasting morbidity), none of the final undertriaged patients were deemed to have been at immediate or obvious risk of adverse outcome.

In 67 cases, the triage midwife was unable to identify an applicable CCA reflecting the patient symptoms. These cases included complications of perineal tears postpartum and severe itching, identifying a possible need for additional CCAs. In these cases, vital sign parameters constituted the foundation for final triage level and none of these patients was triaged to an urgent triage level.

Comment

In previous, similar validation research, time-to-physician is a frequently used outcome measure. Though evaluation of time to assessment is affected by external factors unrelated to triage such as the current strain on the ED and associated units, it is still of value as it provides information on the ED's context. In this study, time to assessment by midwife is presented as opposed to time to physician. Swedish midwives are highly independent in their assessment of patients and manage roughly 40% of all patients visiting the obstetric ED, without involvement of an obstetrician. It is the midwife's

judgment and competence that determines whether the patient needs further assessment by the obstetrician.

Unfortunately, paper V showed similar results regarding vital sign parameters as paper II. A complete set of vital sign parameters was lacking in at least 46% of the patient visits within each triage level, *table 11*. In the absolute majority of cases breathing frequency was not assessed. Even though breathing frequency has been shown to deviate first in conditions such as sepsis, it appears that its significance is unknown or that it is too cumbersome to assess. Its significance in the obstetric population is unknown and due to the large number of missing values in the current data set, no evaluation can be made.

Table 11 *Registered vital sign parameters in 1280 obstetric ED visits.*

	Number *(%)*
Managed by	
Midwife	531 *(41.5)*
Midwife and obstetrician	749 *(58.5)*
Triaged visits*	1259 *(98.1)*
Complete vital sign parameter control	
• *Level 1 - Red*	7/13 *(54)*
• *Level 2 - Orange*	25/46 *(54)*
• *Level 3 - Yellow*	95/236 *(40)*
• *Level 4 - Green*	226/485 *(47)*
• *Level 5 - Blue*	not applicable
Causes for incomplete triage **	
Blood pressure	7 *(1.6)*
Breathing frequency	420 *(98.4)*
Saturation	14 *(3.3)*
Pulse	11 *(0.9)*
Temperature	34 *(8)*

* Vital sign parameters are mandatory when patient is triaged as green or more urgent by symptoms
** Adds up to > 100% as several vital sign parameters may be missing at the same visit

DISCUSSION

The aim of this thesis was to present the development and implementation of the GOTS, combined with evaluation of GOTS' reliability and validity. Additionally, the experience of obstetric staff of working with obstetric emergency triage has been studied, identifying barriers and facilitators for implementation of the working method.

Over the last decades, the field of obstetric emergency care has faced growing challenges with overcrowding, a rising need for a cost-effective care, and an expanding complexity in the obstetric population. Thus, the need for identification of the urgently ill patient seeking emergency care and the subsequent reaction to deviation from normality must be assisted by a safe, efficient and objective OTS. Even though yearly assessments of maternal mortality and morbidity show that we fail to identify and adequality manage severely ill obstetric patients seeking emergency care, the working method is still not routinely implemented within obstetric or general emergency care in Sweden (1, 3, 127).

METHODOLOGICAL DISCUSSION

Several methodological aspects related to the papers included in this thesis can be discussed. This section provides a general overview of these aspects. For strengths and limitations of each study methodology, please see each included paper.

Overall, the lack of a closer collaboration with emergency care physicians and nurses must be acknowledged. In paper II, assessments of paper case scenarios were performed by staff with varying experiences of obstetric patients. However, especially in papers I and IV, a collaboration with triage experienced medical staff could have yielded invaluable knowledge and insight into aspects

of emergency triage. As obstetric patient may fall ill with both pregnancy-related and other conditions, it is important for an OTS to incorporate a wide variety of symptom presentations.

Systematic errors

Systematic errors are constituted by biases, a type of preconceived notions, which can occur both in selection of study participants, collection of data, and when interpretating study results with unknown or insufficient knowledge on confounding factors (128). Systematic errors are unaffected by sample size but may be minimized by meticulous research design and data collection such as well-defined and transparent sampling techniques strengthened by apposite statistical analyses (129).

Selection bias in sampling

When certain members within a population are more likely to be included into a study, the risk of a selection bias increases. In the included paper of this thesis, three types of sampling techniques are used. As obstetric emergency care is a new working method in Sweden, sampling of participants has been restricted to certain settings. This may limit generalizability of the findings.

Convenience sampling

Convenience sampling is a type of non-probability sampling, meaning that all individuals are not eligible for inclusion. The sampling technique is often used in exploratory and qualitative research aiming at developing a basic understanding of for example a new phenomenon and/or when a study is located at a single center (130). Voluntary response sampling, used in paper II, is a type of convenience sampling based on participants volunteering to participate in a study. Convenience sampling is often refrained from as including participants that willingly offers to participate in a study may give rise to a self-selection bias i.e., including participants with differing

characteristics compared to the general population (130, 131). However, as participation in studies must be voluntary, this bias can be difficult to counteract.

Purposive sampling

Likewise, *purposive sampling*, applied in papers III and IV, is often used in qualitative research or in studies where specific knowledge rather than statistical inferences is desirable (131). It can be used to achieve either a heterogenous or homogenous sample, depending on the study aim (130, 131). This too is a non-probability type of sampling and is also known as judgment sampling. The rationale for using the purposive sampling technique is to access certain expertise or knowledge, only possessed by some individuals. The sampling requires clear inclusion and exclusion criteria and the technique relies on the researcher's ability to identify participants that can provide information, beneficial to the study purpose. Purposive sampling implies challenges in avoiding selection biases such as observer bias – when the researchers preconceived notions affects selection of participants and interpretations of results.

Cluster sampling

Cluster sampling, performed in paper V, is a form of probability sampling where, as opposed to non-probability sampling, all members of a population may be selected. This type of sampling can be used for producing results that are generalizable to the population at hand (132). By cluster sampling, the population is divided into smaller units, clusters. Subsequently, a random selection of clusters is made (133). Even though this sampling technique is less likely to be influenced by biases compared to the previous two, while each cluster should represent the population, this is not always the case, and one must be aware of the risk of selection bias.

Information bias

Information bias arises when information is inadequately collected and hence does not represent true information (134). Due to information bias, including recall bias as well as reporting bias, it was deemed impossible for paper III, a qualitative study, to be conducted at the unit where GOTS was developed.

Information bias due to missing data in the medical records may be a limitation in retrospective studies such as paper V. Verification of data is problematic and the quality of retrieved information may differ as the data was not registered for research purposes. Data may be rich in missing values, which must be handled. As an example, visits with missing triage levels in paper V were retrospectively triaged by a midwife blinded to actual outcome. This may not represent the actual triage level but allows for use of the other data connected to that patient visit. Another example is the abundance of missing data on breathing frequency, impairing any conclusions of that vital sign parameter in the examined cohort. Despite drawbacks such as information bias, retrospective cohort and cross-sectional studies are still a relatively effective and inexpensive way of assessing rich data (135).

Systematic errors within qualitative research

Qualitative research aims to achieve a depth of understanding as opposed to breadth (117, 130). Qualitative methods are equally susceptible to biases as quantitative methods and a transparent method description is important within both research fields. The qualitative method and result descriptions, including setting and context, data processing techniques and preconceptions in the researchers, must be perspicuously described to enable the reader to evaluate the results i.e., assess the study's *trustworthiness*. Trustworthiness is constituted by *credibility*, *dependability,* and *transferability* (118). Among other aspects, these concepts correlates to if the data and process of analysis

address the intended focus and whether adequate meaning units are selected in the interpretation of data. Transferability can be compared to external validity i.e., if the results are applicable in another setting.

In qualitative research papers, quotes and the analysis process are presented to allow for the reader make an interpretation of the results as the results cannot be validated by statistical analyses (118, 119). Rather, the researcher is the research tool and is in a dualistic position where the use of preconceptions on the research topic are a prerequisite to enable interpretation of information. Concurrently, data must be interpreted unbiased, so called bracketing (136). Inability to do so may cause interpretation bias (137). One must also be aware that in all qualitative research, the results are contextually interpreted. As results are transferred, contextual factors may change. Nevertheless, the findings are relevant and meaningful (118).

Random errors and sample size

Radom errors occur by chance, reflecting a variation in data that is unknown. Within quantitative research, random errors are reduced by increasing the sample size and by that minimizing their effect on the results. Random errors are addressed by presenting CIs, where a narrow range indicates a more precise result with less risk of random error.

None of the studies in this thesis include a sample size calculation, or power analysis. For paper I and IV sample size calculations were not relevant. For reliable interpretation of IRR sample size should consist of at least 30 comparisons (138). In paper II, 30 paper cases were assessed by 13 participants, generating 418 comparative assessments (60). In qualitative studies undergoing qualitative content analysis according to Graneheim and

Lundman, such as paper III, sample size is secondary to the variation in experiences described (118).

In paper V, an optimal sampling procedure would have included a power calculation, establishing an adequate sample size. This does however require knowledge on the frequency of outcomes. With the study in paper V being the first of its kind, and lacking clinical follow-up information on the specified outcomes, a calculation of an adequate sample size was not feasible.

Instead, CI-range is presented for sensitivity and specificity in paper V. Even though the sample is contextually large, half of the CCAs include less than 50 patient visits. Concurrently, CI-range for some of the individually assessed CCAs is wide. This increases the risk random errors affecting the results, with a risk of not providing adequate information.

GENERAL DISCUSSION

Emergency triage is a complex process and its consequences in the ED are influenced by several biases (139). The ED is a unique environment, requiring a high number of decisions to be made in a short amount of time and under pressure, often with great implications for the patients. Staff often uses adequate cognitive strategies to facilitate such decisions, however, the strategies may also lead to adverse conclusions. When this occurs, the strain on triage staff can be a heavy burden to bear.

The bias of *triage cueing* is especially important. It implies that when triage directs a patient in one initial direction within the ED, for example towards a medical rather than surgical evaluation, this entails guiding attributes for further assessment and management. Triage cueing is a congregation of several other biases such as *ascertainment bias*; seeing what you expect, *anchoring*; a tendency to stick with your first impression and jumping to conclusions,

diagnosis momentum; a tendency for a diagnosis to become established without proper evidence and *Sutton's slip*; going for the obvious diagnose, overlooking other alternatives. These cognitive strategies may sometimes be of assistance when quick decisions are imperative, functioning as mental shortcuts. However, staff in the ED must be aware of using them to avoid delayed or inaccurate diagnosis and treatment (140). In addition, as these mental shortcuts may be missing for the obstetric patient and her symptom presentations, an OTS can provide a support to avoid cognitive pitfalls.

Considerations when evaluating OTSs

To enable evaluation of a triage system's performance, one must start with defining the purpose of triage. What are we aiming to achieve when applying triage in an emergency setting? Increased patient safety, mapping of patient flow, or information to enable organizational planning and resource allocation? Or perhaps all of the above?

Outcome measures

Pervious validity research on OTSs has often intended to study patient safety but has frequently used organizational parameters such as time to triage, LOS at the ED, admission to hospital, and resource utilization as outcome measures. For example, LOS is often used to validate triage systems by comparing values prior to and after implementation, thus claiming to display patient safety by assessing the efficiency of triage. In paper I, LOS under four hours consistently was at a level of 80% despite a substantial increase of patient inflow during the evaluation period. Hence, LOS can be used to evaluate the effectiveness of a unit over time or as a comparison before and after implementation of an OTS, providing valuable organizational information.

However, LOS is highly dependent on several factors within the clinic, such as "the access block" manifested by the inability to transfer patients from the

ED, with the limited discharge rate from the hospital impairing admission of new patients from the ED (12, 89). The workload at any unit affects other interrelated units at the clinic. Assessment of LOS can therefore not be used as a surrogate for patient safety as it provides no information of the ability of a triage system to identify urgently ill patients in need of intervention. Nor can it be used to compare units among each other.

Another frequently used outcome measure is mortality within different time limits such as “at the ED”, “within 3 days”, or “within 30 days”. Mortality is compelling to assess as saving lives is one of healthcare’s main purposes. However, as pointed out by *Pacella and Yealy,* long-term mortality may be influenced by a myriad triage-unrelated factors (90). In addition, mortality is fortunately an extremely rare outcome within the obstetric population in Sweden.

If the primary purpose of triage is defined as *the prioritization of patients in accordance with medical urgency, based on urgency in the moment of triage,* predictive outcome measures should be avoided (141). Rather, outcome measures reflecting urgency at the moment of triage as well as complementing outcome variables focusing on aspects such as patient safety and workplace environment should be the focus of validation research. However, the subject is vastly challenging.

Adding to the complexity, the process of emergency triage is more than the use of a structured triage system, rather it may be considered a working method. Triage systems are inevitably contextual in their practical use, and patient management following the triage process must therefore be evaluated to assess whether the information produced from the triage system is applicable and relevant in the current context. One might argue that instead of the validity of the triage system itself, it is rather the validity of the information produced by

the contextual triage process and the interpretation thereof, that is assessed (85, 142). A triage system might be valid i.e., generate adequate and usable information, in one context yet not be applicable in another. It is not the system that is valid, but the information and the interpretation of that information that is valid. Continuing the "bulls-eye" theory from the introduction section, one could thus argue that there are different "bulls-eyes" depending on the context. Hence, contextual validation is imperative.

In paper IV, the aim was to develop a set of weighted outcome measures representing acuity or urgency at the timepoint of triage. Lacking a definition of urgency, some evaluation of the patient is needed to assess whether her condition is in fact urgent. The outcome measures are reactions to urgent conditions, performed in close proximity to triage. Nevertheless, in paper V it became clear that even though the clinically significant outcome measures are relevant in evaluating the performance of an OTS, it is still of great importance to assess whether the information produced is contextually significant. Two different sensitivity and specificity values became evident, the initial and the final, of which the latter reflects the clinical management of patients and thus, the patient safety. The major contributor to the two different values was the difficulties of assessing the fetus wellbeing, a known aggravating factor in obstetric triage compared to general emergency triage (31, 49, 83). The initial triage level was registered after assessment of the woman but before assessment of the fetus. When fetal distress became evident, the clinical management was altered, becoming equivalent to a higher triage level which usually was not registered in the system. When the pregnant patient presents at a general ED the initial triage level is used for prioritization as there is no possibility to assess the fetus.

Still, the outcome measures defined in paper IV can be used to compare different OTSs in a comparable setting as they provide an objective set of outcome measures. One must however, as pointed out in the paper, assess whether they are applicable in the current setting.

Over- and undertriage

Triage systems aim at being precise, yet over- and undertriage will occur. Over- and undertriage are by some claimed to be a form of criterion validity assessment, as it is assessed by comparison of an actual outcome to a "true outcome"(15). In validity testing, criterion validity is considered to be superior to other forms of validity (24). Even so, the numerical values must be contextually evaluated. In a high flow ED, with extensive overcrowding, undertriage may have severe consequences for the individual patient with prolonged waiting time and untimely interventions. In an ED, with less overcrowding the mis-triage may be less problematic. It is therefore essential for each ED to evaluate the used triage system to assure patient safety.

Only two previous OTSs have undergone evaluation of over- and undertriage, the Swiss Emergency triage Scale (SETS) and the Iranian Ob triage index with over- and undertriage of 9.3% / 12.4% and 6.1% / 17.1%, respectively (59, 66). In paper V, the over- and undertriage was found to be 1.7% and 3% respectively and in paper II over- and undertriage of patients after assessment with GOTS was 9.3% and 21.1%, respectively. These differences clearly depicts the challenges in comparing results from different studies.

Paper II and V apply vastly different study methods, paper II being a paper-case study including all triage levels and all CCAs. A sub-analysis showed that study design was found to largely affect the results by impairing evaluation of certain symptom presentations such as amount of bleeding and

level of pain. In paper V, with a larger sample size, the over- and undertriage was based on actual clinical management with real-life assessments and distribution of triage levels and chief complaints. Hence, these results may be more relevant as they represent contextual over- and undertriage.

Considerations for implementation of obstetric emergency triage as a working method

Implementation of new working methods within health care is often accompanied by attitudes of reluctance and skepticism, the so called *resistance to change* (143). Within implementation science, several TMFs include assessment of organizational readiness to change which may be related to a variety of factors (121, 144).

Barriers and facilitators for implementation

In paper I and III, barriers and facilitators to an effective implementation were identified, involving both facilities as well as administrative systems and staffing. In paper I, these were addressed proactively to enhance the possibility of an effective and successful implementation, presented in *table 8*.

In paper III, personal characteristics of the triage midwife, such as being able to multitask and the ability to cope with interruptions and suddenly escalating patient inflow, were identified as an important facilitator for successful implementation. Clear instructions and management decisiveness regarding implementation were also found to be important facilitators. These findings are consistent with previous research on both obstetric as well as general emergency triage (6, 29, 30).

Paper III also revealed a perception of inherent redundancy in triage, perceived as over-treating healthy patients and the notion of de-normalization of pregnancy and childbirth (125). This too, is aligning with previous research

where perceptions of failing the patient due to the medicalization of a normal condition and compromising holistic midwifery care have been identified (58, 102, 103, 123). Perceptions of questioning the traditional way of assessing obstetric patients have repeatedly been identified (35, 58, 103, 104). However, in paper III the feelings of redundancy was counterbalanced by the creation of an ED mindset and a sense of empowerment and personal growth and development (125).

Contextual attitudes and preconceptions

The field of obstetrics is affected by a strong sense of hierarchy, within and between groups of midwives, auxiliary nurses, and obstetricians. Fear of ridicule from colleagues and senior staff if a raised concern for a patient turns out to be unfounded, has been shown to reduce the inclination to act on abnormal vital signs or symptoms (123, 145). It is essential that such hierarchies and lack of knowledge within different fields of medicine do not impede identification of urgently ill patients. Obstetric triage provides a neutral and objective communication facilitator, allowing for old habits, fears, and biases to be overcome (35, 101, 124, 125, 146).

Awareness of contextual attitudes and preconceptions is essential to assess readiness for change and needs to be addressed and considered when a new working method is planned and introduced. The Swedish maternal care has undergone vast changes during the last 100 years, often greatly affected by international influences. Until the 1970-ies, a profound medicalization took place, introducing effective pain relief and centralization of delivery care, giving obstetricians a more prominent role within delivery care (71, 147).

Following these changes, attitudes evolved towards a more naturalistic delivery care, portraying women as held captives under the recent technological advances (147). Many midwives perceived the technologization

as a threat to their competence and traditionally strong position in delivery care. Following this, the view upon childbearing and labour evolved into two different approaches or attitudes – those of "the natural process of childbearing" vs. "the medicalization of childbearing" (147, 148). Within delivery care the two different approaches became associated with a conflict between midwives, that experienced a loss in professional identity, and obstetricians that appeared to claim areas of expertise that previously belonged to the midwife (71). Today, both attitudes are present within the collegiums of midwives *and* obstetricians (69).

During the 21th century, the delivery care has become increasingly individualistic with the birthing woman's experience and the subsequent portrayal of that experience almost being equally important as the medical outcome. Different desires from the birthing women enables an upholding of the two approaches of naturality and medicalization (147). Today, these approaches still cause conflict and attitude differences (148), contributing to a medical hierarchy. Adding to the complexity, more and more deliveries need medical interventions to be safe thus, again increasing obstetricians' involvement in the delivery care. Several studies have found this hierarchical conflict to complicate the teamwork and collaboration between midwives and obstetricians (58, 71, 123, 149). To move beyond these structures one must be aware of their existence and recognize the importance of differing points of views.

Obstetric triage may very well be perceived as a medicalization, challenging the concept of the natural process of childbearing and delivery. Concurrently it provides an objective instrument for communication on deviations from physiological normality and reduces the risk of biases and subjective assessment of patients.

Education and support

Continuous education on the triage system and working method has previously been identified as a facilitator for successful implementation (35, 102, 150). It is of immense importance to allow for adequate amount of time for education on the triage system itself, the working process and the justification for change in working method.

As an example, in paper II, both RNs and midwives were found to not acknowledge abnormal vital sign parameters. This may be due to unawareness of the importance of vital sign parameters or different cut-off levels for different types of patient groups, resulting in a mistrust in the system (60). Unclear instructions and insecurity of the working method will reenforce the resistance to change.

Several TMFs highlight the importance of fostering supportive climate and organizational conditions (121, 144, 151). TMFs are used for implementation of evidence-based knowledge and even though the innovation in focus of this thesis (GOTS), in itself had limited scientific support, patient safety was and is of outmost importance. A clear communication on the perceived need and benefit of the innovation and a clear and elaborated plan for implementation combined with the overall goal of SU to be a leading emergency hospital assured management support, crucial to proceed with the implementation.

ETHICAL DISCUSSION ON OBSTETRIC TRIAGE

The underlaying ethical principles of triage have been claimed to be both utilitarian - maximising the overall good, as well as egalitarian – the equality in all human beings from birth and their right to equal treatment (139). In 1997, Sweden legislated an ethical platform for priorities in healthcare, developed by the Ministry of Social Affairs in 1995 (152, 153). This ethical platform rests on three principals, graded in descending order.

1. The human value principle – all people have equal value and the same right regardless of personal characteristics and functions in society.
2. The principle of need and solidarity – resources should be distributed according to need. Health care resources should be allocated to those who have the greatest needs, this should apply even if not everyone gets their needs met.
3. The cost-effectiveness principle – a reasonable relationship between costs and effect, measured in improved health and increased quality of life should be pursued.

The National Board of Social Affairs and Health states that the most important element in emergency care is to decide on the prioritization order between incoming patients and their medical urgency (154). Nevertheless, an SBU-report on ED-triage raised concern for a possible conflict between triage methods and the ethical platform of prioritization and that potential consequences for certain patient groups such as pregnant women must be analyzed (155).

Already in the choice whether to use a triage system or not, and subsequently what triage system to use, an ethical decision has been made. Using inapt triage systems or not using triage based on medical urgency at all for the obstetric

population is a violation of the ethical platform of prioritization in healthcare. Inadequate knowledge on the physiological changes in pregnancy and the following consequences for the obstetric patient promotes unequal emergency care for the obstetric patient (31, 77).

Nevertheless, applying OTSs is not without conflict. As previously addressed the scientific support for OTSs is limited and the actual effect on patient outcome to a large extent unknown. Yet, as overcrowding increases within both general and obstetric emergency care, some sort of prioritization must be made to avoid negative patient outcome (102). Despite possible deficits, emergency triage is the gold standard for this prioritization. Even though subjective interpretations and biases inevitably will affect the triage nurse/midwife assessment, a structured triage system can facilitate uniformity and transparence in the triage process, reducing risk of assumptions to influence triage decisions (13). By extension, this can ensure clinical justice for patients and potentially save lives and reduce morbidity. In addition, evaluation and subsequent improvements in care must have structural foundations. Subjective assessments cannot be evaluated in relation to patient and/or organizational outcomes.

Not applying obstetric emergency triage is a violation of the ethical platform for prioritizations in healthcare as it mandates equality in treatment of patients regardless of personal characteristics. Not applying obstetric triage is equivalent to providing inferior care to patients because of their pregnancy, compared to standard care for non-pregnant patients. Whether that standard is correct should be the subject of further research and development, anything else would be unethical.

CONCLUSION

- GOTS is the first OTS developed for and implemented in a Swedish context. Implementation has led to a revised management of obstetric patients seeking emergency care, prioritizing patients according to level of urgency at the moment of triage.
- GOTS has a good clinical sensitivity of 62% and an excellent clinical specificity of 98% and is a valid triage system in the studied context. GOTS also has a good reliability when used by obstetric and non-obstetric staff. Areas of improvement have been identified.
- Staff members perceive that patient safety has improved after implementation of obstetric triage, facilitated by a directed attention towards aberrations, promoting reflection and action.
- Staff members perceive that, given time for implementation, obstetric triage may induce a new mindset in Swedish obstetric emergency care. Triage provides structure and a sense of control through a clear and quick overview of patients. It enhances teamwork by improving communication and reduces work-related stress in an obstetric ED setting.
- There are barriers to overcome and facilitators to utilize to enable an implementation of obstetric emergency triage as a working method.
- When validating triage systems, outcome measures reflecting urgency in the moment of triage should be used to avoid interference by external factors.
- Triage systems must be evaluated contextually. A two-phased validation process, using a set of standardized acuity outcome measures and a subsequent deepened case review is suggested.
- Obstetric triage should be introduced into Swedish obstetric emergency care.

FUTURE PERSPECTIVES

Obstetric triage is a relatively new area within emergency triage and obstetric care and there are several areas to explore further.

Physiological changes occurring during pregnancy are a well-known fact, yet, reference values for normal vital sign parameters and their significance in assessing urgently ill patients are to a large extent unknown. With Sweden's well-structured and highly attended maternity care combined with technological advances of for example smart-watches enabling easy monitoring of vital sign parameters, a large cohort study assessing vital sign parameters at different time points of pregnancy should be feasible.

As previous findings indicate severely lacking competence in managing obstetric patients correctly within non-obstetric emergency care, qualitative studies on non-obstetric emergency staff could provide valuable information regarding needed support systems for the general ED context. Further collaborations between general ED and obstetric emergency care givers should be initiated.

Staff within obstetric care is highly affected by the phenomenon of second victim within healthcare (156-160). Studies on staff experiences of management of so called "near misses" with or without the support of triage systems might establish whether this phenomenon can be affected by the use of triage.

Patient experience is of great importance within healthcare and future research to establish the effect of obstetric emergency triage on patient satisfaction and experiences is needed.

In paper V, areas of improvement for several CCAs are identified. The paper emphasizes that changes or amendments in the CCAs should be performed with reflection and evaluated scientifically. In addition, CCAs covering the first half of pregnancy could be developed, using the experiences and knowledge attained from the development of earlier work.

A major issue for future efforts is the implementation of obstetric emergency triage into routine practice. In the United Kingdom, almost ten years have passed since obstetric emergency triage was addressed by Kenyon et al., developing the Birmingham Symptom-specific Obstetric Triage System (58). In September 2023, a Good Practice Paper on Maternity Triage will be issued and subsequently obstetric emergency triage will be implemented in 89 units (62, 161). Achieving a similar recommendation in Sweden could improve the emergency care for the obstetric population.

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APPENDIX

Appendix 1 An example of a paper-case scenario. Vital sign parameters were provided separately, and participants could choose whether to use them or not.

S: A 33-year-old woman is seeking the obstetric ED because of vaginal bleeding in gestation week 38+5

B: Healthy woman, expecting her first child. BMI 19. Pregnant with the help of IVF after 2 years of infertility. Ordinary check-ups during her pregnancy have been normal except for a slight anemia.

A: Suddenly had a rather large vaginal bleed, seeks care immediately. Bled through her pants and when she went to the bathroom, blood poured down the toilet. No abdominal pain but her belly feels a bit tense and hard at times. Has had Braxton-Hicks contractions before but this doesn't feel the same. Experiences normal fetal movements.

In triage, there are blood clots in her pad.

Chief complaint algorithm: _____

Do you want vital sign parameters on this patient? If so fill in below.

☐ SBP < 80 or ≥ 180 ☐ DBP ≥ 120	☐ SBP 80-89 or 160-179 ☐ DBP > 110	☐ SBP 140-159 ☐ DBP 96-109	☐ SBP 90-139 ☐ DBP < 95	☐ Pat not in need of triage (acc. to local guideline)
☐ RR > 30 or < 10	☐ RR 25 - 29	☐ RR 21 - 24	☐ RR 10 - 20	
☐ Pox < 95 %			☐ Pox ≥ 95 %	
☐ HR > 150 or < 50	☐ HR 120-149	☐ HR < 60 or 110-119	☐ HR 60-110	
☐ Temp °C < 34 or ≥ 40	☐ Temp °C ≥ 39	☐ Temp °C 34.0-35.0 ☐ 38.0-38.9	☐ Temp °C 35.1-37.9	
☐ Decreased			☐ Awake	
☐ Red algorithm	☐ Orange algorithm	☐ Yellow algorithm	☐ Green algorithm	
☐ Red prio	☐ Orange prio	☐ Yellow prio	☐ Green prio	

Final triage level?

BP – blood pressure, *DBP* – diastolic blood pressure, *POX* – pulse oximetry, *Prio* – prioritization, *RR* – respiratory rate, *SBP* – systolic blood pressure