

# Multi-professional simulation training on postpartum hemorrhage in Tanzania and Norway

by

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## **What this research is about**

There is a continuous drama going on worldwide, where women are fighting for their lives on the battlefield of childbirth. Every day, 830 mothers are dying during pregnancy and childbirth, or 300 000 mothers annually (WHO, 2016). Out of these deaths, 99% occur in low-resource countries (WHO, 2015b). Of the 830 deaths daily, 250 are dying because of postpartum hemorrhage (PPH) (Afnan-Holmes et al., 2015). For every mother dying, another 20-30 women are suffering from complications causing long-lasting sequelae (UNFPA, 2016).

According to WHO, most of the maternal deaths are preventable (WHO, 2015b). There is an inequity regarding access to skilled birth attendance, due to the fact that 78% of the world's total births have access to less than 42% of the world's midwives, nurses and doctors (UNFPA, 2014).

Two thirds of the mothers who are developing PPH, have no known risk factors. Active management of third stage of labor is expected to contribute to reduced maternal mortality (POPPHI, 2007), including an intramuscular injection of oxytocin 10 international units after the birth of the newborn (Gulmezoglu et al., 2012). However, birth attendants have to be alert and able to identify and treat PPH accordingly.

Most studies on clinical outcomes after PPH-training have used estimated blood loss after birth as outcome measure (Shoushtarian, Barnett, McMahon, & Ferris, 2014; Sorensen et al., 2011; Spitzer et al., 2014). Visual estimation is known to be inaccurate and an unreliable measurement, with a tendency of underestimation (Al-Kadri et al., 2014; Bose, Regan, & Paterson-Brown, 2006; Hancock, Weeks, & Lavender, 2015).

Different courses have been established in low- and high-resource countries to prepare midwives, nurses and doctors for obstetric emergencies like PPH (Bergh, Baloyi, & Pattinson, 2015; Dao, 2012; Dresang et al., 2015; Evans et al., 2014; Spitzer et al., 2014; The PROMPT Maternity Foundation, 2008). Obstetrical health care is considered a complex system, and an intervention must pay attention to the constantly changing interconnections and

relationships (Dekker, Bergström, Amer-Wählin, & Cilliers, 2013; van Schaik, Plant, & O'Brien, 2015).

Simulation training on PPH was associated with increased confidence level compared to traditional lectures (Andrighetti, Knestrick, Marowitz, Martin, & Engstrom, 2012; Birch et al., 2007). The participants' previous clinical experiences together with their acquired experiences from simulation training, are likely to influence their self-efficacy, understood as judgment of own exercise of control, and collective efficacy, being the belief in the capability to solve a problem through unified efforts. Perceived efficacy beliefs are important for future performance (Bandura, 1997). Educational interventions have resulted in improved perinatal outcomes (Draycott et al., 2006; Mduma et al., 2015; Spitzer et al., 2014).

Literature searches did not identify any educational intervention that led to significant reduction in blood transfusion rates after birth, as an indirect marker for reduced blood loss (Dumont et al., 2013; Sorensen et al., 2011). No follow-up studies were identified exploring the informants' experiences after participation in an educational intervention on PPH-management. It seemed feasible and timely to investigate whether an educational intervention emphasizing teamwork and reflective practice, could contribute to new knowledge and understanding of crucial learning features and learning outcomes for improved PPH-management and maternal health.

The implementation of multi-professional training on PPH-management was carried out in Tanzania and Norway, organized by the local management, faculty and research team. All cadres were involved in the training, which included realistic and relevant PPH-scenarios. The scenarios were followed by debriefing sessions to optimize reflective learning. By combining pedagogical and obstetrical academic traditions with midwifery practice emphasizing the promotion of normal birth, the overall aim was to investigate the effects of this educational intervention. We hypothesized that simulation training would contribute to increased efficacy beliefs and reduction in blood transfusion rate after birth.

The investigation included assessment of how this simulation training may influence individual and collective efficacy beliefs. Another aim was to explore

participants' experiences related to learning features and learning outcomes of the training in multi-professional teams. An issue discussed throughout the project, was how to measure outcomes from the educational intervention related to maternal health, with valid inference of the findings. Finally, blood transfusion rate as dependent variable was chosen as an indirect measurement of blood loss after birth.

Mixed methods design was chosen to investigate staff's experiences, efficacy beliefs and patient outcomes at four study sites: Stavanger University Hospital, University Hospital of North Norway, Kilimanjaro Christian Medical Centre (KCMC) and Mawenzi Hospital, both Tanzania.

## **Utafiti huu unahusi nini**

Kuna mahangaiko mengi sana duniani, ambapo akina mama wanapigania uhai wao katika uwanja wa vita vya uzazi wakati wa kujifungua. Kila siku, wamama 830 wanakufa wakati wa ujauzito na kujifungua, au akina mama 300,000 kwa mwaka. Kati ya vifo hivi, asilimia 99% hutokea katika nchi zenye rasilimali kidogo. Kati ya vifo hivi 830 vinavyotokea kila siku, 250 hufa kwa kutokwa na damu nyingi baada ya kujifubgua (PPH). Na kwa kila mama mzazi anayekufa, kunaaminiki wamama wengine 20-30 wanateseka na matatizo ya muda mrefu yatokanayo na uzazi.

Kufuatana na Shirika la Afya Duniani (WHO), vifo vigi vya uzazi vinaepukika. Kuna hali ya ukosefu wa uwiano katika hali ya kuhudumiwa na wahudumu wenye uwezo, kwa ukweli kwamba asilimia 78% ya vizazi vyote duniani wanahudumiwa na chini ya asilimia 42% ya wakunga, wauguzi na madaktari wote duniani.

Theluthi mbili ya wamama wanaopata PPH, hawakuonesha dalili zozote hatarishi. Hatua ya tatu ya kiutendaji ya uzalishaji inategemewa kuchangia kupunguza vifo vya wamama wazazi, ikijumuisha sindano ya oksitosin uniti kumi baada tu ya mototo kuzaliwa. Hata hivyo wahudumu ukunga lazima wawe tayari na wenye uwezo wa kutambua na kutibu PPH ipasavyo mara itokeapo.

Tafiti nyingi yenye matokeo ya kitabibu baada ya mafunzo ya PPH yametumia makisio ya damu iliyotoka baada ya uzazi kama hatua za matokeo. Makisio ya uoni inajulikana kwa kukosa usahihi na vipimo visivyoaminika, na huwa na mwelekeo wa kukadiriwa kwa upungufu.

Mafunzo mbali mbali yalianzishwa katika nchi zenye rasilimali ndogo na kubwa ili kuwatayarisha wakunga, wauguzi, na madaktari kukabili dharura yoyote wakati wa uzazi kama PPH. Huduma ya afya ya uzazi ni mfumo tata, na pale unapotaka kuungilia lazima utilie maanani hali inayobadilika mara kwa mara ya muunganisho na mahusiano.

Mafunzo mfanano (simulation) ya PPH yamehusishwa na kuongezeka kwa hali ya kujiamini ikilinganishwa na njia ya kawaida ya kufundisha. Uzoefu wa kabla wa utabibu kwa washiriki wa mafunzo, pamoja na uzoefu uliopatikana kwenye mafunzo mfanano, unauwezekano wa kuongeza ufanisi binafsi, unaotambulika

kama kujipima mwenyewa kwa uwezo wako wa kulikabili tatizo, na ufanisi wa pamoja, kama kuamini katika nguvu za pamoja katika kutatua tatizo. Hisia ya kujiamini kwa ufanisi ni muhimu katika utendaji utakaofuata. Kutoa mafunzo kumeonesha matokeo chanya kabla na baada ya kujifungua.

Uchunguzi wa maandiko ya utafiti hayakuonesha kuwa kuna mafunzo yaliyotolewa awali yaliyoonesha kupungua kwa kiasi cha matumizi ya kuongezewa damu baada ya kujifungua, kama alama isyo ya moja kwa moja kwa damu iliyopungua. Hapa kuwezekana kutambua utafiti uliofanyika wa kufuatilia uzoefu wa wahojiwa baada ya mafunzo ya kuhudumia PPH. Imeonekana inafaa na kwa wakati muafaka kuchunguza kama kuwa na mafunzo tatu yanayokazia kufanya kazi kitimu, na kufanaya tafakari baada ya zoezi, kama yatachangia maarifa mapya na kuelewa vipengele muhimu vya mafunzo na matokeo ya mafunzo kwa kuongeza ufanisi wa kuhudumia PPH na afya ya uzazi.

Mafunzo ya wanye weledi mbali mbali juu ya kuhudumia PPH yalifanyika nchini Tanzania na Norway, yaliandaliwa na uongozi mahalia, kiidara na timu ya watafiti. Kada zote zilishirikishwa kwenye mafunzo, ambayo ilihusisha senario halisia na za kufaa za PPH. Senario hizo zilifuatiwa na mrejesho wa utendaji ili kuelewa kikamilifu tafakuri ya masomo. Kwa kuchanganya mbinu elimishi na taaluma ya asili za uzazi pamoja na mazoezi ya ukunga kwa kukazia na kukuza uzazi wa kawaida, lengo la jumla ikiwa kuchunguza matokeo ya mafunzo tatu yaliyotolewa. Tulikuwa na dhana kuwa mafunzo mfanano yataongeza kujiamini kiufanisi na kupunguza kiasi cha watakaongezewa damu baada ya kujifungua.

Uchunguzi ulijumuisha tathimini kuwa ni namna gani mafunzo mfanano yameongeza kujiamini binafsi na kwa pamoja. Lengo lingine likiwa kuchunguza uzoefu wa washiriki katika kujua vipengele vya mafunzo na matokeo ya mafunzo katika mafunzo ya pamoja ya wanye weledi mbali mbali kama timu. Swala lililo jadiliwa wakati wote wa mradi, ni kwa namna gani tupime matokeo ya mafunzo tatu kuhusiana na afya ya uzazi yenye hitimisho halisi ya matokeo ya uchunguzi. Hatimaye, kiasi cha uogezewaji wa damu kama kiegozo tegemezi ilichaguliwa ikiwa kama kipimo kisicho cha moja kwa moja kupima damu iliyopotea baada ya uzazi.

Mbinu mchanganyiko ya kimfumo ilichaguliwa kupima uzoefu wa wa watumishi, imani ya ufanisi na matokeo kwa wagonjwa katika sehemu nne za utafiti: Hospitali ya chuo kikuu cha Stavanger, Hospitali ya chuo kikuu cha Norway Kaskazini, Kilimanjaro Christian Medical Centre (KCMC) na hospitali ya Mawenzi yote yakiwa Tanzania.

## Hva dette forskningsprosjektet handler om

Over hele verden kjemper mange kvinner for livet i forbindelse med svangerskap og fødsel. Hver dag dør 830 kvinner på grunn av komplikasjoner i svangerskapet, under fødselen eller i barseltida, eller 300 000 mødre årlig. Av disse skjer 99% av dødsfallene i lavressursland. Blant de 830 dødsfallene, er det daglig 250 mødre som dør på grunn av blødning etter fødsel/postpartumblødning. For hver mor som dør, vil 20-30 mødre ha kroniske plager etter fødselskomplikasjoner.

Ifølge Verdens helseorganisasjon kunne de fleste av disse dødsfallene ha vært unngått. Det er en skjevfordeling ift kvalifisert fødselshjelp, ved at 78% av alle verdens fødsler har tilgang på mindre enn 42% av verdens fødselshjelpere.

To tredjedeler av mødre som får postpartumblødning, har ingen kjente risikofaktorer for patologisk blødning etter fødsel. Aktiv forløsning av morkaken er ansett som en viktig rutine for redusert maternell dødelighet, inkludert å gi oxytocin 10 internasjonale enheter intramuskulært etter barnets fødsel. I tillegg er det avgjørende at fødselshjelpere er oppmerksomme på og i stand til å oppdage og behandle blødning som måtte oppstå.

De fleste studier på pasientutfall etter opplæring på postpartumblødning har brukt estimert blødning som mål på effekt. Estimert blødning basert på øyemål er kjent som en unøyaktig og upålitelig målemetode, med en tendens til underestimering.

Ulike opplæringsprogram er etablert i lav- og høyressursland for å øke jordmødres, sykepleieres og legers kompetanse på akutt fødselshjelp, som ved postpartumblødning. Obstetikk og fødselshjelp forstås som fagfelt med stor kompleksitet, fordi det i akutte situasjoner også er kontinuerlige endringer i det fysiske arbeidsmiljøet og i mellommenneskelige forhold.

Simuleringstrening på postpartumblødning har resultert i økt tro på egen mestring, sammenlignet med utbytte av tradisjonell undervisning. Helsepersonells tidligere kliniske erfaringer samt erfaringer de har tilegnet seg fra simuleringstrening, vil trolig påvirke deres grad av mestringsforventning, forstått som egen vurdering av mestringsevne ift en spesiell oppgave. Erfaringene vil også påvirke deres mestringsforventning ift teamets evne til

utførelse av en gitt oppgave. Grad av mestringsforventning er viktig for fremtidige prestasjoner. Simuleringstrening har gitt bedre resultater for nyfødte.

Litteratursøk på opplæringsprogram relatert til postpartumblødning har ikke vist til studier med signifikant nedgang i blodtransfusjoner etter fødsel, som et indirekte mål på redusert blødning. Ingen oppfølgingsstudier ble funnet vedrørende deltakeres erfaringer etter simuleringstrening på postpartumblødning. Det ble vurdert som mulig og betimelig å undersøke hvorvidt simuleringstrening som vektla samarbeid og refleksjon, kunne bidra med ny kunnskap og forståelse av viktige læringsaspekter for bedret håndtering av postpartumblødning og effekt ift mødrehelse.

Tverrfaglig trening på postpartumblødning ble iverksatt i Tanzania og Norge, organisert av den lokale sykehusledelsen, de kursansvarlige og forskerteamet. Alle jordmødre, sykepleiere, leger og barnepleiere på føde/barsel var inkludert i treningen, som inneholdt realistiske og relevante scenarier. Etter scenariene fulgte gjennomgang av scenariet og refleksjon med mål om økt læring. Med utgangspunkt i forskning innen pedagogikk og obstetikk, inkludert jordmorfag som vektlegger den normale fødselsprosessen, var det overordnede målet å undersøke effekter av simuleringstreningen. Vår hypotese var at simuleringstrening ville bidra til økt mestringsforventning og redusert antall blodtransfusjoner etter fødsel.

Studien undersøkte hvordan simuleringstreningen påvirket grad av individuell og kollektiv mestringsforventning. En annen målsetning ved studien var å undersøke deltakernes opplevelse av viktige læringsaspekter og nytte av simuleringstreningen. En gjennomgående diskusjon i løpet av prosjektperioden var hvordan vi kunne finne pålitelige mål på effekt av treningen relatert til mødrehelse, og hvordan vi kunne dra slutninger på bakgrunn av våre funn. Vi valgte til slutt å bruke antall blodtransfusjoner som avhengig variabel, og som et indirekte mål på blodtap etter fødsel.

En kombinasjon av kvantitative og kvalitative studiedesign (mixed methods) ble brukt for å undersøke deltakernes erfaringer, grad av mestringsforventning og pasientutfall på fire studiesteder: Stavanger universitetssjukehus,

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## **Abbreviations**

AIP – advances in labor and risk management international program

ALSO – advanced life support in obstetrics

AMTSL – active management of the third stage of labor

BEmONC – basic emergency obstetric and newborn care

CCT – controlled cord traction

CEmONC – comprehensive emergency obstetric and newborn care

CS – cesarean section

FGD – focus group discussion

FGM/C – female genital mutilation and cutting

FFP – fresh frozen plasma

GSE - general self-efficacy scale

Hb – hemoglobin

KCMC – Kilimanjaro Christian Medical Centre

MBR – medical birth registry

MMR – maternal mortality ratio

PPH – postpartum hemorrhage

PPHCE – postpartum hemorrhage collective efficacy

PPHSE – postpartum hemorrhage self-efficacy

PROMPT – practical obstetric multi-professional training

RBC – red blood cell

RCT – randomized controlled trial

SUS – Stavanger University Hospital

TEAM - team emergency assessment measure

UNN – University Hospital of North Norway

WHO – World Health Organization

## Frequently used terms in this project

**Briefing** - crucial information shared before the scenario to prepare participants for simulation training, like relevant theory, setting, confidentiality, equipment, roles and case. Can include hands-on training

**Collective efficacy** - the belief in the capability to manage a specific task through unified efforts

**Debriefing** - to explain, analyze and synthesize reactions as an after-action review, by guidance of a facilitator

**Facilitator** - a “curious” expert guiding a learning process within a group

**Faculty** - facilitators and operators of the birthing simulator

**Inference** - by reasoning to reach a conclusion based on known facts

**Non-technical skills** - cognitive and social skills like communication, situational awareness and decision-making

**Operator** - a person who mimics a patient while operating a simulator

**PPH** - blood loss > 500ml after birth

**Scenario** - to mimic or act out a real-life condition, where an operator using a birthing simulator plays the mother/patient

**Self-efficacy** - one’s judgment of exercise of control related to a certain task, like PPH-management

**Simulation/scenario-based training** - to practice multi-professional PPH-management during scenarios, followed by debriefing of the team

**Technical skills** - ability to carry out technical procedures, like massage of the uterus, bimanual uterine compression

## List of papers

This thesis is based on four papers, which will be referred to in the text by their Roman numerals:

- I. Egenberg S, Øian P, Bru LE, Sautter M, Kristoffersen G, Eggebø TM. Can inter-professional simulation training influence the frequency of blood transfusions after birth? *Acta Obstet Gynecol Scand* 2015 Mar; 94(3):316-23.
- II. Egenberg S, Øian P, Eggebø TM, Arsenovic MG, Bru LE. Changes in self-efficacy, collective efficacy, and patient outcome following inter-professional simulation training on postpartum haemorrhage. *Journal of Clinical Nursing* 2016 Nov 22.
- III. Egenberg S, Masenga G, Bru LE, Eggebø TM, Mushi C, Massay D, Øian P. Impact of multi-professional, scenario-based training on postpartum hemorrhage in Tanzania: a quasi-experimental, pre- vs. post-intervention study. Submitted *BMC Pregnancy and Childbirth* June 2016
- IV. Egenberg S, Karlsen B, Massay D, Kimaro H, Bru LE. “No patient should die of PPH just for the lack of training!” Experiences from multi-professional simulation training on postpartum hemorrhage in northern Tanzania: a qualitative study. Submitted *BMC Medical Education* Oct 2016



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# **1 Introduction**

“The right to health, including access to timely, acceptable, affordable health care of appropriate quality”, is a human rights-based approach to ensure that health policies are designed to improve health for all (WHO, 2015a). From the end of 2015, Millennium development goals and Countdown to 2015 were replaced by Sustainable development goals, aiming at a global maternal mortality reduction to less than 70 per 100 000 live birth by 2030 (UN, 2016; WHO, 2015b). “Policy makers, health professionals, social workers, religious leaders, human-rights advocates and the media all have a responsibility to ask themselves: "what can I do?" Everyone have a role in affecting quality reproductive-health services, which are essential for the reduction of maternal mortality and morbidity, and are an intrinsic human right. The midwife is the obvious catalyst and linch-pin for this effort in the fabric of society” (Kwast, 1998). The scope of midwifery is in addition to promotion of the normal pregnancy, birth and postpartum period for mother and child, to detect complications, access medical care and carry out emergency measures whenever needed (ICM, 2016).

## **1.1 Background**

This project included sites in Tanzania and Norway, where the right to health is declared in governmental regulations of both countries. Tanzanian Ministry of Health and Social Welfare stated: “When a woman undertakes her biological role of becoming pregnant and undergoing childbirth, the society has an obligation to fulfil her basic human rights, which include the right to life, liberty social security, maternity protection and non-discrimination” (Ministry of Health and Social Welfare, 2008). The Norwegian Parliament enacted the Patients’ Rights Act in 1999: “The object of this act is to help ensure that all citizens have equal access to good quality health care by granting patients’ rights in their relations with the health service. The provisions of this act shall help to promote a relationship of trust between the patient and the health service and safeguard respect for the life, integrity and human dignity of each patient” (LOVDATA, 1999).

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The following description of the physiological processes of normal labor might be useful, in order to grasp the dynamics of bleeding after birth and why it is, according to WHO, perceived as preventable in most cases.

### *1.1.1 Postpartum hemorrhage, or - bleeding after birth*

Childbirth is described by four stages: 1<sup>st</sup> stage from onset of true labor to complete dilatation of the cervix, 2<sup>nd</sup> stage from complete dilatation of cervix to the child is born, 3<sup>rd</sup> stage from the child is born to placenta is delivered, and 4<sup>th</sup> stage from delivery of placenta to the mother is stabilized after birth (Oxorn, 1986).

The clinical focus of the PhD-project has been on 3<sup>rd</sup> and 4<sup>th</sup> stage of labor, and purely related to the mechanisms of bleeding after the child is born. During the third stage of labor, the uterine contractions and retraction of the myometrial fibers cause placenta to separate from the uterine wall. The placental tissue is not elastic, and the contractility of the uterus combined with retroplacental bleeding and a change in hormonal level, cause expulsion of the placenta (Foster, 2009; Oxorn, 1986). The placental expulsion is expected to take place within the first 5-30 minutes after childbirth, presented by a small gush of vaginal bleeding. Usually the mother pushes the placenta out soon after birth, supported by gentle traction of the cord or controlled cord traction (CCT) (Gulmezoglu et al., 2012; Jhpiego, 2012; Klein, Miller, & Thomson, 2009). In the 4<sup>th</sup> stage, the myometrial fibers are supposed to compress the blood vessels immediately after birth of the placenta, called the "living ligatures", to cut off flow to the placental site in order to provide hemostasis. If this mechanism fails due to lack of uterine contractility, uterine atony occurs and can cause postpartum hemorrhage (PPH). To prevent PPH, the most important measure is to make the uterus to contract after expulsion of the placenta in this "immediate postpartum period" (POPPHI, 2007).

The expected blood loss after a normal delivery is approximately 200ml, and up to 500ml blood loss after birth is considered normal (Oxorn, 1986; POPPHI, 2007; Sheldon et al., 2014; WHO, 2009). Primary PPH is defined as vaginal blood loss of 500ml or more during the first 24 hours after childbirth, and blood loss of 1000ml or more after cesarean section (CS) due to the blood loss from the surgical incision in addition to the placental bed (Mousa, Blum, Abou El

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Senoun, Shakur, & Alfirevic, 2014; van Stralen, von Schmidt Auf Altenstadt, Bloemenkamp, van Roosmalen, & Hukkelhoven, 2016; WHO, 2012b). Secondary PPH is defined as any abnormal bleeding between 24 hours and 12 weeks after birth (Abdul-Kadir et al., 2014). The causes of PPH are called the 4T's, where 70-80% are believed to be due to tone (uterine atony), while other causes are tissue (including retained placenta), trauma (including lacerations of the genital tract) and thrombin (coagulation disorders) (Oxorn, 1986; Weeks, 2015).

The PPH-incidence based on estimated blood loss is varying, but according to a WHO-study believed to be around 6%. The reported PPH-figure in the same survey was 1.2% (Sheldon et al., 2014). Two thirds of mothers developing PPH have no known risk factors (POPPHI, 2007), and PPH can be deadly within a couple of hours if left unattended (WHO, 2016). For early detection of uterine atony as the most common cause of PPH, abdominal massage after the delivery of placenta is recommended (WHO, 2012a). The most effective prevention of PPH and in accordance with active management of third stage of labor (AMTSL), is an intramuscular injection of oxytocin (Gulmezoglu et al., 2012). Additionally, controlled cord traction and uterine massage belong to AMTSL procedure, although empirical evidence of the effects of uterine massage is insufficient (Abdul-Kadir et al., 2014; Hofmeyr, Abdel-Aleem, & Abdel-Aleem, 2013). Bimanual uterine compression is a recommended life-saving maneuver if the uterus is not responding to regular treatment (Anderson & Etches, 2007).

A placental expulsion within 30 minutes after childbirth is considered normal as long as the retention is not combined with vaginal bleeding. There are four explanations to the retention of placenta: separated but retained, separated but incarcerated, adherent but separable, adherent and inseparable (Oxorn, 1986). Placental retention is often attributed to the use of uterotonic ergot alkaloids (Gulmezoglu et al., 2012; POPPHI, 2007). If retention of placenta is complicated by a profuse bleeding, the placenta has to be removed immediately to ensure contraction of the uterus. Abnormally invasive placenta was in a Danish study, together with lacerations, the most common cause of hysterectomy (Colmorn, Krebs, & Langhoff-Roos, 2016).

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Depending on the health facility's options, treatment to manage severe PPH involves a cascade of increasingly invasive procedures until the bleeding is controlled, like curettage, balloon tamponade, B-Lynch sutures, uterine artery ligation, uterine artery embolization, and subtotal or total hysterectomy (Hofmeyr & Qureshi, 2016). Blood transfusions are still considered hazardous in many respects due to the possibility of severe complications, and should be used only on strict indications (Alter & Klein, 2008).

PPH has to be seen in relation to anemia in pregnancy, which predisposes for PPH as well as reduces the tolerance to blood loss after birth (Weeks, 2015). Even among mothers with three or more risk factors for PPH, only 10% of the PPH-cases were predicted (Prata et al., 2011). Training on assessment of blood loss and monitoring of mothers after birth, should be provided to all maternity staff in order to reduce severity of PPH (Knight et al., 2009).

### *1.1.2 Morbidity and mortality related to PPH*

Worldwide, 27% of maternal deaths are caused by PPH (Say et al.), while in Sub-Saharan countries as many as 30-40% of the maternal deaths are caused by PPH (Mpemba, Kampo, & Zhang, 2014; Sheldon et al., 2014). Estimates on maternal mortality ratio (MMR) show that Tanzania is making progress; MMR dropped from estimated 997 maternal deaths per 100,000 live births in 1990, to 398 in 2015 (WHO, UNICEF, UNFPA, World Bank, & UN, 2015). Tanzania aims at a reduction in maternal deaths to 140 per 100 000 live births by 2030 (Afnan-Holmes et al., 2015).

The PPH-rate is increasing in high-income countries due to labor induction, augmentation and previous CS (Kramer, Dahhou, Vallerand, Liston, & Joseph, 2011; Lutomski, Byrne, Devane, & Greene, 2012). In Norway, MMR was 5 (The World Bank, 2015).

The fact that almost all maternal deaths occur in low-resource countries, reflects inequity related to access to health services (WHO, 2015b). The World Bank has defined "low-resource", resource-limited or low-income country, as countries with a GNI (Gross national income) per capita of \$1.025 or less in 2015, like Tanzania. "High-resource" or high-income countries are those with

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gross national income per capita of \$12,476 or more, like Norway (The World Bank, 2016).

### ***1.1.3 Health professionals' competence in preventing and counteracting PPH***

The most effective interventions that contribute to saving maternal lives, are skilled attendance at birth and emergency obstetric care (Afnan-Holmes et al., 2015). This project was based on an educational intervention, comprising health facilities with skilled birth attendants (nurse midwives and doctors) and additionally, auxiliary nurses or medical attendants with education equivalent to one-year basic nursing. The skilled birth attendants were already educated in how to prevent, identify and treat PPH, including active management of third stage of labor (AMTSL) (POPPHI, 2007). In general, nurse midwives have their main attention on the support and guidance of the normal progress of labor. Being responsible for the mother and the newborn child, they might experience concurrent demands among the two without being able to attend closely to both simultaneously. There might be a potential for improvements of obstetric emergency management among nurse midwives in general.

Because PPH, according to WHO, in most cases is considered preventable (WHO, 2015b), it seemed crucial to investigate and explore potentials for improvements in overall PPH-management. PPH is clinically presenting itself with the same symptoms regardless geography, ethnicity and level of health care. In that sense, simulation training on PPH could be implemented in any context to possibly enhance maternal health services and maternal health.

## ***1.2 Aims of the thesis***

The aim of this PhD-project was to investigate by mixed methods design how the implementation of multi-professional simulation training on PPH for maternity staff might affect patient outcomes related to PPH-management, perceived efficacy levels after training, and to explore perceptions of learning features and learning outcomes. By an educational intervention, data collection and analyses, we aimed at enhanced understanding and new knowledge.

### **1.2.1 Research questions and hypotheses**

The specific research question for every study was the following:

- 1) How did the informants perceive learning features and learning outcomes from the multi-professional simulation training on PPH-management in northern Tanzania? (paper IV)
- 2) What was the staff's perception of self-efficacy, collective efficacy and team functioning related to PPH-management before and after simulation training? (paper II)
- 3) How was multi-professional simulation training on PPH influencing blood loss after birth? (paper I, II and III)

For the quantitative studies, it was considered relevant to formulate hypotheses. The following null hypothesis was set for the quantitative studies: multi-professional simulation training has no effect on PPH and self-efficacy. The H1 hypotheses were: 1) multi-professional simulation training will contribute to positive changes in efficacy beliefs, and 2) the training will reduce overall blood transfusion rate after birth.

### **1.3 Structure of the thesis**

The thesis is divided into seven chapters, including references. Chapter 1 gives an introduction to maternal mortality related to postpartum hemorrhage and the physiological process of normal labor. This chapter ends with aims and structure of the thesis. Chapter 2 presents the theoretical framework by a description of the social cognitive theory in relation to simulation training. Thereafter follows a presentation of previous research on simulation training in general and simulation training on PPH in particular. Chapter 3 presents the mixed methods used and is by far the most extensive chapter. It describes choice of research designs, validity considerations, the intervention of simulation training, the quantitative and qualitative studies, approvals and ethical considerations. Chapter 4 gives the summary of results. Chapter 5 discusses the findings, presents inference of findings and limitations of the project. Chapter 6 concludes on the findings, possible implications and suggestions for future research. Chapter 7 with references is followed by four

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scientific papers, and appendices with list of approvals (for paper I-IV) and a questionnaire (paper II).



## **2 Theoretical framework**

By combining learning theories with obstetrical evidence-based practice, this project investigated possible effects of a multi-professional, educational intervention on PPH. More cadres were involved, with different scopes of practice. While midwifery is a nursing specialty promoting the normal birth (ICM, 2016), obstetrics is the medical field on pregnancy, childbirth and postpartum period, and obstetrics and gynecology a medical specialty. Both nurse midwives and doctors/obstetricians are crucial for teamwork within obstetrical health care. As an important member of a multi-professional team, the midwife should develop a problem solving strategy prior to management of labor complications. At the same time, the midwife should adopt a cautious approach and remain confident in the normal progress and rhythm of childbirth (Blåka, 2002).

In Norway and Tanzania, midwives autonomously supervise and assist mothers in labor, usually with assistance of an auxiliary nurse/medical attendant. Nurses who are specialized in midwifery, have in some Scandinavian countries, like Norway, a significant medical authority (Dekker et al., 2013). The doctor on duty is called in case of complications like PPH, for medical interventions requiring a doctor's attendance or for advice, in Norwegian as in Tanzanian health facilities.

Most deliveries are expected to remain uncomplicated. Still, it is the responsibility of every birth attendant to be aware of and prepared for complications, and to be able to prevent, identify and treat conditions threatening mother and/or child. Obstetrics is globally considered a field of high and complex intensity where a high rate of preventable adverse events result in newborn and maternal morbidity and mortality (Hjort, 2007).

Educational interventions have been associated with improved performance and significant changes especially in perinatal outcomes. However, there is a need for research investigating educational aspects related to maternal health, and how and why changes in patient outcome might occur (Bergh et al., 2015; Bleakley, 2006; Draycott et al., 2015). No study was identified that showed efficient PPH-management leading to significantly reduced blood transfusion

### *Theoretical framework*

rates. This project investigated whether an educational intervention on multi-professional simulation training on PPH could contribute to new knowledge and understanding, and to a reduced PPH-rate after training. Bandura's social cognitive theory served as a theoretical foundation for the learning aspects of this project (Bandura, 1997).

In the following, some central terms within the social cognitive theory will be presented, along with previous research on important learning aspects of simulation training.

#### **2.1 Central terms within the social cognitive theory seen in relation to simulation training**

Social cognitive theory explains a person's actions and reactions, including social behaviors and cognitive processes. Self-efficacy is understood as one's belief in the capability to perform tasks or actions (Bandura, 1997). Collective efficacy is the belief in the capability to solve a problem through unified efforts, which can influence the quality of team performance. The collective belief is dependent on the interactive dynamics where the group represents more than the sum of individual attributes. This relies on knowledge and competencies within the group, interpersonal relations and group structure (Bandura, 1997). Different persons with similar skills, or one person performing under different circumstances, can act and perform very differently depending on their current and fluctuating level of perceived efficacy (Bandura, 1997).

General self-efficacy or self-confidence reflects one's judgment about the ability to manage different tasks or challenges. Confidence is here understood as one's general belief in one's ability to succeed (Bandura, 1984). In Swahili "confidence" was a term used to explain level of self-efficacy in relation to PPH.

There is a distinction between self-assessment and efficacy beliefs, although used interchangeably in the literature. The different terms and the importance of motivation are highlighted in the following:

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### **2.1.1 Self-assessment**

Self-assessment is understood as one's judgment about the ability to carry out a certain task (Moorthy, Munz, Adams, Pandey, & Darzi, 2006). During simulation training, self-assessment is facilitated through debriefing with additional feedback from the facilitator and other trainees. A study in simulation-based assessment among anesthetists found that self-assessment and scores by external assessors were significantly correlated. At a lower level of performance, there was a tendency among participants during simulated anaphylaxis to overrate performance (Weller et al., 2005). The practice of an after-event review for feedback exchange can enhance team self-correction for improved patient safety (Salas, Wilson, Murphy, King, & Salisbury, 2008), and self-assessment can as well enhance motivation for learning and serve as adjustment of inflated self-confidence (Surcouf, Chauvin, Ferry, Yang, & Barkemeyer, 2013). Obstetric emergencies might be so unique that a domain-specific evaluation tool is needed, with a low correlation between external assessment and self-assessment (Morgan, Pittini, Regehr, Marrs, & Haley, 2007).

### **2.1.2 Self-efficacy and collective efficacy**

Self-efficacy; one's judgment of exercise of control related to a certain task (Bandura, 1997), is not a discrete act but the exercise of control. According to social cognitive theory, efficacy beliefs also involve management of thought, affect and motivation. Perceived efficacy levels refer in this setting to health professionals' beliefs about their ability to master PPH-emergencies individually or within a team (Bandura, 1997).

According to social cognitive theory, efficacy beliefs are mainly influenced by four sources, all closely related to learning features and learning outcomes of simulation training (Bandura, 1994): 1) *mastery experiences* are based on experiences of success in real life or through simulation, where real-world experiences can be created, 2) *vicarious experiences* are valuable for level of efficacy due to the importance of role models. Observing colleagues who are managing a task one is expected to handle, can enhance one's belief in the ability to perform likewise, 3) *verbal or social persuasion* through debriefing and feedback can enhance one's perception and understanding of own

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performance. By being persuaded that one has what it takes to perform a certain task, one is likely to try harder to manage. Social persuasion can as well be negative, creating disbelief and lowering motivation to an extent where poor performance is self-fulfilling through low self-efficacy, 4) *physiological state*, like stress reactions and tension during high physiological activation perceived as anxiety, can negatively affect perceived self-efficacy. Having failed in achieving one's aims, one might choose to either avoid similar challenges or choose a much more difficult task – anticipating that one would fail. One's experience of success is very important and is guiding how one makes her/his choices (McClelland, 1988).

However, if a recent experience triggers arousal perceived as a normal reaction and an energizing boost, it will enhance self-efficacy and future performance (Bandura, 1994; Maibach, Schieber, & Carroll, 1996; McClelland, 1988). Relevant skills should be rehearsed in a naturalistic, acute setting that includes induced stress responses. Practicing relatively complex skills in a realistic simulation can enable participants to recall these skills and perform them effectively in demanding situations when psychological arousal is high (Keitel et al., 2011).

#### *2.1.3 The impact of motivation during simulation training*

According to Bandura, people with high self-efficacy who believe they can perform well, are more likely to view difficult tasks as something to be mastered rather than something to be avoided (Bandura, 1997). Simulation training might positively affect the participants' motivation to strive for optimal PPH-management. According to theory of planned behavior, perceived expectations from other persons related to one's ability to act or perform, and one's will to act accordingly, is described as "subjective norm". Together with attitudes and perception of control, subjective norm will produce intentions that determine performance (Ajzen & Sheikh, 2013). Thus, the motivational aspects of team training may influence the effects of simulation training.

Among Tanzanian health care providers, community appreciation has been identified as a key motivational factor and an important indicator of the quality

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of the provided services (Prytherch, Kakoko, Leshabari, Sauerborn, & Marx, 2012).

Important principles of Bandura's social cognitive theory seem to overlap with learning features believed to be of importance within simulation training. Especially the four main sources influencing perception of self-efficacy and collective efficacy, might be highly relevant.

## **2.2 Simulation (or scenario-based) training**

The term simulation is used in many different settings, and there is a need to define what simulation, or scenario-based, training might mean. Within health care, simulation is to mimic or act out a real-life condition without harming the patient. According to Dieckmann, "a simulation is a spatiotemporally and socially limited event, during which humans interact in a goal-oriented way with each other, a simulator, and other equipment for different purposes" (Dieckmann, 2009). Theoretically, any situation can be simulated, but the main focus has been on medical emergencies where the aim is to provide a learning experience that meet the learning goals. Situated learning takes place in a community of practice, where new learners must be given the possibility of participation while gaining experience and competence; legitimate peripheral participation (Acharya, Reyahi, Amis, & Mansour, 2015; White, 2010). This corresponds well with simulation, which is considered a powerful educational tool to be implemented contextually by paying attention to the individual learners, their experiences and their environment (DeWitt, 2003; Zigmont, Kappus, & Sudikoff, 2011).

Emphasis should be put on creation of a safe environment for optimal learning (Topping et al., 2015), and confidentiality is compulsory. A simulation setting should comprise seven steps: a setting introduction, simulator briefing, theory input, scenario briefing, a scenario, debriefing, and closure of the simulation (Dieckmann, 2009). Simulation training is in the context of this project understood as multi-professional training on technical and non-technical skills related to PPH, followed by debriefing in teams.

In order to mimic a situation perceived as realistic and engaging, varieties of low- and high-fidelity simulators are in use. Alternatively, a patient actor can

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make a scenario to be real-life and challenging. Mimicking the realism of bleeding after birth, was in each of the health facilities in this project done by operators who used the birthing simulator MamaNatalie® (Laerdal Global Health, 2015).

According to previous research, the following learning features were identified as important within multi-professional simulation training:

#### *2.2.1 Team training*

Traditionally, knowledge, skills and attitudes have been emphasized as the three key elements of practical training, including simulation training. Teamwork is suggested as an additional fourth dimension of professionalism (Fox, Walker, & Draycott, 2011). Many health care teams are in clinical practice established ad-hoc, and the competence built within the team should not be dependent on the presence of certain team members, but applicable to a given event (Boet, Bould, Layat Burn, & Reeves, 2014). Team training allows the participants by vicarious or indirect experiences to observe colleagues managing related work tasks and thereby enhance own self-efficacy level (Bandura, 1994). Training multi-professional teams are logistically more demanding than training a single profession, but gives the opportunity of strengthening collaborative teamwork and thereby enhance patient safety (Boet et al., 2014). Still, simulation training in teams must challenge team members on the edge of their comfort zone for optimal learning, while still being relevant to all participants (Boet et al., 2014; Stocker, Burmester, & Allen, 2014).

A multi-center study measuring response time to PPH among clinical teams, was associated with improved recognition, administration of drugs and performance of bimanual uterine compression (Marshall, Vanderhoeven, Eden, Segel, & Guise, 2015). A course in Zimbabwe, including almost 300 participants and comprising skills training on a variety of obstetric emergencies, teamwork and practice-based local tools, checklists and techniques, led to a perception of improved teamwork and interprofessional culture. Clinical outcomes indicated a significant reduction in maternal mortality, but no data were provided regarding PPH and blood transfusion rates (Crofts et al., 2015). The collective efficacy-level, being the belief in the capability to solve a problem through unified efforts, influences team

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performance, and team performance influences the perception of collective efficacy. The team becomes an integrated unit more than the sum of the participants (Katz-Navon & Erez, 2005). This relates to “collective competence” which includes three aspects: to make collective sense of events at work, to develop a shared base of knowledge, and to rely mutually on each other (Boreham, 2004). Team members with a high collective efficacy level will mobilize their resources in order to cope with the given tasks, while members with low collective efficacy level will stop trying to solve the task although the team as a whole might be able to handle the situation (Bandura, 1982).

#### *2.2.2 Realism and relevance of the training*

Realism in simulation training is, according to an obstetric editorial, crucial to bridge the gap between training and practice (Fox et al., 2011). To reduce the gap between simulation and reality, the simulation teams should reflect real-life teams and should represent different medical specialties and levels of expertise (Stocker et al., 2014). The learning goals set for the simulation training should ensure relevance for the employees who are participating, and who must be allocated to specific roles according to their profession (Boet et al., 2014).

Scenarios that are experienced as authentic and relevant for participants, are likely to facilitate optimal learning. Skills training before the actual scenario is therefore important to enhance skills, reduce level of anxiety and create a safe environment for learning (Malone, Anderson, & Manning, 2016). Technical skills are complemented by non-technical skills, including team orientation, communication, leadership, situational awareness and decision-making (Rutherford, Flin, & Mitchell, 2012). To some degree, non-technical skills are incorporated into clinical procedures as basis for simulation training (Shields & Flin, 2013), ensuring relevance of the training. Educators and facilitators who have expert knowledge and are able to model professional values by real-world examples, can enhance the learning experience of simulation training (Topping et al., 2015). Realistic scenarios can enable the participants to generalize the learning outcomes beyond the training facilities (Tasa, Taggar, & Seijts, 2007). The level of “simulator fidelity” is in many studies regarded important for

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learning outcomes (Bergh et al., 2015; Eddy, Jordan, & Stephenson, 2016). However, it might be more essential that the sociological fidelity, like gender and professional boundaries, is contextual, believable and at a high level (Sharma, Boet, Kitto, & Reeves, 2011).

#### *2.2.3 Repetition of scenarios/experiences*

Repetition of scenarios are in line with Kolb's experiential learning theory, by many studies referred to as a main framework of simulation training. The experiential learning theory explains how knowledge can be created through exposure to a concrete experience, followed by reflective learning, abstraction of the concept and by applying new frames of understanding during a second experience (Stocker et al., 2014). The more repeats of scenarios to enhance procedural skills, the better performance and retention of skills competence (Vadnais et al., 2012). Within the educational, neonatal resuscitation program "Helping babies breathe", frequent and brief training on newborn resuscitation in addition to a one day-course, resulted in improved perinatal outcome (Mduma et al., 2015). Instructor-led training of "low dose, high frequency" cardiopulmonary resuscitation enhanced retention of skills (Sutton et al., 2011). To enhance obstetric competencies, annual obstetric training seemed sufficient to retain factual knowledge (Crofts et al., 2013). By rehearsals, the skills training can progress successively to higher level of difficulty (Bosse et al., 2015; Stocker et al., 2014).

#### *2.2.4 Reflective learning*

Reflective learning within a multi-professional team will allow cultural context and social conditions to influence and enhance the learning outcomes (Stocker et al., 2014). In a safe environment which is considered prerequisite for critical reflection (Stocker et al., 2014), consecutive debriefing with constructive and emphatic feedback is believed to enhance self-efficacy (Rudolph et al., 2013). Also verbal or social persuasion through debriefing is associated with enhanced self-efficacy (Bandura, 1997). Feedback is said to be the single most important feature for as well education as for simulation training (Hattie, 2009; Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005; McGaghie, Issenberg, Petrusa, & Scalese, 2010), and without critical feedback, the learning outcomes

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of simulation training might be lost (Rudolph et al., 2013). However, debriefing is a powerful tool. Facilitators should aim at clear feedback while at the same time avoid damaging their relation to their colleagues (Rudolph et al., 2013).

Team members who receive performance feedback at team level, gain a stronger shared sense of collective efficacy than if performance feedback is given at the individual level (Tasa et al., 2007). The perception of collective efficacy will influence the quality of teamwork. Perceived level of coordination, cohesion; understood as solidarity and sense of community, and collective efficacy, is according to Salas a self-fulfilling prophesy creating team culture of learning and error reduction (Salas, Wilson, et al., 2008). Reflective practice consists of three steps: 1) to uncover the trainees' frames of understanding, 2) to challenge the frames of understanding by genuine expert curiosity, and 3) by well-founded questions to combine the facilitator's judgment and the trainees' frames of understanding in order to reach new understanding and knowledge (Rudolph, Simon, Dufresne, & Raemer, 2006). This can be done by the following type of questions: "How did you understand the situation?", "What made you choose your actions?", and "If you were given the opportunity to do it once more, would you have done something differently?" Debriefing is a positive approach aiming to prevent defensiveness and strengthening reflective practice (Rudolph et al., 2006). Clinical teaching integrated with teamwork and debriefing sessions, were related to effectiveness of training (Crofts, Winter, & Sowter, 2011).

#### *2.2.5 Team training in a patient safety perspective*

Non-technical skills are understood as cognitive and social skills (Yule et al., 2009). As a part of teamwork, non-technical skills like communication, coordination and cooperation, represent the constant interaction between team members (Salas, DiazGranados, Weaver, & King, 2008). These three approaches are according to Salas et al, crucial for effective teamwork and enhanced patient safety: communication is the effort to exchange precise information, coordination is the explicit strategy to anticipate and respond to each other, while cooperation is the affective component dependent on trust and team orientation. Essential non-technical skills, although not explicitly listed in protocols, include efficient communication like closed loop-communication,

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decision-making skills, patient handover, and teamwork, and are important elements in scenarios for improved patient safety (Budin, Gennaro, O'Connor, & Contratti, 2014). Assessing team communication related to team training on PPH, Siassakos et al concluded that additional training on situational awareness, roles and responsibilities, and clear directed communication, was associated with improved team communication (Siassakos, Draycott, Montague, & Harris, 2009).

The way an organization implements its quality management, will most likely influence patient safety measures and working environments. Human error is one of ten leading causes of death (Rall & Dieckmann, 2005). In perinatal units in United States, failures in communication were by root-cause analyses shown to contribute to around 70% of unanticipated events (Shapiro et al., 2008). Simulation training should challenge the participants in order to motivate them to reflect and learn from mistakes (Stocker et al., 2014). According to Reason, the best people often make the worst mistakes, and effective defenses have to be developed (Reason, 2000). The person approach focuses on the acts carried out at the sharp end; by midwives, nurses, doctors, auxiliary nurses/medical attendants and others in clinical practice. Errors and violations can be perceived as results of mental processes like forgetfulness, ignorance or poor motivation. Understanding errors by a person approach is likely to result in blame, shame and fear of reporting mishaps. System approach to human error, however, recognizes humans as fallible. Errors and mistakes are understood as consequences more than causes, with the aim of changing working conditions to prevent errors from happening (Reason, 2000).

Patient safety climate encloses team respect, no blame if reporting errors, appropriate feedback and good communication (Budin et al., 2014). In order to improve an organization, actions like speaking up when you have a concern, listening to concerns of colleagues and acknowledging the vulnerabilities of the organization, is crucial to patient safety (Pronovost, Weast, Rosenstein, & et al., 2005). Closely related to the person or system approach to human error, is the perspective of resilient organizations. Resilient health care differentiates between Safety-I, focusing on adverse outcome when something has gone wrong, and Safety-II, being the ability to succeed under varying conditions. According to the Safety-II perspective, things go right because we learn from everyday activities and make adjustments necessary for securing the right

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actions and prevent adverse events (Hollnagel, 2014). Resilience within complex systems derives from diversity, not primarily compliance with best practice guidelines (Dekker et al., 2013). Safety-II principles harmonize well with how simulation training, including reflective learning, might stimulate resilience and stress resistance in teams. In situations experienced as demanding, an activation of affective, motivational and behavioral mechanisms can contribute to resilience (Schwarzer & Warner, 2013).

## **2.3 Previous research on training courses related to PPH**

In order to find out what is already known about PPH-management and where new knowledge is needed, literature searches were carried out in BIBSYS, PubMed and CINAHL, related to terms like bimanual uterine compression, birth, bleeding, blood loss, competence, communication, confidence, effects, efficacy, emergency, estimation, evaluation, experience, hemorrhage, learning feature, low- and high-resource, maternal health, midwifery, mortality, motivation, obstetrics, outcome, patient safety, postpartum, PPH, questionnaire, simulation, skills, training, team, transfusion and uterine atony.

### **2.3.1 Courses on obstetric emergencies**

Numerous training courses have been established to improve maternal services including PPH-management (Bergh et al., 2015). During the last 15-20 years, Basic emergency obstetric and newborn care (BEmONC) and Comprehensive emergency obstetric and newborn care (CEmONC), have been implemented in order to enhance knowledge and technical skills in low-resource countries worldwide (Dao, 2012). BEmONC and CEmONC are very inclusive, 3-weekly courses for skilled and semiskilled staff, which focus on training personnel in evidence-based theory and practical competencies. This is done by knowledge update, technical skills training including clinical decision-making, and clinical practicum. BEmONC-training includes hands-on training on skills like manual removal of placenta and bimanual uterine compression. The course emphasizes the importance of knowledge retention and performance. BEmONC-courses provided by Jhpiego, an affiliate of Johns Hopkins University, emphasize a humanistic approach with respectful care as in real-life. When mastering of

### *Theoretical framework*

skills are achieved by hands-on training, the participants are supervised in clinical practice within the frames of the BEmONC-course (Otolorin, Gomez, Currie, Thapa, & Dao, 2015). In CEmONC-courses, emphasis is also on additional services like surgery, blood transfusion, and advanced resuscitation (Dao, 2012).

Advanced life support in obstetrics (ALSO), Practical obstetric multi-professional training (PROMPT) and the Advances in labor and risk management international program (AIP), although developed primarily for high-resource settings, aim to enhance competence levels and meet the demands of skilled, semiskilled and multi-professional teams also in low-resource settings (AAFP, 2016; Advanced Life Support Group, 2016; Dresang et al., 2015; Spitzer et al., 2014; The PROMPT Maternity Foundation, 2008; Walker, Fetherston, & McMurray, 2015). ALSO-training has been disseminated to more than 60 countries globally. PROMPT-courses on emergency obstetrics, including PPH, have some golden rules: the courses must be run, adopted and adapted locally in own units by multi-professional trainers for multi-professional participants. The drills are carried out by using simple anatomic models, patient actors as well as a birthing trainer, and the team training is followed by debriefing sessions (PROMPT, 2016), see Table 1.

*Theoretical framework*

Table 1 Established regional and global training courses on obstetric emergencies

Short form	Course name	Participants	Setting	Duration	Topics
AIP	Advances in labor and risk management international program	skilled and semiskilled staff	global	5 days	Obstructed labor, hemorrhage, sepsis, hypertensive disorders, and complications due to unsafe abortion
ALSO	Advanced life support in obstetrics	skilled and semiskilled staff	global	2 days	A combination of lectures, workstations, simulations with mannequins, and mnemonics developed to teach maternity caregivers evidence-based management of obstetric emergencies
BEmONC	Basic emergency obstetric and neonatal care	skilled and semiskilled staff	low-resource	3 weeks	Lectures on evidence-based practice, human rights, clinical decision-making, infection prevention, best practice for labor and newborn care including AMTSL, hemorrhage, shock, vacuum-assisted delivery, severe preeclampsia, fever, newborn resuscitation, newborn sepsis. Skills training, clinical practicum and criterion-based audit

*Theoretical framework*

Table 1 Established regional and global training courses on obstetric emergencies

Short form	Course name	Participants	Setting	Duration	Topics
CEmONC	Comprehensive emergency obstetric and neonatal care	skilled and semiskilled staff	low-resource	3 weeks	All BEmONC-topics, additional topics like anesthesia, CS and other surgical procedures, blood transfusion and advanced resuscitation.
MOET	Managing obstetric emergencies and trauma	skilled staff	high-resource	3 days	Recognition, resuscitation and treatment of emergencies by lectures, skills stations and workshops
PROMPT	Practical obstetric multi-professional training	multi-professional teams	Global	1 day	Emphasizing clinical practice: simulation of obstetric emergencies like shoulder dystocia, postpartum hemorrhage, breech delivery, neonatal resuscitation
PRONTO	Programa de rescate obstétrico y neonatal: tratamiento óptimo y oportuno	skilled and semiskilled staff	low-resource	2+1 days	Team-building exercises, skills stations, simulation of obstetric and neonatal emergencies followed by debriefing

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The approaches and outcome measures of training programs differ. In the following, the various course concepts focusing on PPH are illuminated in accordance to participants, outcome measures and participants' experiences.

#### ***2.3.2 Training of skilled and semiskilled staff on PPH***

Courses like ALSO comprise specific cadres of maternity staff, not the entire teams. An ALSO-course in Tanzania including exercise on blood loss estimation, AMTSL hands-on training, teamwork-based role plays on PPH and case discussions, resulted in improved AMTSL-skills, bimanual uterine compression and a reduction in collected and measured blood loss after birth. There was no significant reduction in blood transfusion rate (Sorensen et al., 2011). A Kenyan study based on an intervention with the AIP-course, found an increase in estimated mean blood loss after training, possibly due to more careful assessment after intervention. However, the PPH-rate was significantly reduced while blood transfusion rate remained unchanged (Spitzer et al., 2014).

#### ***2.3.3 Team training on PPH-management***

One study on the use of patient-actor during PPH-scenarios, was associated with improved perception of safety and communication (Crofts et al., 2008). Another PPH-related study found no significant change in blood loss >1500ml pre-post training (Shoushtarian et al., 2014). A study evaluating multi-professional training on PPH, found no change in blood transfusion rate post training (Markova, Sorensen, Holm, Norgaard, & Langhoff-Roos, 2012).

#### ***2.3.4 Experiences from training on PPH-management***

A validation of the training package *Helping mothers survive: bleeding after birth* (Jhpiego, 2012), showed increased level in knowledge and confidence after training, mostly seen in relation to bimanual uterine compression for semiskilled and skilled birth attendants (Evans et al., 2014). Skills training using the same training package, increased confidence and bimanual uterine compression skills for health workers of different cadres (Nelissen et al., 2015).

## *Theoretical framework*

*Theoretical framework*



Picture 1 Faculty at UNN Tromsø getting to know MamaNatalie

*Theoretical framework*



Picture 2 Discussion among faculty on the simulation training. UNN Tromsø

## **3 Methods**

### **3.1 Philosophical considerations**

Research questions may be considered the most important determinant for choice of research design to increase the likelihood of successful research. These questions might be advantageous because they help to define the project, set boundaries, give direction or focus and define to which extent your research has provided answers (Robson, 2011). Based on the research questions, philosophical considerations were carried out to clarify the philosophical viewpoint related not only to the planned educational intervention, but also to inference of the findings.

Taken into account that we as individuals cannot perceive the world correctly, we are all biased. To adjust for this lack of objectivism, a post-positivist might by scientific reasoning aim for optimal objectivity by triangulation across multiple measures and methods (Trochim, 2006c). A common form of post-positivism is *critical realism*, claiming that science can study reality, independent of our perceptions of reality (Trochim, 2006c).

The project was considered to be empirical research, with a critical realism perspective. According to Lund, critical realism means «the phenomena studied in scientific research that are not completely constructions in the scientists' "minds", but correspond to real entities or processes which exist independently of us» (Lund, 2005). Critical realism is in this sense relevant for qualitative as well as quantitative research.

A qualitative study, using a constructivistic approach, describes how a group of individuals creates meaning of a common experience or phenomenon (Creswell, 2013). In that sense, findings from focus group discussions would be understood as social constructivism, where knowledge was created through interaction between informants and the researcher (Trochim, 2006c).

In line with critical realism, research questions are not answered by the empirical results of a survey, focus group discussions, numerical data or statistical analyses, but by inference of the findings. It requires that the instruments are standardized in order to exclude threats to internal validity. The

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interpretations and conclusions from different empirical research designs result in a knowledge construction (Lund, 2005). However, no method can guarantee validity of the inference (Shadish, Cook, & Campbell, 2002).

«A hypothesis can be defined as a tentative explanation of the research problem, a possible outcome of the research, or an educated guess about the research outcome» (Prasad, Rao, & Rehani, 2001). In qualitative research, research questions are preferred over hypotheses. We used research questions for the qualitative and quantitative research designs, and set hypotheses for the quantitative part of the project. The following null hypothesis was set for the quantitative studies: multi-professional simulation training has no effect on efficacy beliefs and PPH-rate. The H1 hypotheses were: 1) multi-professional simulation training will contribute to positive changes in efficacy beliefs, and 2) the training will improve PPH-management measured by reduced blood transfusion rate after birth.

### **3.2 Research design**

A randomized controlled trial (RCT) comparing similar groups selected by random assignment, also called a true experiment, is regarded the strongest experimental design to minimize selection bias (Robson, 2011). An alternative, and commonly used design lacking random assignment, is quasi-experimental pre-post design without control groups, but with statistical control for confounding factors.

For this study, a research design that could be considered a mixed methods approach, was chosen. It included a combination of a quasi-experimental design, a survey and a qualitative study, carried out in different contexts. A mixed methods design combining quantitative and qualitative methods (Creswell, 2014), was believed to provide new knowledge on impact on patient outcome as well as comprehensive and nuanced understanding of learning features, learning outcomes and importance of perceived efficacy levels. By using mixed methods, limitations of one method could possibly be outweighed by combining the strengths of different methodology. At UNN Tromsø, a quasi-experimental pre-post design combined multi methods (Creswell, 2014), here being multiple forms of quantitative measures: a survey provided data on efficacy beliefs, while a quasi-experimental pre-post design provided data on

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patient outcome (paper II). The survey served as the theoretical foundation for the learning aspects of this project, and influenced the qualitative data collection (paper IV). A retrospective study (paper I) and a similar quasi-experimental pre-post design at KCMC (paper III) contributed to construct validity of the findings.

### *3.2.1 How to evaluate?*

Researchers who have been evaluating simulation training, often refer to Kirkpatrick and his evaluation model, measuring four levels of achievements: 1) reaction: measuring perception of the training program and level of satisfaction, 2) learning: acquired knowledge, skills and attitudes, 3) behavior: measuring translation of knowledge and skills into action or behavioral change, and 4) results: outcome measured by morbidity and mortality (Bergh et al., 2015; Issenberg et al., 2005; Kirkpatrick & Kirkpatrick, 2008). Another evaluation model is emphasizing the challenges of training implementation, testing the outcome of training at three levels: 1) evidence of progressive improvements in simulation, 2) transfer to true-life patient care practices, and 3) improved patient and public health outcomes. Any intervention which does not improve clinical outcomes, is not a good intervention in patient terms (Fox et al., 2011).

Carrying out a pre-post interventional study together with qualitative research, was considered time consuming due to the different data collection measures and the different methodology for analyses. However, by combining quantitative and qualitative methods in a mixed methods design, triangulation across different perspectives might reach objectivity (Creswell, 2014; Trochim, 2006c).

### *3.2.2 Training attendance*

Previous studies have debated the importance of training attendance, emphasizing mandatory, annual training for obstetric teams (Contratti, Ng, & Deeb, 2012; Siassakos, Crofts, Winter, Weiner, & Draycott, 2009). The participation of maternity staff in the annual simulation training which was investigated by the quasi-experimental study (paper II and III), was mandatory.

### **3.2.3 Sociological fidelity**

Health care services being experienced as a complex hierarchy, can trigger performance anxiety in multi-professional teams due to tension between “positional power”, being assigned a role as leader, and “expert power”. Pediatric residents described performance anxiety and debriefing limitations after experiencing multi-professional simulation training. They experienced positional power of the young doctors in a hierarchical system, while more experienced nurses had expert and informational power. The study concluded that acknowledgement of existing barriers to collaborative practice must be addressed in education and team training (van Schaik et al., 2015). The decision-making power is made legitimate by the educational socialization of medical students (Dekker et al., 2013).

“Sociological fidelity”, like hierarchy, gender and professional boundaries, is describing this diversity among cadres, and social factors should be addressed to open up for conversation and the possibility for reframed understanding and change (van Schaik et al., 2015). A sociological approach where power relations or sociological fidelity are given focus, can enhance transferability from simulation training to multi-professional, clinical practice (Boet et al., 2014). A Scandinavian study presented the conditions under which midwives, obstetrician and nurse assistants worked closely together while representing different experience, expertise, cultures and areas of responsibility. The authors made a clear division between 1) complicated systems being controllable by best practice guidelines, and 2) complex systems being open systems, with numerous components interrelated and in interaction with their environment. The study, identifying labor wards as complex systems, recommended interprofessional team training as an opportunity for every staff member to identify both complex and complicated situations and recognize their colleagues’ constructs and frames of understanding (Dekker et al., 2013).

An evaluation of an Australian ALSO-course for midwives and doctors, found among the midwives a significantly increased confidence related to decision-making. Both cadres valued the opportunity to share professional perspectives and rated the advantages of learning from interprofessional education as positive. A third of the participants believed that different learning needs could be a hindrance for effective learning, and some participants perceived power

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imbalance and inequality within the interprofessional group (Walker et al., 2015).

Even within a system of hierarchy, relational coordination and collective responsibility was linked to success and improved quality of care (Dekker et al., 2013). Through multi-professional team training, team meetings had the additional bonus of creating bonds among employees, who got to know each other on a more personal basis (Contratti et al., 2012). Compassion among co-workers was associated with work satisfaction and teamwork, while negative relations caused emotional exhaustion (Barsade & O'Neill, 2014). Social cognitive theory is relevant for learning outcomes of simulation training on emergencies, where staff is required to act under high psychological activation. A maternity team with high collective efficacy where team members trust each other's capabilities, is according to this theory more likely to provide proper health care. Participants' thoughts during realistic simulations are reflecting a mental state that will appear in similar, real situations (Jones, 2004).

Assessment of emergency obstetric care training programs carried out in low-resource settings, showed in a systematic review lack of strong evidence for improved quality of care. The study recommended training programs including hands-on practice, team approaches and follow-up by stakeholders, arguing that there was no reason to anticipate less need for teamwork in low-resource settings than in western European countries (van Lonkhuijzen, Dijkman, van Roosmalen, Zeeman, & Scherpbier, 2010).

### *3.2.4 Local ownership*

Local ownership of the educational intervention is considered a prerequisite for a sustainable educational program (Contratti et al., 2012; Salas & Rosen, 2013; Soreide et al., 2013). The process of developing local faculty who took ownership in the training of colleagues (paper II and III), adhered to the approach of facilitation instead of traditional instruction (Rudolph et al., 2006). Recruiting faculty who was suitable for the demanding task of debriefing colleagues, was done by the managements who knew their staff well. Faculty was recruited and got prepared to debrief with good judgment (Rudolph, Simon, Rivard, Dufresne, & Raemer, 2007). Additionally, the competence of debriefing could remain within the facility after the intervention. Training of

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faculty, the preparedness of the operators of MamaNatalie® acting as a trustworthy, local woman in labor, learning materials in Swahili (paper III) and the debriefing sessions in Norwegian and Swahili respectively, might have contributed to local ownership, and thereby sustainability of the training.

### **3.3 Validity considerations**

Validity is understood as an approximate certainty of a knowledge claim (Shadish et al., 2002), based on scientific inference including interpretation and generalization of findings. Critical attitude is required throughout the research process to recognize causal knowledge of importance (Lund, 2005). Research questions are not answered from empirical findings directly, but from inference and conclusions based on the results. No method is a guarantee for validity of an inference, because every inference is based on human judgments, known to be fallible (Shadish et al., 2002).

For the research to have internal validity, the inference should be based on the judgment that no other factors than the educational intervention was followed by an observed change in blood transfusion rate after birth. Quasi-experiments must meet some specific requirements: cause must come before effect, cause must covary with the effect, and alternative explanations must be unlikely (Shadish et al., 2002). To account for validity threats, factors like history, maturation, testing threat or Hawthorne effect, and regression threat, had to be accounted and controlled for (Trochim, 2006a). *History* threats represent other events taking place between the time periods (pre-post intervention) independent of the intervention, and which might influence the group before and after intervention, differently. *Maturation* threats reflect the normal development and changes within the groups, and are not related to specific events taking place. Another relevant factor that could represent a threat to internal validity, is the *regression* threat, explained by the regression to the mean of the two groups, if one group represents more extreme findings than the other group. The last, and for this interventional study, very relevant threat to internal validity, is the *testing* threat or *Hawthorne effect*. Hawthorne effect reflects the influence of the attention linked to the intervention, and not the intervention as such. To exclude Hawthorne effect, data collection should

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ideally continue as long as a likely Hawthorne effect is threatening the internal validity.

Another validity concern was the *external validity*, questioning whether a causal effect in one population could be generalized to similar populations. Findings from random samples can as such be generalized for the population the samples were drawn from (Shadish et al., 2002; Trochim, 2006d). To defend the inference of external validity for these studies, descriptions were needed to elaborate the degree of similarity between populations, places (low-resource vs. high-resource settings) and time.

The last concern was to ensure *construct validity*, being the appropriateness of a conclusion based on a measurement like blood transfusions as marker for blood loss after birth. Construct validity in this setting would require that blood transfusion rate reflected severity of blood loss after birth.

### ***3.3.1 Construct validity of clinical indicators of PPH***

Two clinical indicators for blood loss were considered: PPH-rate (blood loss >500ml) based on estimation of blood loss, and blood transfusion rate as a marker for severity of blood loss.

#### **3.3.1.1 Estimation of blood loss**

Visual estimation of blood loss after childbirth is widely preferred due to its relative ease. Birth attendants are assessing visible blood spilled on the bed/madras, on linen and kanga (Tanzanian printed cotton fabric), absorbent paper, in a basin or on the floor/ground, including blood clots, to assess the clinical state of the mother. Blood lost after vaginal birth can easily get mixed with amniotic fluids, urine and stools, while after CS, blood might be mixed with amniotic fluids. The inaccuracy of visual estimation of blood loss varies between 30-50% underestimation, and importantly, increases with increasing blood loss (Al-Kadri et al., 2014; Bose et al., 2006; Hancock et al., 2015).

### **3.3.1.2 Blood transfusion as a marker for blood loss**

At all sites, severe PPH was understood as estimated blood loss > 1000ml. Their PPH-protocols listed preparations for blood transfusion, like sampling blood for crossmatch, and preliminary prescription of two units of blood whenever an uncontrolled profuse bleeding was diagnosed. In order to use blood transfusion rate as a marker for blood loss in these studies, some criteria were set: 1) the routines and indications for prescription of blood units had to remain the same throughout the project, like: a combination of uncontrolled profuse bleeding and/or drop in blood pressure, increased pulse rate, clammy and pale skin and/or dizziness, and 2) the availability of blood units had to remain the same throughout the study period. Thus, using blood transfusion as an indirect measure of effect could possibly reflect the most valid measurement of blood loss after birth.

Units of red blood cells (RBCs) are prepared from whole blood, where part of the plasma is removed. One unit of RBC/whole blood is expected to increase the hemoglobin (Hb) level by 1 g/dl (Sharma, Sharma, & Tyler, 2011).

### **3.3.2 Construct validity of survey measures**

We could not identify any established scale for efficacy beliefs related to PPH-management. Developing a new self-report instrument required a thorough validation process. Items for the questionnaire were developed and discussed with an expert group, and two measurements were developed: a PPH self-efficacy scale (PPHSE) and a PPH collective efficacy scale (PPHCE). PPHSE and PPHCE were pilot tested for preliminary nomological network validation (Trochim, 2006b), and validated by factor analyses in combination with two validated scales: general self-efficacy scale (Schwarzer & Jerusalem, 1995) and team emergency assessment measure (Cooper et al., 2010). Tested by Cronbach's alpha, PPHSE and PPHCE ranged from 0.90 through 0.96 and indicated good reliability (Tavakol & Dennick, 2011).

### **3.3.3 Validation process of focus group discussions**

Qualitative methods can uncover threats to validity as well as help to explain experimental findings (Shadish et al., 2002). According to Shadish et al,

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relevant validity concerns are the same, regardless methodology used to develop the claimed knowledge. To formalize and structure the discussions, an interview guide was used throughout the study. The qualitative study comprised ten focus group discussions with a total of 42 informants. The analytic process was conducted consecutively after the data collection, to ensure similar perception of meaning units. By acknowledging preconceptions and considering the constructed knowledge on learning features and learning outcomes by inference as partial and situated, the study aimed at methodological reflexivity (Malterud, 2001). To ensure trustworthiness of the findings, manifest content analysis was performed, based on the English translation of the transcripts (Graneheim & Lundman, 2004). Additionally, triangulation by using multiple and different sources and methods, provided validity to the findings (Creswell, 2013).

In order to give an overall picture of the project, the implementation of multi-professional simulation training will be presented before the description and reasoning of study designs.

### **3.4 *Interventional study***

The training implemented within this project was carried out according to the Utstein formula of survival, which emphasizes the equal importance of the following three factors: medical science, educational efficiency and adequate local implementation (Soreide et al., 2013). The intervention was carried out in Tanzania and Norway simultaneously. Generally, Tanzanian staff had clinical experience on severe complications that largely exceeded clinical practice in a high-resource country like Norway. Due to the realistic, practical approach, simulation training was believed to have a potential among staff with a clinical approach to problem solving, irrespective of available resources and of PPH-frequency.

#### **3.4.1 *Faculty***

Faculty (facilitators and operators) was recruited by the departmental management at UNN Tromsø, KCMC and Mawenzi Hospital. Characteristics for faculty were clinically experienced and respected nurse midwives and doctors, likely to remain as employees and a valuable resource at their facilities.

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The research coordinator at each facility was responsible for the logistics, which also included establishing multi-professional teams for training.

A two-day preparatory course for faculty included discussions on evidence-based PPH-practices and review of the local PPH-guidelines for diagnosis and management. The management at all three sites were invited to participate in the local preparatory course in order to secure ownership. The faculty shared and discussed relevant articles on system approach to human error, how to facilitate debriefing by leaving the known role of an instructor to facilitate instead, and the quality of debriefing with good judgment (Rudolph et al., 2007). At KCMC and Mawenzi Hospital, the course for faculty was facilitated by a senior consultant at KCMC, being director of ALSO in Africa.

Purposely, the project did not introduce any new equipment to be used during childbirth, like costly blood collector bags which possibly could have provided more accurate estimates of blood loss, but according to the study of Zhang et al., most likely not reduced the PPH-rate (Zhang et al., 2010).

The faculty practiced how to operate the birthing simulator MamaNatalie<sup>®</sup>, which includes a baby, uterus, placenta, urinary bladder, and a blood tank containing up to 1500ml of artificial blood (Laerdal Global Health, 2015). The bleeding could be small or profuse for participants to see and feel, and to hear in case the blood was dripping onto the floor. By spending time on the different features of the birthing simulator and how to operate it for the sake of realism, they learned how to respond appropriately to the various actions of PPH-management carried out by the participants. While the operator's hands were hidden behind MamaNatalie<sup>®</sup>'s abdominal skin, the operator had to open/close the blood tank and inflate/deflate the uterine balloon according to actions taken by the participants.

An especially useful technique for the operators was possibly how to cover one hand behind the inflated uterine balloon in order to make the uterus feel appropriately firm or atonic. Simulating a contracted uterus was done by making a fist when squeezing the uterine balloon and pronate the hand behind the balloon, or simply to hide one's flat hand behind the balloon for an atonic uterus. This technique could additionally prevent the operator's hand from

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getting sore because of the force used repeatedly by participants during uterine massage and bimanual compression.

The birthing simulator was strapped onto the operator, who acted with an attitude representing a laboring woman in her cultural context. For comfort and convenience, the operator used rain trousers. This allowed the participants to manage PPH as in a real case, being free to put “the patient” in a supine position on the bed, or Trendelenburg position if practically possible, in accordance with the PPH-protocol. Additionally, the local language and dialect of the operator, the expression of pain and eventually anxiety during PPH-management, facial expressions and body language, might have increased the realism of the simulation.

At the two Tanzanian sites, the faculty got familiar with the pictorial learning materials “Helping mothers survive: bleeding after birth” (Jhpiego, 2012).

### *3.4.2 Protocols on PPH*

For the training of colleagues, the faculty had prepared an easily recognizable case for the PPH-scenarios: PPH was caused by uterine atony, the most common cause of PPH. The trainees were during the briefing session given clinical and recognizable information on the mother in the scenario, related to parity, length of pregnancy, previous obstetric history, progress of labor and report on the newborn. Additional information was given on the placenta, blood loss and medication. The learning goals for the training were focusing on prevention, identification and treatment of PPH, and adequate communication.

The local PPH-protocols were based on guidelines and recommendations from international organizations: WHO, International Confederations of Midwives (ICM), International Federation of Gynecology and Obstetrics (FIGO), in addition to guidelines from national health authorities. All the actual sites had their own procedure on PPH, which was corresponding with WHO guidelines (KCMC, 2012; UNN, 2012). The main points in the algorithm for prevention and treatment of PPH, are: call for help, administer oxytocin, deliver placenta if not yet expelled, massage the uterus, secure IV access, empty urinary bladder and check on vital signs, identify cause of bleeding, request crossmatch and units of blood, perform bimanual uterine compression if needed. The facilitator

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provided on request additional information that could not be obtained by examination of MamaNatalie®, like blood pressure, pulse, and whether the skin was cold and clammy.

The learning materials (Evans et al., 2014; Jhpiego, 2012) used during the training at KCMC and Mawenzi Hospital, included a graphic flipbook, an action plan, and a provider's guide, and were translated to Swahili by the research team for this project. Respectful care during pregnancy and childbirth, included in the learning materials, is in line with what childbearing women have expressed as important for themselves and their newborns (Renfrew et al., 2014). The operator provided a high degree of realism by enabling the participants to engage with the mother character, challenging them on the need for respectful care and proper communication.

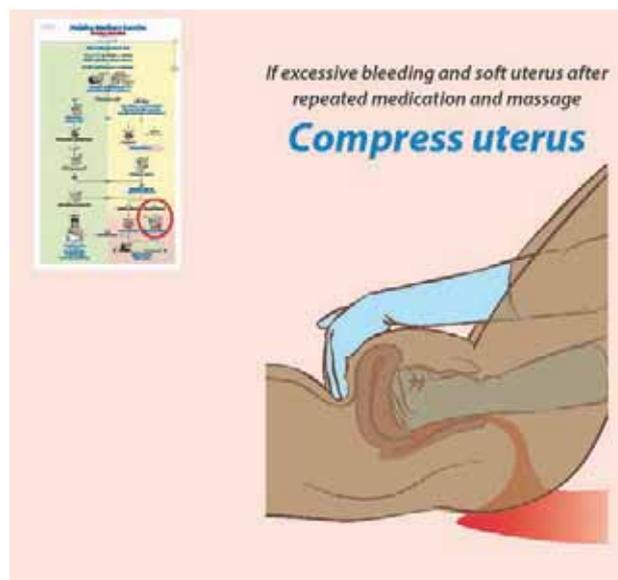


Figure 1 Bimanual uterine compression

The PPH-scenario required technical skills on uterine massage and bimanual compression, see figure 1, and the operator responded to the actions during the simulation. The scenario ended when the team controlled the bleeding and stabilized the mother, or decided that a surgical procedure was needed.

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During the subsequent, second training at KCMC and Mawenzi Hospital in 2014/15 (after the time period for data collection of patient outcome), the departmental management asked for more focus on estimation of blood loss. To meet this request, we organized specific skills training on estimation of blood loss by visualizing stained bed sheets, soaked gauze or sanitary pads and even artificial blood clots for improved accuracy. The clots were made by a mixture of water, gelatin plates (6 plates per 100ml water) and artificial blood concentrate/food color/rosella, wrapped in plastic foil to mimic the membranes.

### *3.4.3 Debriefing*

The facilitator debriefed the team with a “good judgement approach” that used her/his expert opinion by valuing the unique perspective of each participant (Rudolph et al., 2007), while referring to the learning goals. The debriefing was carried out in the local language (Swahili or Norwegian) for optimal understanding and within the comfort zone of the participants. Rigorous reflections included a descriptive, an analytic and an application phase. Every trainee was challenged on his/her understanding of the PPH-case and how it was managed, their perception of individual and team achievements and preferable future actions.

Debriefing a team after a scenario should be facilitated in an honest and yet emphatic manner to improve suboptimal performance and to help sustain adequate performance (Rudolph et al., 2013). By repeating the scenario after honest feedback during debriefing, with the same participants in the same roles within the same team, the participants are likely to improve their performance (Stocker et al., 2014).

### *3.4.4 The implementation of team training*

The implementation of simulation training on PPH was at all sites carried out within the hospital premises. Teams comprised a small group of 4-5 midwives/doctors/auxiliary nurses who were engaged in the scenario, while the other half of the group were observers. At first, the group reviewed the PPH-protocol and discussed to which extent the protocol was adhered to in the daily, clinical practice, to ensure the same theoretical foundation for PPH-management. The facilitator explained the frames of simulation training, and

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informed about the confidentiality to ensure a safe environment for learning. Every participant was given a role reflecting their profession. In some scenarios, a participant took the role as relative. Before the first scenario, a normal childbirth was demonstrated for the team, followed by hands-on training on uterine massage and bimanual uterine compression for all participants.

Each scenario was followed by debriefing led by the facilitator, where every participant was challenged on her/his frames of understanding within the team.

### *3.4.5 Practical considerations of the implementation*

Due to considerations by the local management, the educational intervention was carried out in a similar way at all sites but with local adaptations.

At UNN Tromsø, roles were swapped after one scenario for repeat of another PPH-scenario with a different facilitator. This was due to logistical considerations because the training simultaneously included scenarios on other obstetric emergencies not included in this project, and all groups were to rotate simultaneously. At KCMC and Mawenzi Hospital, roles were swapped after repeat of the PPH-scenario for two subsequent PPH-scenarios with the observers now actively participating, while the previous participants were observing. The facilitator remained the same throughout the day.

Subsequent training for all old and new maternity staff was at all sites carried out 12 months after the first training.

At UNN Tromsø and KCMC, approximately 80% of the staff participated in the initial or subsequent training. At UNN Tromsø this was explained partly with maternity leave absences and residents' rotation schedules, in combination with a relatively high turnover. Only two days of training each year made it difficult for all staff to attend. At KCMC, the absence of some staff members eligible for training, was partly due to competing tasks because of heavy workload.

The training lasted 6 hours (Tanzania) and 8 hours (Norway, with additional scenarios besides PPH) respectively, and lunch was served to faculty and participants at every day of training. In Tanzania, the local ethical committee

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requested an allowance to be given to faculty and participants, as a token amount to cover transport costs.

The birthing simulators were left at the sites as property for the obstetric department, for them to continue similar training and thereby enhance sustainability of the project.

### **3.5 Quantitative research – data based on birth cohorts**

Based on the research questions, different quantitative research designs were chosen to provide answers. One question was: How was multi-professional simulation training on PPH influencing blood loss after birth? During the research process, this question was modified to: How was multi-professional simulation training on PPH influencing blood loss after birth - measured indirectly by blood transfusion rate? The studies answering this research question are described in paper I, II and III.

At SUS, Norway, the quantitative study had a retrospective design because the educational intervention was implemented before this project, and data were collected after the simulation training, from both pre- and post- cohort (paper I). In 2009, 11.2% of mothers were diagnosed with PPH, and almost 21% of them were transfused. In 2010, the obstetric departmental management decided to implement annual, multi-professional training for all midwives, doctors, and auxiliary nurses in the maternity wards, aiming for improved maternal outcomes related to emergency obstetrics. The birth cohort from 2009 was compared to the birth cohort in 2011 based on PPH-rate (estimated blood loss >500ml), considering the two birth cohorts as a comparison of equivalent individuals.

For the two other sites: UNN Tromsø, Norway and KCMC, Tanzania, the quantitative design had a quasi-experimental design without control groups (paper II and III). Considering visual estimation of blood loss an unreliable measurement (Al-Kadri et al., 2014; Bose et al., 2006; Hancock et al., 2015), we chose blood transfusion rate after birth as an alternative indicator for severity of blood loss. However, PPH-rate based on estimated blood loss and

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blood transfusion rate were both used as dependent variables for changes in patient outcome after simulation training.

### *3.5.1 Study population - birth cohorts*

The study population at SUS (paper I) and UNN Tromsø (paper II) comprised all women who delivered newborns with gestational age  $\geq 23$  weeks. While the study population at SUS comprised the birth cohort one year before and after training, the study population at UNN Tromsø comprised birth cohorts from two years before/after training for increased power.

The study population at KCMC (paper III) comprised all mothers with a gestational age  $\geq 28$  weeks one year before/after training. In all three studies, mothers who gave birth before arrival at the hospital, were excluded.

### *3.5.2 Study sites - birth cohorts*

The sites were chosen due to similarities and differences, investigating whether the studies on simulation training in different contexts could provide different knowledge and as well give room for generalization of findings.

1) Stavanger University Hospital (SUS), Norway, serves an unselected population of 320 000 citizens, with approximately 4800 births annually. The birthing simulator MamaNatalie® (Laerdal Global Health, 2015) used in the PPH-scenarios was known to the PhD-candidate by experience through the simulation training leading to the retrospective study.

2) University Hospital of North Norway (UNN) Tromsø, Norway, with 1400 births annually, is a tertiary university hospital providing basic health care and highly specialized treatment for citizens in the North Norway region, comprising around 5000 deliveries annually within the region.

3) Kilimanjaro Christian Medical Centre (KCMC), Tanzania, being a relatively well-equipped zonal consultant hospital in East Africa, has a catchment of 15 million people and 4000 births annually. In year 2000, KCMC established a Medical birth registry (MBR) database. The MBR database maintains records information on every birth at KCMC, based on patient files and an interview

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with every mother during the first 24 h after childbirth. MBR data includes demographics, the mother's health before and during pregnancy, labor characteristics, the mother's health after childbirth up to 7 days after delivery, and the health of the newborn (Bergsjø, Mlay, Lie, Lie-Nielsen, & Shao, 2007).

### ***3.5.3 Data sampling procedures – birth cohorts***

The Department of Laboratory Medicine (paper I and II) provided information on the total number of blood products given to mothers after birth, identified by their personal identity number, the procedural code of transfusion; type of blood products and number of units. The Obstetric Departments at all sites provided data on each mother within the birth cohorts, and Medical Birth Registry KCMC provided information on the birth cohorts including the random samples (paper III). Additional data on blood transfusions were retrieved from the hospitals' birth registries (paper I and II), while data on blood transfusions were collected from the hospital files at KCMC (paper III). The time line for receiving blood transfusion was the period of admission. To ensure reliable data quality, we individually checked the hospitals' patient record systems for relevant information on all the women with estimated blood loss >500ml.

The primary outcome measures were estimated blood loss after birth and blood transfusion rate pre-post training, while the time period pre-post training was the main independent variable. To control for confounding factors explaining changes pre-post training, data on maternal characteristics like parity, maternal and gestational age, and labor characteristics including frequencies of surgical procedures, were collected. The Hb level before admission, the lowest Hb level during admission, and the Hb level at discharge were recorded (paper I and II). At KCMC, data on female genital mutilation and cutting (FGM/C) were collected (paper III).

At UNN Tromsø, the blood transfusions distinguished between the overall rate of red blood cell (RBC) transfusion and severe PPH needing  $\geq 5$  units of RBC, platelet concentrate, and/or fresh frozen plasma (FFP) (paper II).

The birth cohorts in all three studies did not change during the study periods.

### ***3.5.4 Statistical analyses – birth cohorts***

Pre-post changes for categorical variables for patient outcome were analyzed using the Chi-square test or Fisher's exact test. Continuous variables were tested with normality plots and, when normally distributed, presented as the mean and standard deviation (SD). Continuous variables were compared for significant differences with the Mann–Whitney U Test (paper I, II and III).

Binary logistic regression was performed (paper I and III) using number of blood transfusions as dependent variable, to exclude possible confounding factors as explanation of the findings. Possible confounders and the main factors of interest were tested one by one for their effects on the transfusion rate. In the final model, variables were not included that had unadjusted p-values >0.25, high frequencies of missing values, and/or were associated with high residuals. When plotting data in SPSS, missing values were replaced by 0, expecting that these variables most probably had no value/were negative/0.

For the analyses (paper I, II and III), the IBM SPSS Statistics, Version 21.0 and 22.0 were used (IBM Corp., Armonk, NY, USA).

## ***3.6 Quantitative research – survey among staff***

The second research question leading to the other part of the quantitative study, was this: What was the perception of self-efficacy and collective efficacy levels related to PPH-management among staff before and after simulation training on PPH? (paper II). Assuming that PPH possibly was perceived as a less threatening obstetric emergency due to many options of treatment in a high-resource setting, the self-report might contribute to interesting knowledge of their existing concepts related to cognitive and behavioral indicators.

### ***3.6.1 Study population and site – survey***

At the University Hospital of North Norway (UNN) Tromsø, 79% of a total maternity staff of 104 midwives, obstetricians and auxiliary nurses participated in the initial training. The subsequent training after 12 months comprised 80% of the staff of 106 employees, of whom 21 staff members were newly employed.

### ***3.6.2 Data sampling procedure – survey***

Staff members were asked to give their consent before participating in the survey. The questionnaire was distributed to the participants at UNN Tromsø at three time points: before the training (pre-test), 3 months after initial training (post-test) and 15 months after the initial training (follow-up test) (paper II).

The PPHSE, PPHCE and TEAM (Cooper et al., 2010) had 8, 13 and 11 items respectively. Among the staff eligible for participation in the survey, 88% participated in the pre-test, 62% in the post-test and 72% in the follow-up test.

### ***3.6.3 Statistical analyses – survey***

Multivariate analyses of variance (MANOVA) were performed for data from independent samples, due to the fact that parts of the samples were replaced between the time points of measurements. Multivariate repeated measures analyses were performed as follow-up analyses for dependent samples, comparing results for identical pre-post and pre-follow-up samples. The participants were too few to investigate differences between professions. Cohen's *d* was computed for estimation of the effect size of the changes (Cohen, 1977). All the other analyses were performed using IBM SPSS Statistics v.22.0.

## ***3.7 Qualitative research***

A qualitative study was carried out at two Tanzanian health facilities that had implemented the same educational intervention on PPH-management (paper IV). A descriptive and exploratory design with focus group discussions (FGD) was chosen to answer the research question: How did the informants perceive learning features and learning outcomes from the multi-professional simulation training on PPH-management?

### ***3.7.1 Semi-structured interview guide***

A semi-structured interview guide was developed for the purpose of formalizing the FGDs and get answers to thematic and dynamic questions related to PPH-management (Creswell, 2013; Kvale & Brinkmann, 2015). The

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guide contained seven questions based on the social cognitive theory, and challenged the informants on their efficacy beliefs related to individual and team management of PPH. The interview guide included also questions directly elaborating the informants' previous experiences from PPH-emergencies, see table 2.

Table 2 Interview guide for focus group discussions

1.	Can you elaborate how the simulation training contributed to change in confidence level regarding PPH-management?
2.	Can you elaborate how the training influenced how you consider the importance of managing PPH?
3.	Can you explain how the training influenced your way of working as a team?
4.	Please share experiences of events where you used knowledge and skills learned from the training.
5.	Can you describe any change in how you perceive being responsible for a mother developing PPH?
6.	In which way has the training affected your perception of calling for help?
7.	In which way might the training have benefited the patients?

### 3.7.2 Study population - focus group discussions

Two months after the last simulation training, employees who had participated once or twice in the simulation training, were invited to participate in consecutive FGDs. The departmental management at both hospitals informed their staff verbally of the upcoming discussions. Recruitment to the FGDs depended totally on availability to participate. The 21 informants from each of the two hospitals were recruited by convenience.

All interviewees who accepted to participate, gave their verbal consent which was audio recorded, and the informants were guaranteed anonymity. They were free to withdraw from the study at any time.

### ***3.7.3 Data sampling related to focus group discussions***

Four and six discussions respectively were carried out at the two health facilities, comprising informants who had an average working experience of 10-11 years. Out of the 42 informants, 69% had participated in the simulation training twice. They were nurse midwives, doctors being residents, assistant medical officers or medical officers, and medical attendants.

The FGDs were carried out at the hospital premises, and each discussion lasted in average 54 minutes. The Tanzanian research assistant carrying out the FGDs, is an experienced interviewer. All but one FGD were carried out in Swahili and audio-recorded. The research assistant and his co-workers transcribed the discussions verbatim, and the transcripts were translated by two translators from Swahili to English.

To rule out preconceptions of beliefs regarding the informants' experiences of the training, was not possible. When preparing the interview guide, the actual FGDs and the analyzing process, the interviewer as well as the first author were aware of own preconceptions and aimed at openness towards the content of the discussions.

Simultaneously with the FGDs, data on patient outcome were collected from KCMC. However, the results from the data collection were not yet known and inferences on findings not made. Thus, the FGDs were carried out without being influenced by quantitative findings.

### ***3.7.4 Manifest content analyses***

The analytic process of manifest content started by importing all transcript into Nvivo 11 Pro software (QSR International, 2016). To get a first impression of the content, all transcripts were read repeatedly and peer checked to avoid personal bias. The manifest content analysis was performed in accordance with Graneheim and Lundman's qualitative content analyses to ensure trustworthiness: 1) each focus group discussion was identified as a unit of analyses, 2) the content was coded by Nvivo nodes, describing the meaning of the different segments of the text. The nodes were in conjunction with themes reflected in the interview guide. Coding meaning units and checking for

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accuracy was done by the first author, 3) in order to shorten the meaning units while still preserving the core content, the units were condensed, 4) the Nvivo nodes were reduced to a smaller and more manageable number based on commonalities among the codes, while constantly compared to the units of analyses. The nodes were grouped into categories of interacting themes, 5) the nodes were accumulated into three global categories in order to reflect the purpose of the research, to be exhaustive and to be sensitive to the manifest content; educational aspects of the simulation training, perceived competence, and motivational and emotional aspects. The quotes were grouped into sub-categories based on the analyses of meaning. Only segments of the entire text were coded (Graneheim & Lundman, 2004).

To avoid having overlooked other meaning units being either ordinary or unexpected themes, or themes difficult to classify, all transcripts were rechecked for additional meaning units. The categories with all the nodes were re-evaluated to ensure optimal categorization. The quotes within each category and sub-category were examined for relationships and systematized according to the research questions.

For the samples within the different study designs, described in chapter 3.5, 3.6 and 3.7, see Table 3.

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Table 3 Data collection, samples and data analyses

Paper	Data collection	Sample	Data analyses
I	Birth cohort	pre training (n=4777) post training (n=4872)	Quantitative analyses: Pearson's chi-square test, Fisher's exact test, t-test, Mann-Whitney U-test, multivariate logistic regression analyses
II	Survey (staff)	pre-test (n=72) post-test (n=51) follow-up test (n= 61)	Quantitative analyses: factor analyses, Cronbach's alpha, Pearson product moment correlations, Cohen's <i>d</i> , multivariate analyses of variance, multivariate repeated measures analyses
II	Birth cohort	pre training (n=2703) post training (n=2743)	Quantitative analyses: Pearson's chi-square test, Fisher's exact test, Mann-Whitney U-test
III	Random sample birth cohort	pre training (n=1650) post training (n=1606)	Quantitative analyses: Pearson's chi-square test, Fisher's exact test, t-test, Mann-Whitney U-test, multivariate logistic regression analyses
IV	Focus group discussions (staff)	10 FGDs (n=42)	Manifest content analyses

### **3.8 Approvals paper I-IV**

The process of getting the necessary approvals required separate application procedures for every study site.

#### **3.8.1 Paper I Retrospective design**

The Regional Committee for Medical and Health Research Ethics assessed the study to be quality work not needing ethical approval (2012/308/REK West). Approvals for access to and analyses of patient data were granted from the Research Department and the Data Protection Officer at Stavanger University Hospital. These approvals were needed only once throughout the study.

#### **3.8.2 Paper II Pre-post multi methods design**

Ethics Committee approval was obtained from The Regional Committee for Medical and Health Research Ethics (2013/116 REC West, with modifications approved 17.07.2015) due to the need for extended data sampling. Approvals for access to, and analyses of patient data, were granted by the hospital's Research Department and the Data Protection Officer in 2014 and renewed in 2015.

Stavanger University Hospital approved storing of data from all the study sites on the research server at the hospital. The approval for UNN Tromsø was registered REK 2013/116, ePhorte 2013/371-2.

#### **3.8.3 Paper III Pre-post quantitative design**

The study at KCMC was approved and renewed on a yearly basis, locally and nationally by: 1) Kilimanjaro Christian Medical College Research Ethics and Review Committee; research proposal no. 504, clearance certificate no. 537, 2) National Institute for Medical Research; ref NIMR/HQ/R.8a/Vol.IX/1550, and 3) Tanzania Commission for Science and Technology; research permit no.2013-245-ER-2013-112. In addition, an ethics permit was granted from the Regional Ethics committee, Norway, 2013/115 REK Vest. A Residence Permit for the Norwegian researcher was issued by the Immigration Services Department, Tanzania.

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The Regional Committee for Medical and Health Research Ethics, Western-Norway, reviewed and approved the project in Tanzania to be carried out by a Norwegian researcher, (reference number 2013/115) dated 10.05.13.

Stavanger University Hospital approved storing of data from KCMC and Mawenzi Hospital, registered ID324, ePhorte 2013/371 - 20138/2013.

### **3.8.4 Paper IV Qualitative design**

Ethical approvals and permissions were given for this study as a part of the study at KCMC and Mawenzi Hospital, Tanzania, see above heading 3.8.3.

### **3.9 Ethical considerations**

For the quasi-experimental studies, all maternity employees were allocated for simulation training. However, participation in the studies was voluntary and based on written consent. A consent form with a description of the study was provided for all to sign on the beginning of the day of training. The questionnaires used at UNN Tromsø were coded for confidentiality. For the FGDs, informants were not identified with name on the tapes recorded from the discussions. The health facilities and the informants were coded for anonymity throughout the analyzing process of the survey and the FGDs.

Probability of access to reliable patient data was a determining factor for choice of methodology. The application process of ethical clearances was time demanding, but no studies were carried out without all necessary approvals, ethical clearances and permits. De-identified data collected throughout the project, were stored at the research server at Stavanger University Hospital.

Information about the studies and the simulation training was made available to women giving birth at UNN Tromsø, KCMC and Mawenzi Hospital throughout the study period.

Corruption, or informal payment, is known to be a challenge within Tanzanian health services (Maestad & Mwisongo, 2011), however incompatible with transparency required within research. We carried out this research without

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facing any corrupt behavior or attitudes, and all payments were documented and receipts signed for transparent project accounts.

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Picture 3 PPH-scenario in a multi-professional team. KCMC

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Picture 4 Repeat of same scenario with the same participants. KCMC

## **4 Summary of results**

### **4.1 Paper I**

Can interprofessional simulation training influence the frequency of blood transfusions after birth? (Egenberg, Øian, Bru, Sautter, Kristoffersen and Eggebø, 2015)

The aim of the first study was to investigate whether the simulation training on PPH-management was followed by change in estimated blood loss. The simulation training comprised multi-professional teams of midwives, nurses, obstetricians, doctors specializing within obstetrics and gynecology, and auxiliary nurses. The study was conducted on births cohorts comprising 4777 mothers before training (2009) and 4872 mothers after training (2011). The retrospective design used RBC transfusions and estimated blood loss after birth as indicators of PPH. Data were collected from the registry of the Department of Immunology and Transfusion Medicine and from the hospital's electronic birth registration system.

Results showed no reduction in estimated blood loss, but a statistically significant reduction of 41% in RBC transfusions from before to after the training ( $p < 0.01$ ). Before the simulation training (2009), 20.8% of the mothers with an estimated blood loss  $>500\text{ml}$  received RBC transfusions. After the simulation training (2011), 12.3% of the mothers diagnosed with PPH got transfusions. Calculating the overall transfusion rate, 2.3 % and 1.4% of the mothers, respectively, were transfused before/after training ( $p < 0.01$ ), see table 4.

The number of platelet concentrate and fresh frozen plasma (FFP) transfusions remained unchanged.

Additionally, we collected data on mothers with estimated blood loss  $< 500\text{ml}$  to exclude bias of a possible unprecise study population based on estimation of blood loss. Among mothers who had no PPH-diagnosis, the frequency of blood transfusions was 1.2% before and 0.7% after training ( $p=0.02$ ).

### *Summary of results*

No significant differences were observed in maternal characteristics before and after training, time periods being the main independent variable. The mean hemoglobin level under admission and at discharge remained unchanged, see table 5, which displays the Hb-level (g/dl) during admission and at discharge. Administration of intravenous iron remained the same throughout. To control for possible confounders, logistic regression analysis was performed to compare time periods. The odds ratio remained stable in all combinations of possible confounding factors, and odds ratio was 0.53 in the final model.

Research suggests that estimation of blood loss is an unreliable measurement, and increased focus on PPH after the simulation intervention, is likely to have raised estimations (Spitzer et al., 2014). Results based on estimated blood loss are therefore difficult to interpret. Changes in RBC transfusions may be more reliable indicators of PPH-related blood loss, and results suggest that blood loss after birth was reduced after the simulation training.

The findings supported the hypothesis of a reduction in bleeding after birth after multi-professional simulation training. However, due to the study design, a causal link could not be documented.

## **4.2 Paper II**

Changes in self-efficacy, collective efficacy, and patient outcome following interprofessional simulation training on postpartum haemorrhage (Egenberg, Øian, Eggebø, Arsenovic and Bru, accepted by Journal of Clinical Nursing Nov 2016)

Results from this multi methods, quasi-experimental study were based on two types of data: a survey, and patient outcome.

### **4.2.1 The survey**

The aim of the survey was to investigate whether interprofessional simulation training on PPH-management enhanced efficacy beliefs. The survey was based on a self-report questionnaire investigating maternity staff's perceived efficacy levels related to PPH-management, individually and as teams. The study was conducted among staff at three different time points. 82 of 104 staff members

### *Summary of results*

(79%) participated in the initial training. Of the 82 participants, 72 answered the pre-test questionnaire (88%). Three months later, 51 participants answered the post-test (62%). At the time of the subsequent training one year later, 85 of 106 staff members (80%) participated. Of the 85 participants, 61 answered the follow-up test (72%).

There is scarce documentation on the influence of simulation training on collective efficacy and perceived team functioning. These constructs were included to determine whether simulation training is likely to improve collective efficacy and team functioning related to PPH as an obstetric emergency, using the PPHCE and TEAM scale (Cooper et al., 2010).

Findings from the survey instrument developed for this study, showed significant changes in perceived PPH self-efficacy ( $p < 0.01$ ), PPH collective efficacy ( $p < 0.01$ ) and team functioning ( $p = 0.01$ ).

To estimate the effect size of the changes in perceived efficacy beliefs, Cohen's  $d$  was computed. Given the general guidelines of considering Cohen's  $d$  of 0.8 as large, the effect size for perceived collective efficacy from pre- to follow-up test of 0.84 was considered being strong. Perceived self-efficacy related to PPH-management had an effect size of 0.71 from pre- to follow-up test (15 months). Within-subject changes for the staff who answered the pre-test and the post-test questionnaire, or the pre-test and the follow-up test questionnaire, showed similar results.

#### **4.2.2 Patient outcome**

The aim of this study was to investigate whether the training was followed by reduced blood transfusion rate after birth. The study was conducted on births cohorts comprising 2703 mothers before training (2011-2012) and 2743 mothers after training (June 2013-May 2015). The patient outcome was based on estimated blood loss and blood transfusion rate within the birth cohorts. Data were collected from the registry of the Department of Immunology and Transfusion Medicine and from the hospital's electronic birth registration system.

### *Summary of results*

Results showed that 4.6% of the mothers received blood transfusion before the simulation training, while after training, 4.4% of the mothers were transfused ( $p = 0.8$ ), see table 4. However, there was a marginal, significant reduction in blood products given as treatment of severe PPH;  $\geq 5$  units of RBC, platelet concentrate, and/or FFP as treatment of PPH ( $p = 0.04$ ).

Apart from a significant increase in performed CS during the study period, there were no significant differences in maternal characteristics. The hemoglobin level under admission and at discharge remained unchanged, see table 5.

The findings supported the hypothesis on positive changes in perceived efficacy after simulation training, while the hypothesis on reduced overall reduction in blood transfusion rate after simulation training was rejected.

### **4.3 Paper III**

Impact of multi-professional, scenario-based training on postpartum hemorrhage in Tanzania: a quasi-experimental, pre- vs. post-intervention study (Egenberg, Masenga, Bru, Eggebø, Mushi, Massay and Øian, submitted for publication 2016)

The aim of this study was to investigate whether an educational intervention of multi-professional simulation training was followed by change in blood transfusion rate after birth. The initial simulation training comprised 70 out of 83 employees (84%). Among the participants were 35 nurse midwives, 11 doctors and 24 medical attendants. The subsequent training after one year comprised 67 out of 87 employees in the maternity (77%), of these were 40 nurse midwives, 7 doctors and 20 medical attendants.

The quasi-experimental study on patient outcome was conducted on random samples comprising 1650 mothers before training and 1606 mothers after training from births cohorts (2012) and (November 2013-October 2014) respectively. The patient outcome was based on blood transfusion rate within the birth cohorts. Data were collected from Medical Birth Registry KCMC and from hospital files.

Results showed that 3.2% of the mothers received blood transfusion before the simulation training (2012), while after training (November 2013-October

### *Summary of results*

2014), 1.7% were transfused, a reduction of 47% ( $p < 0.01$ ), see table 4. Labor characteristics like CS and vacuum deliveries increased significantly throughout the study period ( $p < 0.01$ ). To control for confounding factors like CS, transfers, maternal age, labor induction and FGM/C, logistic regression analysis was performed. Blood transfusion rate as the dependent variable, was significantly associated with time period as the main independent variable.

The findings supported the hypothesis of a reduction in blood transfusion rate after multi-professional simulation training.

The following table shows the number of mothers within the birth cohorts who received blood transfusions at SUS and UNN Tromsø pre-post training (paper I and II), and number of transfused mothers from random samples at KCMC pre-post training (paper III), see table 4.

*Summary of results*

Table 4 Number of transfused mothers before/after simulation training

	Number of transfused mothers before training	Number of transfused mothers after training	p-value
<b>SUS 2009/2011</b> (total n=4777/4872)	111 (2.3%)	67 (1.4%)	< 0.01
<b>UNN Tromsø 2011-12/2013-15</b> (total n=2703/2743)	123 (4.6%)	121 (4.4%)	0.80
<b>UNN Tromsø: ≥5 units of blood products</b>	17 (0.6%)	7 (0.3%)	0.04
<b>KCMC 2012/2013-14</b> (random sample, n=1667/1641)	53 (3.2%)	28 (1.7%)	< 0.01

Table 5 Mean Hb-level during admission and at discharge

	Before training	After training
<b>SUS 2009/2011</b> (transfused 111/67)		
Lowest Hb-value during admission	7.6	7.5
Hb-value at discharge	9.2	9.2
<b>UNN Tromsø 2011-12/2013-15</b> (transfused 123/121)		
Lowest Hb-value during admission	7.1	7.1
Hb-value at discharge	9.0	8.9

#### **4.4 Paper IV**

“No patient should die of PPH just for the lack of training!” Experiences from multi-professional simulation training on postpartum hemorrhage in northern Tanzania (Egenberg, Karlsen, Massay, Kimaro and Bru, submitted for publication 2016)

The aim of this study was to gain enhanced understanding and new knowledge on the most important learning features and learning outcomes, being a follow-up study after multi-professional simulation training in northern Tanzania. The training had comprised realistic scenarios and debriefing sessions for reflective learning, which were repeated for enhanced learning.

The study was conducted among 42 maternity employees from two Tanzanian hospitals who had participated once or twice in the training, using a qualitative design. During ten focus group discussions, the informants described their experiences related to learning features and learning outcomes of the PPH-training. A semi-structured interview guide was used during the discussions, which were audio-recorded, transcribed, translated from Swahili to English, and analyzed by manifest content analyses.

According to the findings, the informants expressed enhanced level of confidence after the training, as well as reduced perception of stress. They experienced team training as the overall most important learning feature. For the first time, all who worked together, trained together, and the informants described that they developed a shared frame of understanding of PPH-management. An important factor within the team training was the improved communication and perception of responsibility during an emergency. The most important learning outcome according to the informants, was proper teamwork, and the benefits of teamwork like confidence, less stress and the perception of improved maternal health care services, were highly valued. They also regarded the enhanced appreciation from the mothers and the community as an important motivational factor.

The informants recommended that the multi-professional training should be continued and disseminated to other health facilities nationally.

*Summary of results*



Picture 5 A PPH-scenario in another multi-professional team. KCMC

*Summary of results*



Picture 6 PPH-scenario at Mawenzi Hospital, with IV fluids and blood transfusion

*Summary of results*



Picture 7 Another PPH-scenario. Mawenzi Hospital

## **5 Discussion of central findings**

This thesis investigates outcomes related to the implementation of multi-professional simulation training on PPH-management for maternity staff. The thesis aims at answering research questions concerning: 1) participants' experiences of important learning features and learning outcomes of the training (paper IV), 2) changes in perceived individual and collective PPH-related efficacy and team functioning (paper II), and finally, 3) changes in blood loss after birth (paper I, II and III). In this section it will be discussed what answers the empirical findings give or indicate to the research questions.

The implementation of simulation training in Tanzania and Norway was in line with a need for research exploring learning features and learning outcomes that could lead to improved clinical outcomes (Bergh et al., 2015; Draycott et al., 2015), and research on team training in low-resource settings (van Lonkhuijzen et al., 2010). According to Fox et al, the intervention is not good unless it results in improved clinical outcomes (Fox et al., 2011). No previous studies were identified that described an educational, multi-professional intervention on PPH-management by using mixed methods design to explore educational aspects and investigate efficacy beliefs and changes in patient outcome after simulation training.

Findings from the qualitative study (paper IV), which explored the reactions from informants on educational aspects like learning features and learning outcomes of the simulation training, supported previous research emphasizing the complexity of obstetric emergencies and the importance of building team coherence and trust (Salas, Wilson, et al., 2008). By reflective learning through debriefing sessions, the informants seemed to have developed shared mental frames regarding PPH-management, which enabled them to communicate properly. They expressed an enhanced level of confidence, and the feeling of stress was according to them reduced.

The expressed experiences from the training (paper IV) was in particular related to team training as a significant learning feature and improved teamwork as a learning outcome in clinical practice. This was made possible by realistic scenarios followed by reflections in teams. Informants expressed a

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development of mutual understanding of roles and responsibilities, acknowledging the contribution of everyone in the team to save lives. Nurse midwives and medical attendants expressed that they felt empowered and motivated to take responsibility in an emergency where they previously had avoided participation. Doctors indicated that they felt relieved by not being left alone during an emergency. The combination of midwifery emphasizing the normal labor, and efficient, multi-professional teamwork in times of complications, required a collaborative preparedness that seemed enhanced during the simulation training. According to the informants, they had been able to change their daily practice and by doing so, improved their maternal services after training.

According to the manifest content analysis, the findings from the focus group discussions (paper IV) did not provide negative remarks about the training or suggestions for improved simulation training in teams. The most likely explanation for this is the time frame of 15 months from the initial training to the FGDs. During this period, as stated in the discussions, they had practiced teamwork and experienced the benefits of working in teams. They had also participated in the subsequent training after a year. Informants recommended the training to be continued at their hospitals and disseminated to other health facilities to save maternal lives.

The experiences from teamwork described in the FGDs, seemed to correspond with changes in efficacy beliefs among participants at UNN Tromsø (paper II). The results indicated that the participants experienced enhanced individual and collective PPH-related efficacy beliefs after the training, understood as individual and collective expectations towards mastering of a PPH-emergency. It was not possible in this study to include a control or comparison group that could have enabled us to control for other possible influences on PPH-related efficacy beliefs. However, changes in efficacy beliefs were quite substantial according to Cohen's criteria for effect size (Cohen, 1988). We are not aware of other circumstances that were likely to have caused this amount of change in PPH-related efficacy. It is therefore likely that the improvements could be attributed to the simulation training. Findings suggest that the training resulted in enhanced beliefs in exercise of control, individually and as a unified effort during PPH-emergencies. According to the qualitative study, the findings on motivational and emotional aspects showed that informants experienced

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increased confidence and reduced stress levels (paper IV). The informants expressed strengthened efficacy beliefs, which together with appreciation from patients and community, seemed to increase their motivation and will to manage PPH. The survey showed the largest improvement for collective efficacy during 15 months from pre-test to follow-up test (paper II). This is likely to indicate that the team training contributed to enhanced teamwork, although this was already practiced in the maternity ward. Most likely, the realistic PPH-scenarios and the consecutive reflective learning allowed the staff members to develop a shared understanding of the importance of PPH-management in teams. The changes measured for team functioning, were also reflecting the change in collective efficacy, as the unified effort to manage PPH. Team functioning was probably also indicating that team coordination towards PPH was perceived as enhanced.

Findings from the survey on efficacy beliefs before/after simulation training on PPH-management in Norway (paper II), support the likelihood of transferability of findings from focus group discussions, exploring experiences regarding educational aspects of similar training in Tanzania (paper IV).

To answer the research question on possible clinical outcomes of the simulation training on PPH, changes in estimated blood loss and blood transfusion rate from before to after the training were compared (paper I, II and III). Investigating the estimated blood loss after birth pre-post training, we found no change in mean estimated blood loss. Although estimated blood loss is commonly used to diagnose PPH, a systematic review concluded that blood loss estimated as a volume, was a highly inaccurate measurement (Hancock et al., 2015). As such, estimation of blood loss may not be a reliable indicator of actual blood loss after birth, and PPH-rate. The simulation training may have heightened the awareness of blood loss, and as a result, increased the estimation of blood loss after the training. If the simulation training at the same time enhanced team efficiency and thereby achieved reduction in blood loss, this may explain why the estimated blood loss pre-post training remained unchanged.

Results from pre-post comparisons of blood transfusions, see table 4, support this interpretation of results on estimated blood loss. These results showed a significant reduction in blood transfusion rate (paper I and III), and a marginal

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change in blood transfusion rate related to severe PPH after training (paper II). The use of blood transfusion is generally standardized according to indications for blood transfusions and availability of blood units, which for these studies remained unchanged. In order to use a measurement likely to reflect indirectly the severity of blood loss and results perceived as reliable, blood transfusion rate was chosen as the dependent variable for patient outcome in the three studies.

Similar type of educational intervention (paper I, II and III) provided inconsistent results, and a scientific reasoning might provide some likely explanations to the different results. One may infer the reduction in transfusion rate related to severe PPH as an indication of enhanced teamwork (paper II), due to increased collective efficacy perceptions after training. But we cannot explain with certainty why the significant changes in perceived self-efficacy and collective efficacy levels, expected to predict enhanced future performance (Bandura, 1994), did not result in significant change in overall blood transfusion rate at UNN Tromsø.

One explanation could be that the practical intervention differed to some extent. At UNN Tromsø, the participants were not given the same possibility of rehearsals as participants at KCMC. This lack of repeat within the same role in the same team, might have had consequences for optimal learning outcomes.

Simulation training has traditionally aimed at enhancement of knowledge, skills and attitudes, and now lately at teamwork (Fox et al., 2011). The results from our studies on patient outcome (paper I, II and III) seemed to confirm the importance of teamwork in multi-professional teams. At SUS and UNN Tromsø (paper I and II), working in teams was commonly practiced before the educational intervention. But the multi-professional training most likely added a structure to communication, cooperation and coordination among staff members that enhanced team orientation, at SUS enabling a reduction in transfusion rate of 41% (paper I). At KCMC, the team training was a novel experience to the staff (paper III). Through debriefing, which most likely strengthened reflections in teams, the multi-professional staff seemed to develop this shared mental frame regarding PPH-management. They expressed that their shared understanding made them work more efficiently, having confidence in own mastering as well as the team's competence (paper IV).

### *Discussion of central findings*

Additionally, the faculty at all study sites agreed to emphasize the system approach to human error. By doing so, they might have created a safe environment for learning and supported a culture without blames and fear of reporting errors. By focusing on what went well and why the team managed PPH, simulation training could enhance stress resistance and resilience (Hollnagel, 2014). The safety-II principles on how to learn from daily events and make adjustments accordingly, are important within obstetrics perceived as a complex system. All maternity staff were involved in the training at all sites, and the staff possibly got to know each other better during training. Positive relations among staff is known to enhance teamwork (Barsade & O'Neill, 2014).

The findings from the qualitative study, where the informants expressed increased confidence and improved teamwork (paper IV), were in line with the significant increase in perceived self-efficacy, collective efficacy and team functioning (paper II) after simulation training. Mastery and vicarious experiences, social persuasion and experiences regarding physiological state, seemed to have strengthened their efficacy beliefs. Enhanced efficacy beliefs regarding PPH-management were expected to predict improved team performance during PPH-emergencies. Changes in patient outcome after simulation training (paper I, II and III) could be understood as a consequence of improved team performance. The findings on improved patient outcome, by a blood transfusion rate reduction of 41 and 47% respectively (paper I and III), indicated that multi-professional simulation training enabled the participants to improve their PPH-management. Participants' experiences seemed to reinforce the clinical findings within this project.

The validity of the findings should be questioned, and a possible Hawthorne effect explaining the reduction in blood transfusions, should be considered (Barnes, 2010). A Hawthorne effect would most likely vanish when the intervention ended (Schwartz, Fischhoff, Krishnamurti, & Sowell, 2013). The educational intervention comprised an initial training session and a subsequent training 12 months later. The collection of data on patient outcome was done for 12 months before/after training (retrospectively for paper I, pre-post for paper III) and for 24 months before/after training (paper II). Particularly in the SUS-study (paper I), the presence of the first author as training coordinator and facilitator could have influenced the level of attention towards clinical PPH-

### *Discussion of central findings*

management. At both SUS and KCMC (paper I and III), we checked the points of time when the blood transfusions were administered, to control for Hawthorne effects. The transfusions were equally distributed throughout the first 12 months post intervention. There was no indication of larger reductions in transfusions just after the simulation training was completed, than at the final stage of the data collection. An equal distribution of blood transfusions during 12 months post training at SUS and KCMC, makes it less likely that the observed reductions in transfusions could be explained by Hawthorne or similar effects. However, data on blood transfusion rate beyond this time period, could have given us better indications of a possible Hawthorne effect.

Our findings correspond with studies emphasizing contextual implementation of simulation training in teams, with realistic and relevant scenarios followed by debriefing sessions for reflective learning (PROMPT, 2016; Sorensen et al., 2015). However, no other studies were identified that described significant reduction in blood transfusion rate after this kind of training. Due to challenges concerning internal validity (e.g. lack of comparison group) and construct validity (lack of objective, direct measure of blood loss), conclusions concerning a causal relation between the simulation training and a reduction in blood loss after birth, should only be made with caution. However, checking for possible confounding factors, we did not identify any confounding factors explaining the change in transfusion rate after training (paper I and III).

#### **5.1 Methodological strengths and limitations**

The implementation of contextual, multi-professional team training was perceived as a very important pedagogical approach by the participants of the training, and a strength of this project.

During the quasi-experimental study period, the hospital management at UNN Tromsø and KCMC actively ensured that no other implementation of interventions to reduce transfusion rates, took place (paper II and III).

Another strength of the study was the obstetric data being consecutively recorded in electronic patient journals, individually checked for quality control and thereby believed to be reliable data (paper I, II, and III). However, KCMC patient data based on MBR was found to be somehow incomplete. Extracting

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data on blood transfusions based on random samples of the birth cohorts to provide representative sample of the population (paper III), revitalized this data collection. By carrying out a mixed methods design, triangulation of research methods made limitations of one design being outweighed by the strength of another.

#### **5.1.1 Limitations of the project**

There are several limitations of the educational intervention and data collection.

Performing a quasi-experimental pre-post study on an educational intervention without random assignment or comparison groups, is considered a limitation of this study.

While staff at KCMC participated in two scenarios and observed two other PPH-scenarios (paper III), staff at UNN Tromsø participated once and observed a PPH-event once, due to logistics of the day of training (paper II). More studies emphasize the importance of repeats (Bosse et al., 2015; Stocker et al., 2014), allowing the participants to rehearse skills to reach higher level of difficulty. At UNN Tromsø, where the participants were not given the possibility of rehearsal of the same scenario within the same roles and with the same team, might have limited the benefits of their training.

The difficulty of involving all employees eligible for simulation training due to workload and competing tasks (paper II and III), was seen as a limitation of the study. During obstetric emergencies like PPH, it was considered important that every staff member could identify complex situations and recognize their own and colleagues' mental frames in the situation (Dekker et al., 2013). By being absent from training, staff members might have had less options of developing shared understanding with colleagues.

The survey informants were asked to relate the answers to PPH-events during the last three months and answer the statements based on their experience (paper II). Not all informants could recall PPH-emergencies within such time frame, which might have made it more difficult to respond to some of the questions.

### *Discussion of central findings*

The findings from the focus group discussions (paper IV) could have been more comprehensive if a participating observer would have been present, enabling latent content analyses in addition to manifest content analyses.

The time period for data collection should be discussed for the sake of validity. While the questionnaire was carried out just before/3 and 15 months after initial training (survey paper II), the findings on patient outcome reflected data collected within one year (paper I), two years (paper II), and one year (paper III), respectively. The qualitative study was carried out 15 months after initial training (paper IV). We have no data confirming that the changes identified throughout this project, remained after this period of time.

*Discussion of central findings*



Picture 8 Debriefing session for reflective learning. Mawenzi Hospital

*Discussion of central findings*



Picture 9 Debriefing is also laughter. Mawenzi Hospital

## **6 Conclusions**

Findings from the studies included in this thesis, indicate that implementation of simulation training on PPH-management is likely to lead to better handling of PPH. Positive changes after training were found at all study sites: 1) participants described increased confidence and competence related to PPH-management (paper IV), 2) the survey results indicated significant increase in efficacy beliefs, which is expected to enhance performance (paper II), and 3) the significant changes in blood transfusion rates were most likely due to simulation training in teams (paper I and III). The changes in transfusion rate related to severe PPH at UNN Tromsø indicated the same tendency, validated by triangulation of research designs (paper I, II, III and IV).

Triangulation across different methodological approaches contributes with new knowledge on important features of simulation training. The findings indicate change in mental frames among informants after training, leading to a strong perception of teamwork, confidence and less stress.

At facilities where blood transfusions are available, blood transfusion rate seems to be the most reliable indirect measurement on bleeding after birth. Findings indicate that an educational intervention on PPH-management, including realistic and relevant PPH-scenarios repeated for enhanced learning and followed by reflective learning in teams, can contribute to reduced maternal morbidity and mortality related to bleeding after birth.

### ***6.1 Possible implication for clinical practice***

The fact that 250 mothers die every day due to PPH, is beyond imagination (Afnan-Holmes et al., 2015; WHO, 2016). Additionally, PPH-rates are increasing in high-resource settings, partly due to labor interventions. Established training programs are scaled up to prepare birth attendants for complications like PPH, however, like in Sub-Saharan countries, the maternal mortality remains unacceptably high (UNICEF, 2016).

Inference of findings from this project suggests that an educational intervention like multi-professional simulation training on PPH in teams, might make a

## *Conclusions*

difference in similar settings in low- and high-resource countries. Through triangulation across research designs, similarity in findings across contexts suggests that the findings could be generalizable. Enhanced skills in combination with increased collective efficacy indicate improved performance related to bleeding after birth, with positive consequences for maternal health.

The sustainability of training programs is very important, and post-training follow-up should be emphasized in the planning and implementation of high quality training packages (Bergh et al., 2015).

### **6.2 Suggestions for future research**

In low-resource settings where simulation training is not yet established on a national level, it seems feasible and timely to investigate a dissemination of a multi-professional educational intervention on PPH by a RCT in different types of urban and rural health facilities. Such an intervention should also include small health facilities within primary health care where options for PPH-treatment are limited and the need for adequate PPH-management is urgent.

Research is also needed to investigate the transferability of this kind of multi-professional educational intervention in teams from PPH to other obstetric emergencies.

Qualitative follow-up studies after educational implementations are needed to create additional knowledge on important learning features and learning outcomes in low- and high-resource settings. Additionally, research on educational interventions based on safety-II principles is needed within the complex system of obstetrics.

The duration of follow-up after an educational intervention is of importance to ensure a sustainable program and measure possible effects over an extended period of time.

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**Paper III**

Paper not yet published

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