Health professionals’ experiences and views related to obstetric ultrasound in Rwanda and Vietnam

Sophia Holmlund

Department of Clinical Sciences
Obstetrics and Gynecology
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“Women are not dying of diseases we can’t treat... They are dying because societies have yet to make the decision that their lives are worth saving.”

Mahmoud Fathalla, past president of the International Federation of Gynecology and Obstetrics (FIGO)
“I shall pass through this world but once. Any good therefore that I can do or any kindness that I can show to any human being. Let me do it now. Let me not defer or neglect it for I shall not pass this way again.”

Stephen Grellet
My passion for pregnancy, childbirth and babies started at a very early age. When I was thirteen years old, I had the opportunity to complete a week’s work experience in the delivery ward in my hometown Lycksele. This week inspired me a lot and I decided to become a midwife. During the following years, I read everything I could find about pregnancy, childbirth and parenting. Immediately after completing my upper-secondary school education, I moved to Stockholm and started training to become a nurse. In parallel, I worked at the delivery- and postnatal ward and felt very much at home. It was a miracle to witness the beauty of birth and the power of nature. I remember walking home from a night shift, feeling that I had witness something unique.

During my nursing education I wanted to complete my Bachelor’s essay about late abortion. The teachers didn’t think this was a suited area for a nurse to write about, however, I convinced them and wrote the essay. After graduating as a nurse, I continued to work in the field of maternal health in Uppsala. Only a year later I was accepted to the midwifery education in Umeå. It was a small group of interested students with encouraging teachers and I really enjoyed the education. For the first time I felt that other people had a similar burning interest as I had. In order to be able to do research in the future, I also completed my Masters Degree. The years went by and while I was working as a midwife at the maternity ward I also gave birth to three lovely children of my own. Although I really liked my job, I felt that I wanted to move forward. Fortunately, I was given the opportunity to work part time as a Project assistant in a research project and that was when my interest to become a PhD student began.

One day I received a phone call. It was an Obstetrician at my work. She asked me if I was interested in becoming a PhD student in a project about obstetric ultrasound. Despite the fact that I had no experience of ultrasound performance, the international approach to the project appealed to me. I decided to apply. I was accepted and that was where my PhD journey started. During my four years as a PhD student I have seen so many new places, met people I would have never met otherwise and learnt so many new things. Although there have been times of struggle and doubt, the new experiences have also pushed me to grow as an individual. Finally, this is the time when one era ends and another begins. Let me never cease to be curious.

“To acquire knowledge, one must study; but to acquire wisdom, one must observe”

Marilyn vos Savant
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ABSTRACT

Background

Obstetric ultrasound has become an indispensable part of antenatal care and hospital-based care in high-income countries, where it is universally used for screening, diagnostic and surveillance purposes. In low-income countries, obstetric ultrasound examinations are being increasingly used, although insufficient numbers of trained health care providers is commonly a barrier to obstetric ultrasound utilisation. Since 2016, the World Health Organization has recommended an ultrasound examination before 24 weeks of gestation in order to estimate gestational age, improve detection of fetal anomalies and multiple pregnancies, reduce induction of labour in post-term pregnancies and improve women’s pregnancy experience. Many pregnant women express great interest in ultrasound examinations because they can view and receive information about fetal well-being. Although it is recommended that obstetric ultrasound is only used for medical indication, the number of examinations that women receive during pregnancy varies substantially between and within countries and between different socio-economic groups. In Rwanda, the guidelines for antenatal care do not include any ultrasound examination, whereas in Vietnam, the Ministry of Health recommends three ultrasound examinations during pregnancy. Globally, midwives and obstetricians encounter complex clinical situations in which rapid technical improvements in fetal surveillance and pregnancy interventions are components that influence clinical decisions, thereby implicating maternal and fetal health outcomes.

Aims

The overall aim of this thesis was to explore health professionals’ experiences and views on the role of obstetric ultrasound in relation to clinical management, including ethical aspects, in two low-to-middle-income countries with different characteristics, cultures, religions and health care systems.

Methods

The study settings were Rwanda and Vietnam. A two-step study design was used comprising an initial qualitative phase followed by a second quantitative phase. Study I (Rwanda) and Study III (Vietnam) are based on focus group discussions in which data were analysed using latent and manifest content analysis. Study I included six focus group discussions with 23 midwives working in maternity care. Participants were recruited from six different hospitals in urban and rural areas of Kigali and in the Southern province. Study III included four focus group discussions with 25 midwives working in maternity care at three different hospitals in the Hanoi area. Study II (Rwanda) and Study IV (Vietnam) are cross-sectional studies using descriptive statistics, Pearson’s chi-square test and
univariate- and multivariable logistic regression analyses. A questionnaire, including items based on the results from previous qualitative studies, was composed and used as the data collection tool. For Study II, a national sample of 907 health professionals (midwives, nurses, obstetricians, physicians) working in maternity care at 108 health facilities representing all provinces of Rwanda was recruited. Study IV constituted a regional sample of 824 health professionals (midwives, obstetricians/gynecologists) working in maternity care at 29 health facilities in urban, semi-urban and rural parts of the Hanoi area of Vietnam.

Main findings

Obstetric ultrasound was regarded as a highly valued tool for pregnancy management in Rwanda as well as in Vietnam (Papers I–IV). In Rwanda, access to ultrasound was described as poor, especially for women living in rural areas (Paper I). Participants employed in health facilities outside the area of the capital of Kigali were less likely to report that there was access to obstetric ultrasound when needed, compared to participants employed in health facilities in the Kigali area (OR 0.53; 95% CI 0.39-0.73) (Paper II). In contrast, access to obstetric ultrasound was described as being very high in all health facilities in urban, semi-urban and rural areas of Hanoi (Paper III & Paper IV). In Rwanda, if a pregnancy was considered normal, obstetric ultrasound was not routinely performed (Paper I), while pregnant women in Vietnam were reported as undergoing several further ultrasound examinations in addition to the three examinations recommended by the Ministry of Health (Paper III). Obstetricians/gynecologists/other physicians were the main ultrasound operators in Rwanda as well as in Vietnam, where sonographers also performed obstetric ultrasound examinations. Midwives in Rwanda expressed a need to be trained in ultrasound, particularly those working at health centres in rural areas where ultrasound was rarely available (Paper I). A majority of health professionals (91.3%) also agreed that maternity care in Rwanda would improve if midwives were qualified to perform basic ultrasound examinations (Paper II). Suboptimal pregnancy management due to a lack of or insufficient ultrasound training was reported by health professionals in both Rwanda (65%; Paper II) and Vietnam (37.1%; Paper IV). When health professionals were asked to assess the extent to which specific strategies could improve the utilisation of ultrasound, more training for ultrasound operators was suggested by 94.5% of the Rwandan participants (Paper II) and 92.8% of the Vietnamese participants (Paper IV). The high attraction rate of pregnant women to obstetric ultrasound was described in both settings. The use of obstetric ultrasound without medical indication was described as a troubling phenomenon, especially in Vietnam, where participants also reported that pregnant women sometimes replaced antenatal care surveillance with ultrasound examinations (Paper III).
Conclusions

Obstetric ultrasound plays a significant role in pregnancy management in Rwanda, although access varies significantly. The findings indicate that physicians in Rwanda are in need of additional formal ultrasound training in order to increase the quality of ultrasound surveillance and to improve maternal and fetal health outcomes. To increase ultrasound access for all pregnant women in Rwanda, midwives could potentially be trained to perform basic ultrasound examinations. In the regional Hanoi area of Vietnam, ultrasound is a well-integrated tool in pregnancy management and access was high at all the included health facilities. However, overuse and commercialisation of obstetric ultrasound examinations were described as common and need to be addressed to achieve adequate allocation of resources. It was suggested that a higher number of physicians sufficiently trained in ultrasound and additional formal training for ultrasound operators would improve maternal and fetal health outcomes.

The increasing use of obstetric ultrasound in low-to-middle-income countries has apparent benefits. However, increased access to ultrasound resources is still needed in many rural areas. The rapid development of technology in maternity care needs to be accompanied by medical guidelines stating the appropriate indications for ultrasound surveillance. Increased awareness among pregnant women of the essential components of antenatal care is also required. A reduction in non-medical ultrasound examinations may contribute to better allocation of the available resources to pregnant women who require further medical attention.

Keywords: Prenatal ultrasonography, pregnancy, midwife, obstetrician, health personnel, health professional, prenatal care, epidemiology, cross-sectional study, focus group discussion, qualitative content analysis, Rwanda, Vietnam
SAMMANFATTNING PÅ SVENSKA

Bakgrund


Obstetriska ultraljudsundersökningar ingår ej som obligatorisk undersökning i riktlinjerna av mödrahälsovård i Rwanda emedan ”Ministry of Health” i Vietnam rekommenderar tre undersökningar under en normal graviditet. Barnmorskor och obstetriker över hela världen hanterar komplexa, kliniska situationer där den snabba tekniska utvecklingen av graviditetsövervakning har lett till ökade möjligheter till utvärdering och intervention under graviditeten vilket har implikationer för hälsan hos den gravida kvinnan och fostret.

Syften

Det övergripande syftet med denna avhandling var att undersöka hälso- och sjukvårdspersonalens erfarenheter av och syn på användningen av obstetriskt ultraljud i relation till klinisk handläggning av graviditet, inkluderande etiska aspekter, i två låg- till medel-inkomstländer med olika sociokulturella samt socioekonomiska karakteristika, religioner och sjukvårdssystem.

Metod


Resultat

Obstetriskt ultraljud uppfattades som ett mycket viktigt verktyg i den kliniska handläggningen av graviditeten i både Rwanda och Vietnam (Artikel I-IV). I Rwanda rapporterades en bristande tillgång till ultraljud, speciellt för gravida kvinnor boende på landsbygden (Artikel I). Deltagare som arbetade på sjukvårdsinrättningar utanför huvudstaden Kigali (Rwanda) rapporterade att gravida kvinnor hade tillgång till obstetriskt ultraljud i lägre utsträckning jämfört med deltagare som arbetade i Kigali-området (OR 0.53; 95 % CI 0.39-0.73) (Artikel II). Tillgång till obstetriskt ultraljud beskrevs däremot som välighetsvis god i alla inkluderade sjukvårdsinrättningar i både stad- och landsbygdsmiljöen i och kring Hanoi (Vietnam; Artikel III & Artikel IV). Om en graviditet bedömdes som normal utfördes inga ultraljudsundersökningar i Rwanda, emedan gravida kvinnor i Vietnam rapporterades in regel genomgå många fler ultraljudsundersökningar än de tre som rekommenderas i de nationella riktlinjerna (Artikel III). Obstetriker/gynekologer/andra läkare uppgavs utföra de allra flesta obstetriska ultraljudsundersökningarna i Rwanda. Samma situation gällde i Vietnam emedan även sonografer (läkare) utförde obstetriska ultraljud. Barnmorskor i Rwanda uttryckte ett behov av att få bli utbildade i att utföra ultraljudsundersökningar, speciellt för de barnmorskor som arbetar på hälsocentraler på landsbygden där tillgången till ultraljud rapporterades mycket begränsad (Artikel I). Majoriteten av deltagarna i Rwanda (91 %) instämde att mödrahälsovården och förlossningsvården skulle kunna förbättras om barnmorskor var kvalificerade i att utföra basala ultraljudsundersökningar (Artikel II). I både Rwanda (65 %; Artikel II) och Vietnam (37 %; Artikel IV) rapporterades att otillräcklig ultraljudsutbildning ibland kunde leda till bristfällig handläggning av graviditet. Majoriteten av deltagarna i både Rwanda (94,5 %; Artikel II) och Vietnam (92 %; Artikel IV) uppgav att ytterligare utbildning av ultraljudsoperatörer skulle kunna förbättra ultraljudsanvändningen. I både Rwanda och Vietnam beskrev deltagarna att gravida kvinnor uttryckte ett stort intresse av att genomgå ultraljudsundersökningar. Icke-medicinska ultraljuds-
undersökningar beskrivs som problematiska, speciellt i Vietnam, där deltagarna också rapporterade att kvinnor ibland valde att genomgå ultraljudsundersökningar istället för sedvanliga mödrahälsovårdskontroller (Artikel III).

**Slutsatser**

Obstetriskt ultraljud är en mycket viktig del av den kliniska handläggningen av graviditet i både Rwanda och Vietnam, även om tillgången till ultraljud varierade kraftigt mellan länderna. För att förbättra kvaliteten på ultraljudsundersökningarna samt förbättra hälsan för gravida kvinnor och deras foster, så behöver läkare i Rwanda sannolikt ytterligare ultraljudsutbildning. Ett ökat antal gravida kvinnor skulle kunna få tillgång till obstetriska ultraljudsundersökningar i Rwanda om barnmorskor blev utbildade i att utföra basala ultraljudsundersökningar.


**Nyckelord:** Obstetriskt ultraljud, graviditet, barnmorska, obstetriker, hälso- och sjukvårdspersonal, mödrahälsovård, epidemiologi, tvärsnittsstudie, fokusgruppsdiskussioner, kvalitativ innehållsanalys, Rwanda, Vietnam
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### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
</tr>
<tr>
<td>ANC</td>
<td>Antenatal Care</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CRL</td>
<td>Crown-rump length</td>
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<tr>
<td>FGD</td>
<td>Focus Group Discussion</td>
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<tr>
<td>LGA</td>
<td>Large for gestational age</td>
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<tr>
<td>ISUOG</td>
<td>International Society of Ultrasound in Obstetrics and Gynecology</td>
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<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>MMR</td>
<td>Maternal Mortality Ratio</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
</tr>
<tr>
<td>SGA</td>
<td>Small for gestational age</td>
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<tr>
<td>SRB</td>
<td>Sex Ratio at Birth</td>
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<td>WHO</td>
<td>World Health Organization</td>
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DEFINITIONS AND GLOSSARY

Antenatal care (ANC)
Antenatal care constitutes screening for health and socioeconomic conditions likely to increase the possibility of specific adverse pregnancy outcomes; providing therapeutic interventions known to be effective; and educating pregnant women about planning for safe birth and emergencies during pregnancy and how to deal with them (1).

Antenatal care coverage (at least one visit; ANC1+)
The percentage of women aged 15-49 with a live birth in a given time period that received antenatal care provided by skilled health personnel at least once during their pregnancy (1).

Antenatal care coverage (at least four visits; ANC4+)
The percentage of women aged 15-49 with a live birth in a given time period that received antenatal care by any provider four or more times during their pregnancy (1).

Confidence interval (CI)
The interval, with a given probability (e.g. 95%), within which is contained the population value of a summary measure such as a mean from a sample (2).

Cross-sectional study
A study that examines the relationship between diseases (or other health outcomes) and other variables of interest as they exist in a defined population at one particular time (3).

Data saturation
Relates to the degree to which new data repeat what was expressed in previous data (4).

Epidemiology
The study of the occurrence and distribution of health-related events, states, and processes in specified populations, including the study of the determinants influencing such processes, and the application of this knowledge to control relevant health problems (3).
Human rights

Rights inherent to all human beings, regardless of race, sex, nationality, ethnicity, language, religion, or any other status. Human rights include the right to life and liberty, freedom from slavery and torture, freedom of opinion and expression, the right to work and education, and many more. Everybody is entitled to these rights, without discrimination (5). (United Nations conclusion based on the Universal Declaration of Human Rights.)

Logistic regression

Statistical models which describe the relationship between a qualitative dependent variable (that is, one which can take only certain discrete values, such as the presence or absence of a disease) and an independent variable. A common application is in epidemiology for estimating an individual’s risk (probability of a disease) as a function of a given risk factor (6).

Maternal death

Death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes (7).

Maternal mortality ratio (MMR)

Number of maternal deaths per 100,000 live births (7).

Maternity care

The constellation of health services provided by a physician, nurse, midwife, hospital or birthing centre to a pregnant woman during: 1) pregnancy (prenatal care); 2) delivery; and 3) after delivery (postnatal care) e.g. managing complications, if any (8).

Obstetrics

A medical-surgical specialty concerned with management and care of women during pregnancy, parturition, and the puerperium (6).

Odds

The ratio of the probability of occurrence of an event to that of nonoccurrence, or the ratio of the probability that something is one way to the probability that it is another way (2).
Odds ratio (OR)

An odds ratio (OR) is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure (9).

Reproductive rights

Reproductive rights embrace certain human rights that are already recognized in national laws, international laws and international human rights documents and other consensus documents. These rights rest on the recognition of the basic rights of all couples and individuals to decide freely and responsibly the number, spacing and timing of their children and to have the information and means to do so, and the right to attain the highest standard of sexual and reproductive health. It also includes the right to make decisions concerning reproduction free of discrimination, coercion and violence, as expressed in human rights documents (10).

Skilled health personnel (often referred to as “skilled birth attendants” or SBAs)

Competent maternal and newborn health (MNH) professionals educated, trained and regulated to national and international standards. They are competent to: (i) provide and promote evidence-based, human-rights-based, quality, socioculturally sensitive and dignified care to women and newborns; (ii) facilitate physiological processes during labour and delivery to ensure a clean and positive childbirth experience; and (iii) identify and manage or refer women and/or newborns with complications. In addition, as part of an integrated team of MNH professionals (including midwives, nurses, obstetricians, paediatricians and anaesthetists), they perform all signal functions of emergency maternal and newborn care to optimize the health and well-being of women and newborns (11).

Power, statistical

Roughly, the ability of a study to demonstrate an association or effect if one exists. The probability that the test hypothesis will be rejected if it is false; it is equal to $1 - \beta$, where $\beta$ is the probability of type II error (failing to reject a false null hypothesis). The statistical power of a study is influenced by factors as the frequency of the condition under study, the magnitude of the effect, the study design, and sample size (3).
Ultrasonography, prenatal

In this thesis known as Ultrasound during pregnancy or Obstetric ultrasound. The visualization of tissues during pregnancy through recording of the echoes of ultrasonic waves directed into the body. The procedure may be applied with reference to the mother or the fetus and with reference to organs or the detection of maternal or fetal disease (6).

World bank income groups

WHO Member States are grouped into 4 income groups (low, lower-middle, upper-middle, and high) based on the World Bank list of analytical income classification of economies for the fiscal year, which is based on the Atlas gross national income per capita estimates (released July annually) (12).

References


INTRODUCTION

Global maternal health

Most healthy pregnant women will experience a normal physiological process during pregnancy and will give birth to a healthy child (1). However, every day, approximately 830 women die because of pregnancy or delivery-related complications (2). The vast majority of maternal deaths (99%) take place in developing countries, where Sub-Saharan Africa accounts for more than half (66%) of maternal deaths globally (3) and South Asia accounts for one third (4). In Sub-Saharan Africa the lifetime risk of maternal death is one in 180 women, compared to one in 4,900 women in developed countries (4). The global maternal mortality rate was estimated at 216 deaths per 100,000 live births in 2015 (5). The world’s lowest maternal mortality levels are found in a number of European countries, with Finland having the lowest rate of 3 deaths per 100,000 live births (2). The most common global cause of maternal death is haemorrhage (27%), followed by hypertensive disorders (14%) and sepsis (11%). More than one quarter of maternal deaths are attributed to indirect causes such as pre-existing medical conditions including HIV (6). Most obstetric complications can be preventable if pregnant women had access to skilled birth attendants and high quality medical care (7, 8). Globally, from 2012–2017, almost 80% of all births were attended by skilled health personnel (9), an increase from 62% in the period from 2000–2005. However, there are major differences between regions. In sub-Saharan Africa, which has the world’s highest maternal mortality ratio (MMR), only 59% of births are attended by skilled health personnel (8).

Millennium Development Goals

In 2000, the United Nations, together with the world’s leaders, formulated the eight Millennium Development Goals (MDGs) to combat poverty through different interventions (7). The MDG5 aimed to improve maternal health by reducing maternal mortality by 75% between 1990 and 2015, and to achieving universal access to reproductive health by 2015 (7). During this period, there was a global reduction of maternal deaths by 44% (3), from 385 per 100,000 live births in 1990 to 216 per 100,000 live births in 2015 (2). Thanks to efforts to achieve the MDGs, there has been significant progress towards better reproductive health among women in the developing countries. However, there is still a great need for improvements.
**Sustainable Development Goals**

In 2014 a new set of Sustainable Development Goals (SDGs) was developed resulting from the previous MDGs. SDG3, “Ensure healthy lives and promote well-being for all at all ages” is one of the 17 goals that was created for 2015–2030, where a reduction in maternal mortality and universal access to sexual and reproductive health care are among the key areas (10). One of the SDG3 targets is to reduce global maternal mortality to less than 70 deaths per 100,000 live births and no individual country should exceed 140 maternal deaths per 100,000 live births by 2030 (11). To achieve this global goal, developing countries must reduce their MMR by at least 7.5% annually between 2016 and 2030. Only three countries, i.e. Rwanda, Cambodia and Timor-Leste, with a MMR greater than 100, reached or exceeded this goal between 2000 and 2015 (3).

**The Rwandan setting**

Rwanda is a landlocked country in Central Africa, situated in the Grand Lakes region comprising a surface area of 26,338 square kilometres. Rwanda is one of Africa’s most densely populated countries (12) and, in 2019, has an estimated 12.3 million inhabitants with a population growth rate of 2.3% per year (13). Rwanda is classified as a developing country with a gross domestic product (GDP) of 9.14 billion USD in 2017 (5) and the total poverty rate in 2017 was estimated at 38.2% (less than RWF 159,375 per adult equivalent per year in January 2014 prices; approxi. 235 US dollar) (14). The ethnic groups are mainly Hutus (84%) and Tutsis (15%). Rwanda is officially a democracy with the current President Paul Kagame in office since year 2000 (15). Rwanda have a young population with 51.5% of the population being 19 years or younger. A majority (87%) of the Rwandan population aged six years or older have ever attended school. In urban areas, 12.4% of the male population have attended a university education while only 1.5% of males in rural areas. For women, 10.4% of the urban population have attended a university education while only 0.9% of women in rural areas. The literacy rate for men is estimated to 78% and 69% for women (14). Life expectancy at birth has increased from 49 years in 2000 to 66.7 years in 2017 (16). Rwanda is divided into four provinces: the Northern, Southern, Eastern and Western province, and Kigali city. The majority (84%) of the population live in rural areas (17). Kinyarwanda is the national language of Rwanda. French and English are also official languages. In 2017 the Rwandan government accepted Swahili as the fourth official language, particularly for trade purposes with other members of the East African community (18). The majority of men (58%) and women (76%) work in the agricultural sector (19), and a majority of workers (58%) have more than one job (14). The dominant religion in Rwanda is Christianity (93%) where 44% are Catholic and 38% are Protestant. The number of Muslim adherents is approximately 2% of the population (19). The public pyramidal health system includes bottom-to-the-top; health posts, health centres, district hospitals and referral hospitals. Health centres represent entry into the health system for
pregnant women in labour and the majority (60%) of all women give birth at health centres (17, 20). Mean time for walking to a health centre is accounted to be 33 minutes in urban areas and 54 minutes in rural areas (14).

The 1994 genocide of the Tutsis devastated the Rwandan population and its economy when nearly 1 million people were killed (21). It also exacerbated a number of development constraints that had existed before 1994. The already poorly developed productive infrastructure was completely destroyed, including most health facilities, and the nation was deprived of a generation of trained professionals in major areas such as health and education. In 1999, the government introduced community-based health insurance (CBHI or its French name Mutuelles de Santé) as a long-term strategy for addressing financial barriers to health care for all, as recommended by the World Health Organization (WHO) (22). Rwanda is the country in Sub-Saharan Africa with the highest enrolment in health insurance (23). In 2017, CBHI covered 83.6% of the Rwandan population (24), 6% of the population are covered by RAMA insurance (Rwandaise d’Assurance Maladie) for civil servants, and additionally, Military Medical Insurance and private health insurance (23). However, at the same time, the majority of women in Rwanda reported that they had experienced problems accessing health care at least once and almost 50% reported that lack of money for treatment was a serious problem (19). The individual cost for the CBHI is based on income and includes a free premium for the poorest (16). Men and women have equal access to health insurance (14). Despite this, there is a conflict between what the Rwandan state wants to achieve in terms of gender equality and the existing culture, that are heavily influenced by the norm of masculinity. Rwanda has promoted women’s empowerment (25). In the 2018 election to the parliament, 64% of all seats were held by women (26). However, women in Rwanda are highly exposed to intimate partner violence with poor access to help and support services, and they also experience poorer living conditions than men (25). The framework for Rwanda’s future development called “Vision 2020” was published by the Government in 2000 to present key priorities for the future (27). This plan laid the ground for the subsequent development that Rwanda has achieved, particularly in the health sector, but also in education, housing and finance (28). Currently, the vision is to become an upper-middle income country by 2035 and a high-income country by 2050 (24).
Map of Rwanda

Reproductive health in Rwanda

Rwanda has made significant progress in improving women’s health and is one of nine countries that demonstrated an MMR of more than 100 in 1990 and achieved the MDG5, showing at least a 75% reduction in MMR from 1990–2015, i.e. MMR was reduced from 1,300 to 210 per 100,000 live births (3). Until 2005, most pregnant women in Rwanda gave birth at home, assisted by traditional birth
Introduction

attendants. In 2006, a facility-based childbirth policy was launched, with the goal of providing all pregnant women with a full package of antenatal, childbirth and post-partum health care services, essential newborn care for their babies and prevention of mother-to-child transmission of HIV. Preventive and curative services for maternal health in Rwanda are delivered through a network of peripheral health centres, district hospitals and referral hospitals that have played a key role in reducing geographical barriers to health services (19, 29). The achievements in maternal health are also partly due to community health workers using mobile phone (RapidSMS system) in communication with the rest of the health system for monitoring mothers and newborns (19). In 2014/2015, more than half of all women giving birth were transferred from a lower to a higher level health facility and the main reason for the transfer was to ensure more advanced health care and provision of caesarean section (30). In 2017, a total of 326,841 births occurred in Rwanda with more than 90% with a skilled birth attendant present. A small number of pregnant women (0.63%) tested positive for HIV (17). The Sex Ratio at Birth (SRB) was 1.023 male births per female births in 2017 (31). There has been an increase of women giving birth by caesarean section, from 9% of all women in 2010 to 12% from 2014–2015, although the caesarean section rate in Kigali city increased from 18% in 2010 to 22% from 2014–2015 (32). Rwanda is assessed as being on track to achieving the SDG targets with support from the Rwandan government, donors and local as well as international agencies (33).

The abortion law in Rwanda is very restrictive and abortions are considered to be one of the leading causes of preventable maternal mortality in the country (34). Until 2012, abortion was legally permitted only when two physicians could certify that an abortion was necessary in order to save a woman’s life and protect her physical health. In addition to approval from the two physicians, approval from a court was also required and this was very hard to accomplish. The revision of the law in 2012 extended the grounds for when abortion is permitted. This included fetal abnormalities, incest, rape and forced marriage. The penalty for a woman for having an illegal abortion was also reduced from 5–15 years in prison to 1–3 years (35, 36). In the new Ministerial Order N°002/MoH/2019, the Rwandan government removed the requirement of court approval as well as permission from a second physician, thereby enabling one physician to approve an abortion until 22 weeks of gestation. Although the abortion right is still restricted, additional permissible grounds for abortion are if the pregnant person is a child (37).
The Vietnamese setting

Vietnam is a one-party communist state located in the eastern part of Asia comprising a total surface area of 331,230 square kilometres. The population has reached more than 91 million people, of which 26% are women of reproductive age (15–49 years). Almost 34% of the population live in urban areas. Life expectancy at birth in 2016 was 73.4 years (38, 39). Vietnam has 63 provinces with Hanoi being the capital city. There are more than 50 different ethnic groups in Vietnam and the majority of the population belongs to the Kinh group (40). Approximately one fourth of the population is categorized as religious believers, with Buddhism being the most common religion. However, 95% of the population are professing some kind of spiritual beliefs (41). In recent decades, there has been a dramatic change in the economic conditions in Vietnam. Gross domestic product (GDP) has increased from USD 31.17 billion in 2000 to USD 223.78 USD in 2016 (5). Poverty, according to the World Bank definition, i.e. less than USD 1.25 per person per day, has been reduced from 58% of the population in 1993 to 7% in 2015 (38, 42). According to The World Bank, in 2010 Vietnam changed from being considered a low-income country to being considered a lower middle-income country (43). The adult literacy rate was estimated to 94% in 2009. Currently, there are more female students attending upper secondary and tertiary education levels than males (44).

At the end of the 1980s, the “Doi Moi” (renovation) policy led to a series of changes in the health system. Privatisation of health care became common and an official user fee was introduced at public health facilities. At the beginning of the 1990s, out-of-pocket payment for health accounted for more than 70% of total health financing. As a result, several reforms were introduced in order to increase access to health care, among them the 2003 “Health Care Fund for the Poor”, with the aim of increasing access to health care for the most vulnerable people (43, 45). The “Health Insurance Law” of 2008 created a Social Health Insurance program and was an important step towards universal coverage. In 2012, the “Master Plan for Universal Coverage” was introduced with the aim of at least an 80% health insurance enrolment rate of the entire population by 2020 (45). Efforts have been made for residents to seek health care for common conditions at lower healthcare levels. However, despite this, provincial and national hospitals continue to account for a large amount of all inpatient services, and overcrowded upper level referral hospitals are a major problem in Vietnam (46, 47).

Domestic violence against women has been recognized as a serious problem by the Vietnamese government, and there is a strong commitment to end violence against women and to promote gender equality. The findings from the National Study on Domestic Violence in 2010 reported that the prevalence of ever-physical or sexual violence by husband, among ever-married women, were 34% (48).
Historically, Vietnam has practiced a family planning policy in order to reduce high birth rates. The two-to-three child policy was first initiated in the northern part of the country but was adopted nationwide upon the reunification of the country in 1975. Since 1975, when the Vietnam War ended, the fertility rate has dropped from about 6.1 births/women to 2.1 in 2016 (49, 50). The Vietnamese Government took strong political measures towards achieving the MDG goals (51). The maternal mortality ratio decreased from 139 per 100,000 live births in 1990 to 54 per 100,000 live births in 2015 (3). Reproductive health services are provided in every province in Vietnam, from commune to central level (43). However, the Ministry of Health has implemented the “Population and Reproductive Health Strategy” for 2011–2020 where one of the targets is to improve maternal health with increased equality between areas and regions (52). In 2015, 1.6 million children were born in Vietnam (53). Hospital-based delivery increased from around 35% to 94% from 1999–2014 (42, 54) and in 2014, 94% of all births were attended by a skilled health professional (54). The caesarean section rate in 2014 was 43% in urban areas compared to 21% in rural areas (53). Abortions have been legal in Vietnam up to 22 weeks of gestation since the 1960s. First trimester abortion is provided at commune, district, provincial and central level, while abortions in the second trimester are only provided at provincial and
central level. Vietnam is considered to have one of the highest abortion rates in the world (55). Almost 270,000 abortions were reported in public health facilities in 2015. An additional 89,000 abortions were estimated to have been conducted in the private sector, giving a total of approximately 360,000 abortions per year (39). This is however, far below the figures from 1995 when the abortion rate peaked at over 1.3 million abortions per year in Vietnam (56). The number of repeat abortions is high, partly because of inadequate use of contraception and a son preference tradition (39, 57). Many young and unmarried people in Vietnam have difficulties accessing reproductive health services for contraception use (40). In 2014, 75.7% of all married women aged 15–49 years were using contraceptive methods. However, contraceptive prevalence rates are only based on married women although more than 30% of all women in reproductive age are unmarried (39). Prenatal sex determination using ultrasound is common in Vietnam and since 2004, a skewed sex ratio at birth (SRB) has also been demonstrated. The 2016 SRB showed 112 males per 100 females in Vietnam in relation to the estimated natural biological level of 105 male births per 100 female births (58). Since 2003, fetal sex diagnosis has been prohibited in Vietnam, as have sex-selective abortions (59). Despite this, a majority of women in Vietnam are aware of the sex of their fetus (60), which indicates that these regulations are not adhered to by health care providers.

Antenatal care services

Good health care during pregnancy is of great significance to maternal and fetal health. Antenatal care (ANC) links the pregnant woman to the health system and increases the chance of giving birth with a skilled attendant, which contributes to better health throughout the life of both the mother and the child (61). ANC directly reduces morbidity and mortality through detection and treatment of complications during pregnancy, and indirectly through the identification of pregnant women at risk of complications with referrals to an appropriate level of care (62).

Health promotion, prevention, screening and diagnosis of disease, as well as communication with and support for the pregnant woman and her family are important components of good ANC (63). An important indicator used by WHO is “Antenatal care coverage (at least one visit)” (ANC1+), which is the percentage of women aged 15–49 years who received ANC at least once during pregnancy from a skilled health professional (64). In 2002, the WHO ANC model, also known as focused ANC (FANC) or basic ANC, was introduced with recommendations of evidence-based interventions four times during a normal pregnancy (65, 66). ANC4+ is another indicator used by WHO to evaluate access and use of health care during pregnancy. For each country, the number of women aged 15–49 years with a live birth in a specific time period who received ANC four or more times with any provider are estimated (64). Receiving ANC4+ increases the likelihood of receiving effective maternal health interventions. In 2016, 86%
of all pregnant women globally received ANC at least once while only 62% received at least four visits (64). The same year (2016), WHO updated its earlier recommendations on ANC with priorities on person-centred health and well-being, not only the prevention of morbidity and death. In the “2016 WHO ANC model”, the word “contact” is used instead of “visit”, as “contact” implies an active connection between a health care provider and a pregnant woman. The “2016 WHO ANC model” recommends a minimum of eight ANC contacts, i.e. one contact before gestational week 12, two contacts in the second trimester and five contacts during the third and last trimester. These practical guidelines focus on routine ANC for normal pregnancies and are intended to inform the development of health policies and clinical protocols (67).

**Antenatal care in Rwanda**

In 2003, Rwanda started following the WHO model with recommendations of four ANC visits during a pregnancy (68). The majority of ANC services in Rwanda are provided at health centres with referrals to district hospitals in the event of intercurrent diseases or obstetric complications (69, 70). Ultrasound is not included as a routine examination in ANC for women with normal pregnancies, although pregnant women who can afford to pay can go directly to referral hospitals where ultrasound is available. General physicians are the main providers of obstetric ultrasound examinations (71). In 2014/2015, 99% of all pregnant women in Rwanda received at least one ANC visit while only 44% received four or more visits (17). A timely contact with ANC within the first trimester is associated with an increased chance of attending the recommended number of ANC visits during pregnancy (69). In Rwanda, 56% of all pregnant women in 2014/2015 received their first visit before the fourth month of pregnancy. There has been an increase in this number since 2010, when only 31% of pregnant women received their first ANC visit during the first trimester (19). Barriers to timely contact with ANC in Rwanda have been identified to include lack of knowledge, multiparous pregnant women, a partner unwilling or unable to attend ANC, being poor or experiencing problems with health insurance, and finally, the ANC culture (69). Nurses and medical assistants are the main health providers of ANC in Rwanda. Midwives accounted for only 0.6% of all ANC visits in 2014/2015 while medical doctors accounted for 3.5–5.4% of all visits. The proportion of pregnant women consulting a medical doctor for ANC is higher in urban areas than rural areas, especially pregnant women residing in the capital Kigali. Pregnant women with secondary or higher education, and those in the richest quintile also consult a medical doctor more often than those with no education and those on lower incomes (19). The content of ANC is of great significance to health outcomes. The Demographic and Health Survey of 2014-15 showed that the majority of pregnant women in Rwanda (97%) had a blood sample taken during their last pregnancy and 84% had their blood pressure measured (19). However, health professionals in ANC clinics in Rwanda have reported suboptimal practices on conditions of pregnancy that needed urgent
referral for adequate management (70). There are also reports of pregnant women perceiving the quality of ANC services as suboptimal (72).

In 2018, Rwanda was selected by WHO to champion the new ANC guidelines with a minimum of eight contacts (73). Although the new recommendations are welcomed, countries with severely constrained budgets need to consider whether these guidelines are beneficial in light of the vast investment required (74). However, analyses of the cost-effectiveness of the introduction of the 2016 WHO ANC guidelines in Rwanda show that it would likely be cost-effective in terms of health gains (75).

**Antenatal care in Vietnam**

The ANC recommendations in Vietnam were updated in 2016 in the “National Guideline for Reproductive Health Care”. This recommendation includes at least one contact in the first and second trimester, respectively, and two contacts in the last trimester (76). In 2000, 69% of all pregnant women were estimated to have received at least one ANC visit while 96% were estimated to have received it in 2014 (54). Although almost all pregnant women in Vietnam currently attend some form of ANC (53), there are major disparities in ANC utilisation between rural and urban areas, and significant inequities along socio-economic and ethnic lines (77). In 2014, 86% of pregnant women in urban areas received ANC4+ compared to only 68.5% of pregnant women in rural areas (53). There is a lack of quality of content of ANC in Vietnam. The Vietnam Multiple Indicator Cluster Survey 2014 showed that only 56.2% of women had their blood pressure measured, and blood and urine samples checked during their last pregnancy (78). Another study also reported that 20% of women underwent a blood test at least once during pregnancy and only 39% underwent a urine test, which could help detect adverse outcomes (79).

In Vietnam, obstetric ultrasound is now considered an indispensable part of ANC and almost all Vietnamese women undergo ultrasound examinations during pregnancy (80, 81). The Ministry of Health in Vietnam recommends three ultrasound examinations during pregnancy, in gestational weeks 11–13, 20–24 and 30–32 (76). However, many women in Vietnam receive more than the recommended number of examinations (80, 81). Physicians, mainly sonographers, are the main providers of ultrasound examinations in Vietnam (personal communication). There is currently no known regulation indicating the certification or qualifications for other health professionals, for example, midwives, for providing various technical services such as ultrasound examinations (39).

**Ultrasound during pregnancy**

Ultrasound in pregnancy management has become an indispensable part of practice in high-income countries, where it is universally used for screening,
diagnostic and surveillance purposes. Its use has shown benefits including assessment of the number of fetuses, placental location, estimation of gestational age and detection of fetal anomalies (82), as well as overall assessment of fetal well-being among other things (83). Before the 1960s, obstetric caregivers had very little insight into a pregnant woman’s uterus. In the mid-1960s, M-mode (motion-mode) ultrasound was developed and its use for measuring fetal heart rate was recognized. A major breakthrough was the B-mode (brightness-mode) static ultrasound imaging developed of the 1970s. The B-mode technology was the first to provide two dimensional images of the fetus and the pregnant uterus and it became possible to measure the biparietal dimeter of the fetal head (84, 85). In the mid-1990s, the use of three-dimensional ultrasound (3D) rapidly increased (86). Since the 1970–80s, ultrasound has become part of routine surveillance during pregnancy in many high-income countries (87, 88). It has been assumed that routine ultrasound examinations would benefit all pregnancies because of the risk of adverse outcomes in pregnancies without risk factors, too (83). Routine ultrasound examinations during pregnancy have been described as “meeting and connecting with the baby” and the examination may also be considered an important step towards parenthood (89, 90). Although many low-income countries have successfully introduced ultrasound imaging during pregnancy, lack of training of ultrasound operators, lack of equipment and an insufficient number of ultrasound operators are common barriers to its use (91, 92). The 2016 ANC guidelines by WHO recommend one ultrasound examination before 24 weeks’ gestation to estimate gestational age, improve detection of multiple pregnancies and fetal anomalies, reduce the number of inductions due to post-term pregnancy and improve a woman’s pregnancy experience. Implementation of the 2016 WHO ultrasound recommendation in low-resource settings involves a number of challenges in logistics, infrastructure, finance and human capacity (67). However, the use of obstetric ultrasound in low-income countries has likely contributed to achieving the Millennium Development Goal 5 (93) for reducing maternal mortality by 75% between 1990 and 2015 (2).

**Safety aspects of ultrasound**

Overall, current evidence shows that diagnostic ultrasound is safe for a pregnant woman and her fetus (94). However, ultrasound generates energy that may cause biological effects in tissues (95, 96). An association between exposition to ultrasound during pregnancy and subsequent non-right handedness among boys has been shown. This association suggests that prenatal ultrasound may affect the development of the fetal brain (97, 98). Other studies have been unable to confirm this finding (99) or have demonstrated a significant but weak association between ultrasound screening and non-right handedness (100). According to the ISUOG (International Society of Ultrasound in Obstetrics and Gynecology), obstetric ultrasound should only be used for medical diagnosis by health professionals who have been trained in safety and proper operation (101). The
ALARA principle, As Low As Reasonably Achievable exposure, must be taken into account when performing ultrasound examinations. The examination should be kept as short as possible with output levels as low as reasonably achievable to produce a useful diagnostic result (95). Doppler ultrasound for assessment of feto-placental circulation is not recommended as a routine for normal pregnancies (102) because of the risk of temperature increase, particularly during the sensitive first trimester (103). However, Doppler ultrasound in high-risk pregnancies reduces the risk of perinatal mortality and may decrease the number of obstetric interventions (104) when performed at the lowest possible energy levels for a limited time (105).

First and second trimester ultrasound

The primary aim of a first trimester ultrasound examination is to determine whether the embryo is alive and whether or not it is an intrauterine pregnancy. The number of embryos can also be determined in the first trimester. To estimate gestational age, the embryo can be measured by crown-rump length (CRL) (103). The measurement of CRL between 7+0 and 13+6 weeks of gestation has been recommended as the most appropriate method for determining gestational age. The biological variation in size is less during the first trimester than later in the pregnancy (106). However, the ISUOG recommends one second-trimester ultrasound as a baseline against which subsequent examinations may be compared for evaluation of growth and health. In the second trimester, a routine ultrasound examination is often performed between 18 to 22 weeks of gestation. Although dating ultrasound is more accurate in the first trimester, a second-trimester ultrasound is set as a compromise between dating and timely detection of fetal congenital anomalies (107). During the second trimester, a combination of measurements of biparietal diameter, head and abdominal diameter and femur length should be used to determine gestational age (106). Prenatal screening with evaluation of cardiac activity, fetal number, fetal anatomy and the placenta is also recommended in a second-trimester ultrasound examination (107).

Third trimester ultrasound

In the third trimester of the pregnancy, obstetric ultrasound is mainly used selectively for specific clinical indications. A systematic review from 2015 concludes that routine late pregnancy screening, after 24 weeks’ gestation, has no benefit for the mother or the baby when used in low-risk pregnancy populations or among unselected pregnancies (108). However, complications such as abnormal fetal growth (SGA and LGA), decreased amniotic fluid (oligohydramnios) and increased amniotic fluid (polyhydramnios) can be diagnosed using obstetric ultrasound and can facilitate the clinical management of pregnancy (103).
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Basic ultrasound training and examination

According to the ISUOG, formal basic ultrasound training should include theoretical and practical training as well as a skills examination (109). A basic ultrasound examination should include fetal viability and movement, number of fetuses, assessment of gestational age and comparison of biometric values with gestational age, assessment of fetal size through biometric measurements, evaluation of the amount of amniotic fluid, evaluation of the appearance and location of the placenta and fetal presentation (109). Health professionals who perform obstetric ultrasound vary between countries. In some settings ultrasound examinations are performed by obstetricians/gynecologists or radiologists, while in other settings, clinical officers, ultrasonographers and midwives also perform some of these examinations (110). An abnormal finding in a basic ultrasound examination may lead to a referral to a comprehensive examination performed by a specialist (109). Studies performed in low-to-middle-income countries show that training of midwives or other health professionals with no prior experience of performing basic ultrasound is valuable, particularly in remote health facilities, and could be a feasible way of screening for high-risk pregnancies (111, 112).

Health professionals in maternity care

There is a huge shortage of health professionals in maternity care globally, especially in the poorest countries where maternal and perinatal mortality rates are the highest (113, 114). In order to reduce global maternal mortality rates to 50 per 100,000 live births by 2035 (115), the threshold of 59.4 skilled health professionals per 10,000 population was set as a global goal by WHO. Currently, two thirds of countries globally have not yet reached this goal (114). The shortage of health professionals is associated with poor quality of emergency obstetric care services which, in turn, can discourage facility use during childbirth (116). Besides the lack of workforce such as the number of midwives, many countries face a major challenge in improving the quality of health professionals and the health care that they provide. WHO has stated that health services are only as effective as the persons responsible for delivering them (114). There is a direct association between the level of skilled birth attendance and a reduction in the maternal mortality ratio (117). Midwives, when educated and regulated by international standards, could meet 87% of the global need for sexual, reproductive, maternal, newborn and adolescent health (1) and could also enable access to specialist care when needed. Investment in midwives has also shown to be a cost-effective approach to reducing maternal and neonatal mortality and stillbirths (118).
Health professionals in maternity care in Rwanda

One of the major challenges in the health sector in Rwanda is the shortage of qualified human resources because many people were killed or fled the country during the genocide of 1994 (21, 119). Due to the shortage of midwives, nurses are the main birth attendants in Rwanda (19). There are three categories of nurses: A2 nurses with education at secondary school level, A1 nurses trained for three years at a nursing school and A0 level nurses who possess a Bachelor’s degree (117). The majority of nurses in Rwanda are A2 level or lower (70). Before 1997, there was no midwifery cadre in Rwanda. Through different reforms and initiatives, such as the “Human Resources for Health” (HRH) programme, in which the Rwandan faculty collaborates with academic institutions from the United States, there has been an increasing number of trained health professionals in recent years (120, 121). During the first years of the HRH programme, from 2012–2017, 22 training programmes were supported and it is estimated that 4,600 students will have graduated by 2019 (122). Between 2013 and 2016, four new midwifery schools opened. Nowadays, Rwanda is following the global standard for midwifery education with at least 3 years for direct entry and 1.5 years for post-nursing programmes. However, the standard curriculum is not followed by all schools in Rwanda (123). At the start of the HRH programme in 2012, the majority of physicians were general practitioners. Only one quarter of physicians were specialists and the majority of them were employed in or around the capital of Kigali (124). The HRH programme has increased the number of physicians, specialists and speciality areas (28). In 2015 it was reported that there was an estimated 910 midwives, 742 physicians and 8,751 nurses employed throughout Rwanda (17), a significant increase since 2009 when there were 49 midwives and 579 physicians (125). However, the target of the HRH programme is to reach 955 physicians, of which 565 are specialists and 10,171 nurses with A1 or A2 education by the end of 2019 (126).

To further strengthen the workforce in Rwanda, particularly at health centres in rural locations, the training of clinical officers started in 2011. The curriculum for the education of clinical officers is focusing on clinical care, community health and health facility management. There is a bridging programme of 18 months for A1 nurses and a 4-year programme for A2 nurses (127, 128). The target is to have 500 clinical officers/medical assistants by the end of 2019 (126). In the mid-1990s, community health workers were introduced and have been providing essential health services at each of Rwanda’s nearly 15,000 villages since 2004–2005. In each village, three community health workers are elected by the village members, and one of them is specifically responsible for reproductive and maternal health issues. They are all trained to deliver basic care with the intention of linking the patient with the health system (21, 120). Community health workers and health facility staff receive additional remuneration based on their health service provision, which is called performance-based financing (PBF). PBF also covers the health facilities that are financially rewarded based on a number of
indicators (120). Currently, the Ministry of Health in Rwanda has assessed that there is a high overall risk that highly qualified health professionals will leave the public health sector in Rwanda. Thus, retention strategies in the health sector need to be accelerated (24).

Health professionals in maternity care in Vietnam

Vietnam has three different levels of midwifery education: a university education lasting 4 years, a junior college education lasting 3 years and a secondary level education lasting 2 years. In 2013, the majority (94%) of all midwives had 2 years’ training at secondary level or lower (39). In 2015, the Ministry of Health in Vietnam issued the circular 26/2015TTTLT-BYT BNV that required the termination of all elementary and secondary educational programmes in health by 2021. Instead, from 2025, the minimum qualification for being registered as a midwife will be 3 years’ training (39, 129). Although a competency-based curricula has been introduced to meet the standards of the International Confederation of Midwives (ICM), there are several issues with the quality of midwifery training, including a shortage of instructors (39).

To ensure universal access to reproductive health services, the Ministry of Health has issued a policy of letting Village Birth Attendants (VBA) fill the gap of trained health professionals at the village level, particularly in remote and disadvantaged areas. The VBAs complete six months of competency training to provide health information, education and communicate with pregnant women in order to convince them to seek maternity care at health facilities. In addition, VBAs can provide preliminary treatment in the event of complications during home births, although the main method of dealing with obstetric complications is to assist in the timely transfer to a health facility (39). The number of physicians in Vietnam has increased significantly since 1990 (43) and in 2016 there were 8.4 medical doctors per 10,000 inhabitants (38). However, the distribution of medical doctors is still unequal with 59% of all doctors working in urban areas while one third of the general population is urban (45). Medical doctors are trained for six years. 38% of medical doctors are specialists. Highly qualified health professionals such as resident physicians and midwives who have graduated from university work primarily at central and provincial hospitals. There is also a cadre of assistant doctors with four years’ training who primarily work at rural commune health stations and district hospitals (130).

Reproductive rights and human rights

Reproductive rights are not a diverse set of rights but can be recognized in national and international law, as well as in international human rights documents (131). Human rights are the rights inherent to all human beings, regardless of sex, nationality, ethnicity, race, religion, language or any other status, without discrimination. It also includes the right to life, liberty, education and work, freedom of expression and opinion, freedom from torture and slavery
and many more (132). Protection of women’s rights in relation to reproductive health has not been a priority globally. Women’s reproductive health raises issues for many legal traditions because the subject is related to sensitive subjects such as sexuality and morality (133). The modern era of human rights applicable to women’s health started with the UN Charter of 1946 and the Universal Declaration of Human Rights adopted by the General Assembly in 1948 (134). However, reproductive rights were not mentioned in the declaration from 1948 but initially became a subcategory of human rights in the Tehran Proclamation of 1968 (135). Later, at the International Conference on Population and Development (ICPD) in Cairo in 1994, governments from 179 countries adopted the “ICPD Programme of Action” in which reproductive health and human rights are cornerstones of population and development concerns (136). In the “ICPD Programme of Action”, reproductive rights include the right of all individuals and couples to decide the number, spacing and timing of their children with the right to have the information and means to do so. This means that everyone should have access to contraception no matter their residence, sex and age. It also includes the right to attain the highest standard of sexual and reproductive health such as access to ante- and post-natal care for both mother and child, and prevention and treatment of sexually transmitted diseases, as well as the right to not be married before becoming an adult, to not be forced into marriage and the right to make reproductive decisions free of coercion, violence and discrimination (131). Three of the MDGs are directly related to reproductive rights, such as MDG 4: Reduction of child mortality, MDG 5: Improvement of maternal health, and MDG 6: Combating HIV/AIDS and other specified diseases. The “ICPD Programme of Action” has contributed to significant improvements in health, poverty reduction, education and gender equality towards the MDG goals (131, 136).

The international CROss Country UltraSound Study (CROCUS)

This PhD project is part of the CROss Country UltraSound Study (CROCUS Study), which is an international study aimed at investigating midwives and obstetricians’ experiences and views regarding the use of ultrasound in relation to clinical management, including ethical aspects. The CROCUS Study has been designed as a two-phase project, with qualitative and quantitative components, and is being conducted in a number of low-income-, middle-income and high-income countries in Europe, Africa, Asia and Oceania. The participating countries are Australia, Norway, Sweden, Rwanda, Tanzania and Vietnam. The countries involved in the CROCUS Study have been selected to represent a variety of contexts, including culture, religion, gender perspectives, legislation, organisation of obstetric and maternal health care and organisation of and access to ultrasound examinations during pregnancy.
Scientific methods

Historically, the quantitative approach has dominated, particularly in medicine, but qualitative methods are being increasingly used in medical and public health research (137). The distinction between qualitative and quantitative research methods is often framed in terms of using words instead of numbers for the qualitative method or using open-ended questions instead of closed-ended questions. However, a more complete way of viewing the differences of methods included in these two paradigms are through the philosophical perspectives of knowledge, research design and data collection that the researchers bring to the study (138, 139).

The naturalistic paradigm

The naturalistic paradigm, also referred to as the qualitative paradigm, is an approach to exploring and understanding the meaning that individuals or groups ascribe to a problem or research question (138). The focus is on what, how or why a phenomenon occurs rather than measuring it (140). The naturalistic paradigm concludes that knowledge comes from the internal reality of a person or group. The reality is viewed as fluid and ever-changing (138) and understanding is dependent on subjective interpretation (141). Typical data in the naturalistic paradigm are, for example, videos, interviews and recordings. Qualitative studies can stand alone or be accomplished prior to quantitative studies in order to gain a better understanding of an unknown research topic, for example, establishing the questions used in a survey. Qualitative studies can also follow quantitative studies by helping to explain phenomena observed in quantitative studies (138, 140). Examples of different kinds of qualitative methods are Ethnography, Grounded theory (138) and Content analysis (141). For this thesis, Content analysis is used as the qualitative method.

Content analysis

The study of the meanings of communications dates back to the theological studies of the late 17th century. At the beginning of the 20th century, the method was used as a quantitative method for newspaper analysis. The term content analysis first appeared in English in 1941. The qualitative approach to content analysis has its roots in literary theory, social sciences and critical scholarship, e.g. feminist theory (142), but is nowadays also often used in nursing research and education. The quantitative description of content analysis often studied the manifest content of communication while the qualitative approach also included interpretations of latent content. Both manifest and latent content analysis include interpretation but it varies in depth and abstraction level (141). The unit of analysis e.g. an interview, is read several times in order to become familiar with the data. The text is then divided into meaning units that are condensed, abstracted and labelled with a code. Based on the aim of the study and the input from co-researchers, the codes are compared according to differences and
similarities and sorted into sub-categories and categories. In the final step, the underlying meaning, the latent content, in the categories is formulated as a theme (141).

**Trustworthiness in qualitative research**

The concepts of describing quality differ between qualitative and quantitative research (141). Quality in qualitative research can be described as trustworthiness and the concepts of credibility, transferability, dependability and confirmability are often used instead of the quantitative terms internal validity, external validity, reliability and objectivity. Credibility is the way in which the researcher demonstrates the true picture of the phenomenon (143). To ensure credibility, the researcher must carefully select participants with various experiences of the research question, for example, participants of various gender, age and different perspectives. This contributes to a richer variation in the study phenomena. The selection of data method and the amount of data are also important to further establishing credibility. When using qualitative content analysis, the selection of suitable meaning units, ensuring that categories and themes cover the data and provide representative quotations from the transcribed text, are additional means of achieving credibility (141). Although qualitative research does not aim to apply to wider populations, the researcher must provide a detailed context of the fieldwork so the reader can justify whether the findings can be applied to other settings, i.e. transferability (143). Transferability can be facilitated if there is a clear description of the context, participants’ characteristics, data collection and the process of analysis (141). In contrast to the positivistic term of reliability, which aims to able to repeat the same study with the same results, it is hard to meet full dependability in qualitative research as the nature of the phenomena changes all the time. However, the process within the study should be reported in detail, for example, in detailed field notes, to enable future researchers to repeat the study, although not necessarily with the same results (143). Confirmability or objectivity can be achieved if the researcher demonstrates that findings emerge from the data and not their own opinions. To reduce the effect of investigator bias, thorough discussions about the findings with researchers from different backgrounds within the research group can be performed, as well as a description of the researcher’s predispositions. However, real objectivity is discussed as being difficult to ensure also in quantitative studies since the tests and questionnaires are designed by human beings (143).

**The positivistic paradigm**

The positivistic paradigm, also referred to as the quantitative paradigm, represents a traditional form of research originating in the 19th century with writers such as Auguste Comte. The positivistic paradigm views knowledge as being derived from an external, measurable reality and is thought to be objective in its perspective and outcome. Researchers try to find causal relationships
between variables and pose these in terms of hypotheses or questions. A quantitative sample includes large, preferably random samples and numbered data are analysed using statistical procedures (138, 139). Quantitative research can be divided into observational, quasi-experimental and experimental design, in which experimental research is placed at the top of the evidence pyramid after systematic reviews and meta-analyses (138).

Epidemiology

The definition of epidemiology includes the study of the occurrence and distribution of health-related events, states and processes in specified populations, including the study of the determinants that influence such processes and the application of this knowledge to control relevant health problems (144). Distribution refers to the time, place and person affected by a health-related event, state or process, for example, a disease. Determinants comprise all the biological, physical, social, cultural, economic and behavioural factors that affect health. Diseases do not occur randomly as certain populations are more likely to acquire a condition than others. Thus, epidemiology aims to characterize the patterns of occurrence in order to prevent, detect or treat a disease (144, 145). Common study designs used in epidemiology are cohort study, case-control study, trial, case series and cross-sectional study. Although there are different ideas that underlie these study designs, the joint strategy is to seek associations between exposures (potential causes) and outcomes (disease). Cohort study, case-control study and trials are commonly viewed as analytic epidemiology which focus on exploring hypotheses about causal relationships. Case series and cross-sectional studies are mainly categorised as descriptive design which provide information about disease pattern or risk factors but not about the underlying causes (146).

Validity and bias in epidemiological studies

To assess the quality of epidemiological research, there are two types of validity to consider: internal validity and external validity. Internal validity means the ability to correctly measure what was intended to be measured (147). It includes the degree to which a study is free from systematic error or bias. Internal validity depends on how the study subjects are selected, how information is collected and how analyses are conducted. Internal validity is a prerequisite for external validity (144). External validity is the degree to which the study results can be generalized to other populations or groups (144). Bias is a key issue in epidemiology as it is common in research and it undermines the internal validity of a study. Bias, or errors, mean deviations from the truth (146, 147). Systematic error is found when there is consistent errors in a particular direction leading to distortion of the result. Another kind of error is random error, which means a variation in measurement that has no connection with other measurements (144). Bias arises when errors affect groups differently in a study. Bias can be divided into: 1) selection bias, 2) information bias and 3) confounding (146, 147).
Selection bias is the result of how the study population is selected, i.e. how participants are included or excluded in a study (146). Information bias results from a misclassification of the exposure, outcome or both. One example of information bias is recall bias in which participants must rely on memory of remote exposures (147). Confounding means mixing together or blurring of effects. In the measurement of the association between an exposure and an outcome, a third variable (confounder) can arise that mismeasures this relationship. This third variable, i.e. the confounder, is associated with the exposure and it also affects the outcome but is not an intermediate link between the exposure and the outcome (147).

Statistical analyses

A statistical test intends to decide whether a statistical hypothesis should be rejected or not (144). For this thesis, the Pearson’s chi-square test of independence was used for exploring the relationship between two nominal categorical variables. The Chi-square test compares the observed proportions or frequencies for each category with the expected values if there would have been no association between the variables (148). Univariate and multivariable logistic regression analyses were also performed calculating odds ratios (OR) and their 95% confidence interval (CI). In regression analysis, a mathematical model is constructed in order to describe the relation between one independent variable, X, and another variable, Y. The logistic method then predicts Y, knowing X. Multiple regression is used to make a simultaneous assessment of the relation between several variables and Y. If there is no association, the odds will be the same, i.e. OR will be 1 (146).
RATIONALE

Obstetric ultrasound is a well-integrated tool for pregnancy surveillance in many high-income countries and its use is also rapidly increasing in some low-to-middle-income countries. In Rwanda, obstetric ultrasound is not included as a surveillance tool in the ANC guidelines for normal pregnancies. Little is known about health professionals’ experiences and views on access to and quality of ultrasound services in Rwanda. To fill this gap, this thesis investigated health professionals’ experiences and views related to obstetric ultrasound using both qualitative and quantitative methods. This knowledge could be used by decision-makers when implementing the 2016 WHO guidelines and to further improve pregnancy outcomes.

In Vietnam, the national guidelines recommend that three ultrasound examinations are performed during pregnancy. Obstetric ultrasound is known to be a widely-used tool in most health facilities. However, few studies have investigated health professionals’ experiences and views on obstetric ultrasound. This thesis aims to fill a knowledge gap by using both qualitative and quantitative methods to explore different aspects of ultrasound use from the perspective of midwives and obstetricians/gynecologists. The results from this thesis can benefit authorities in their work to further improve education and guidelines regarding proper ultrasound use.
AIMS

Overall aim

The overall aim of this study was to explore health professionals’ experiences and views on the role of obstetric ultrasound in relation to clinical management, including ethical aspects, in two low-to-middle-income countries with different characteristics, cultures, religions and healthcare systems.

Specific aims

Specific objectives and research questions to investigate were:

• To explore midwives’ experiences and views of the role of obstetric ultrasound in relation to clinical management, including ethical aspects (Paper I & Paper III).

• To explore different aspects of ultrasound from health professionals’ perspectives (Paper II & Paper IV):
  - What are health professionals’ views of the role of obstetric ultrasound for clinical management of pregnancy?
  - How do health professionals view access to obstetric ultrasound?
  - How do health professionals assess their skills in performing obstetric ultrasound examinations?
  - What do health professionals believe would improve the utilization of obstetric ultrasound?
MATERIALS AND METHODS

This PhD project included both qualitative and quantitative study designs. In Rwanda, focus group discussions (FGDs) that included midwives were performed (Paper I), followed by a cross-sectional study using questionnaires directed at health professionals working in maternity care (Paper II). In Vietnam, similarly to Rwanda, FGDs that included midwives (Paper III) were performed, followed by a cross-sectional study using a questionnaire aimed at health professionals working in maternity care (Paper IV). The same questionnaire (but in different languages) was used in both settings.

Table 1. Overview of methods and materials in Papers I to IV.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Study design</th>
<th>Participants</th>
<th>Analysis methods</th>
<th>Setting</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Focus group</td>
<td>23 midwives: 6 focus groups</td>
<td>Qualitative manifest and latent content analysis</td>
<td>Urban and rural areas of Kigali and the Southern province of Rwanda:</td>
<td>Digitally recorded focus group discussions using an interview guide</td>
</tr>
<tr>
<td></td>
<td>discussions</td>
<td></td>
<td></td>
<td>3 district hospitals, 2 university teaching hospitals and 1 private</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>hospital</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Cross-sectional</td>
<td>907 health professionals: 29 obstetricians/</td>
<td>Epidemiological and bio-statistical methods:</td>
<td>Urban and rural areas of Kigali and all four provinces of Rwanda:</td>
<td>Questionnaires</td>
</tr>
<tr>
<td></td>
<td>study</td>
<td>gynecologists, 222 other physicians, 269 midwives,</td>
<td>Pearson’s chi-square test and univariate logistic</td>
<td>provincial, referral, district, private hospitals and health centres.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>387 nurses</td>
<td>regression</td>
<td>N=108 health facilities</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Focus group</td>
<td>25 midwives: 4 focus groups</td>
<td>Qualitative manifest and latent content analysis</td>
<td>Urban, semi-urban and rural parts of Hanoi, Vietnam: 1 district</td>
<td>Digitally recorded focus group discussions using an interview guide</td>
</tr>
<tr>
<td></td>
<td>discussions</td>
<td></td>
<td></td>
<td>hospital, 1 provincial hospital and 1 national hospital</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Cross-sectional</td>
<td>824 health professionals: 289 obstetricians/</td>
<td>Epidemiological and bio-statistical methods:</td>
<td>Urban, semi-urban and rural parts of Hanoi, Vietnam: national,</td>
<td>Questionnaires</td>
</tr>
<tr>
<td></td>
<td>study</td>
<td>gynecologists and 535 midwives</td>
<td>Pearson’s chi-square test, univariate and</td>
<td>provincial, district hospitals and maternity homes. N=29 health</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>multivariable logistic regression</td>
<td>facilities</td>
<td></td>
</tr>
</tbody>
</table>

Thematic interview guide

A thematic interview guide was developed by the CROCUS Study research team to be used in FGDs that included midwives and individual interviews with obstetricians/physicians (not included in this thesis). The interview guide included a set of core themes to enable comparisons between all countries participating in the CROCUS Study.
Table 2. Key domains in the thematic interview guide.

<table>
<thead>
<tr>
<th>Health professionals’ experiences and views of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The role of obstetric ultrasound for clinical management of complicated pregnancy.</td>
</tr>
<tr>
<td>The importance of obstetric ultrasound in comparison to other surveillance methods during complicated pregnancy.</td>
</tr>
<tr>
<td>Clinical situations where the interests of maternal and fetal health have been in conflict.</td>
</tr>
<tr>
<td>Whether the woman may be considered to act as an instrument for fetal treatment.</td>
</tr>
<tr>
<td>If/when the fetus can be regarded as a person.</td>
</tr>
<tr>
<td>Situations where the fetus has been regarded as a patient with his/her own interests.</td>
</tr>
<tr>
<td>Their professional role in relation to other occupational groups working with obstetric ultrasound examinations or the outcomes of these examinations.</td>
</tr>
<tr>
<td>Their perceptions of the community’s views of obstetric ultrasound.</td>
</tr>
<tr>
<td>Other issues in relation to ethical aspects of the use of obstetric ultrasound.</td>
</tr>
</tbody>
</table>

The questionnaire

Results from FGDs (149-152) and individual interviews (71, 153-158) conducted in all six countries in the larger CROCUS Study were discussed in the research group and generated items for the questionnaire in order to quantify the experiences and views reported. The content areas from the FGDs and individual interviews were reformulated to a set of questions and statements and these were linked to a Likert scale. The questionnaire included 105 questions and statements, all with fixed response options. The mean time for answering the questionnaire was approximately 30 minutes. For the studies included in this thesis, the following items were investigated: health professionals’ evaluation of self-reported skills in ultrasound performance, the role of ultrasound in the clinical management of pregnant women, the view of access to obstetric ultrasound and how the utilisation of obstetric ultrasound could be improved. Sociodemographic questions included in the questionnaire were based on previously used and validated tools. The disseminated questionnaire was the same for all health professionals in all countries in the CROCUS Study in order to enable comparisons to be made between different countries and different health professions.

The Rwandan questionnaire

The questionnaire, originally developed in English, was initially translated into French because French is commonly used in the healthcare system in Rwanda. The questionnaire was pilot tested at two district hospitals using a total of ten physicians and ten midwives/nurses. The participants could choose to answer the English or the French version of the questionnaire. Several midwives and nurses in the pilot study reported difficulties in understanding the questionnaire in English and French and asked for a version in Kinyarwanda. Because Rwanda is a multi-linguistic country, a decision was taken to offer the questionnaire in three languages: English, French and Kinyarwanda. The questionnaire in Kinyarwanda was also pilot tested with five physicians and five midwives/nurses at another
Materials and methods | 25

The second pilot test resulted in some minor changes in the wording of the Kinyarwanda version. Parts of the questionnaires were back-translated from French and Kinyarwanda into English by an external person in order to evaluate the quality of the translation. The conclusion was that the translation was satisfactory.

The Vietnamese questionnaire

The questionnaire was translated from English into Vietnamese by a native Vietnamese speaking person not included in the research team. In order to capture any errors in the translation, the Vietnamese questionnaire was also back-translated into English by another external person. There were differences in a few other words found in the back-translated version but the overall meaning of the questions and statements was the same. The questionnaire was then pilot tested using ten obstetricians, six midwives and two sonographers at a hospital not included in the data collection. The participants in the pilot study commented that the questionnaire took a long time to answer. However, the decision was made to retain all the items (questions and statements) as all of them were considered important to the study.

Paper I

Data collection and sample

This study used a qualitative study design and data were collected through focus group discussions (FGDs) with Rwandese midwives. Data collection was performed in January 2015. The hospitals at which the midwives worked were purposively selected in order to include participants at all levels of health care who provide obstetric ultrasound examinations. Three district hospitals, two university teaching hospitals and one private hospital in the urban and rural parts of the Southern province and the capital Kigali were included. The recruitment of participants was organised by two local persons from the research team (JN and JPS) who contacted the heads of the selected health facilities and who all agreed to help with the recruitment. All available midwives working on the day of data collection were invited to participate in the FGDs. Because of the high workload at some of the health facilities, two to six participants were included in each FGD although a higher number than two was aimed for. Before initiation of the study, all participants were provided with written information about the study and a consent form to sign if they agreed to participate. A brief questionnaire about background characteristics was also provided to the participating midwives. The FGDs were held in Kinyarwanda, the national language of Rwanda, by one of the local researchers (JPS) in the CROCUS team. Two other researchers from the CROCUS team (IM and KE) attended as observers and took notes on informal communication during the FGDs. An interview guide was used to ensure that all topics of interest were included in the FGDs (Table 2). The FGDs lasted 25–45
minutes and were digitally recorded in order to be used during analyses. A total of 23 midwives participated in the study in six FGDs. Data saturation was assessed as being achieved after the sixth FGD.

**Data analysis**

An external Rwandese person transcribed the FGDs and translated the text from Kinyarwanda into English. One member of the research team (JPS) simultaneously listened to the recordings while reading the text to ensure that the transcription and translation were correct. To validate the translation, another person outside the research team back-translated parts of the English text into Kinyarwanda. This control detected some minor differences in wording, but the sense of the whole was the same. The FGDs were analysed using Qualitative manifest and latent content analysis, inspired by Graneheim and Lundman (141). The transcripts were initially read several times to get a sense of the whole. Meaning units were then identified, condensed and coded by the first author (SH). All codes were reviewed by the last author (IM) and some additional codes were included. The codes were discussed and sorted into content areas by SH and IM. Sub-categories and categories were then identified and an overall theme emerged. During the analyses, parts of the recordings were listened to again by JPS to clarify some of the participants’ statements. At the end of the analysis phase, the findings were discussed among all co-authors until consensus was reached.

**Paper II**

**Data collection and sampling**

This study applied a cross-sectional study design and data were collected through questionnaires. Participants comprised health professionals providing maternity care to pregnant women in urban and rural parts of all four provinces of Rwanda and the area of Kigali City. The health facilities were selected in order to achieve representativeness of health professionals providing maternity care at hospital level. All provincial and referral hospitals were purposively selected for the study, as well as the twelve largest private hospitals. In the next step, a statistician randomly selected four district hospitals from each province of Rwanda. To gain additional experiences, some health centres were also included in the study because most women in Rwanda give birth at health centres, although ultrasound is rarely available there. Every health centre next to each district hospital was selected, and two to three health centres in the rural areas of each province were randomly selected for inclusion in the study.
Table 3. Health facilities included in Paper II.

<table>
<thead>
<tr>
<th>Health facility level</th>
<th>No. of health facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provincial hospitals</td>
<td>4</td>
</tr>
<tr>
<td>Referral hospitals</td>
<td>7</td>
</tr>
<tr>
<td>Private hospitals</td>
<td>12</td>
</tr>
<tr>
<td>District hospitals</td>
<td>20</td>
</tr>
<tr>
<td>Health centres</td>
<td>65</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108</strong></td>
</tr>
</tbody>
</table>

A sample size of 290 obstetricians/physicians and a corresponding number of nurses/midwives working at hospital level were calculated based on the estimates of prevalence of background and outcome variables. As the topics of interest in this study are previously largely unexplored, we used the estimated outcome that required the largest sample size: Every woman should undergo ultrasound examination in pregnancy to determine gestational age and the background variable Work experience over and under 5 years. The sample size was estimated in order to detect a difference in proportion of 0.10 with a power of 80% and a significance level of 5%.

Eligible participants were obstetricians/gynecologists, other physicians, midwives and nurses working in maternity care but with different experiences of obstetric ultrasound. The inclusion criteria were either performing ultrasound examinations, using the results of examinations in clinical work, or referring pregnant women for ultrasound examinations. The local co-authors (JPS and JN) contacted the heads of the health facilities who agreed to facilitate with eligible participants on the day of the data collection. Four local data collectors, working as nurses or clinical officers and experienced in data collection procedures in the field, were trained by the research team and performed the data collection at all selected health facilities. The data collection was conducted from November 2016 to March 2017. The eligible health professionals working on the day of the data collection at each site received both verbal and written information about the study and were informed that their participation was voluntary. All participants signed a consent form and were ensured that no identifiable data would be collected. A total of 912 participants were included in the study. However, five of them worked as radiology technicians and were therefore subsequently excluded from the sample. Thus, the final sample comprised 907 participants. After the data collection, two experienced data entry clerks entered the data into SPSS. To evaluate data quality, 10% of all questionnaires with 115 variables were scanned and re-entered into SPSS by the first author (SH). The error rate was 0.7%. However, some items were not readable because of poor scan quality and the error rate could therefore theoretically vary between 0.7-2.0%.
Data analysis

For this study, 42 (N=105) questions and statements were analysed. Categorical variables were presented with numbers and proportions (n and %) and Pearson’s chi-square test was used to test the difference between variables. A p-value of <0.05 was set as statistically significant. Univariate logistic regression analyses were performed to assess patterns in opinions between the independent variables current health profession, health facilities and area of health facility and dependent variables, including different levels of agreement of statements regarding obstetric ultrasound (Table 4). The variable current health profession was categorised into four groups based on their profession and level of health facility: obstetricians/gynecologists working in hospitals (OG), other physicians working in hospitals (P), midwives/nurses working in hospitals (MNH) and nurses/midwives working in health centres (NMHC). This categorisation was made because most of the midwives were working at hospital level and most of the nurses were working at health centre level. The variable health facilities was categorised as health centres and hospitals in the analysis. The variable area of health facility was categorised as health facilities in the area of Kigali and the area outside Kigali in order to assess differences in different areas of Rwanda.

In the univariate logistic regression, the response options were dichotomized as either 0=not at all and not very much and 1=a fair amount and a great deal, or 0=disagree and strongly disagree and 1=agree and strongly agree. The univariate regression analyses were presented with odds ratios (OR) and their 95% confidence intervals (CI). For continuous variables, such as age and years in profession, mean values and standard deviations (SD) were calculated.
Table 4. Statements and questions and their response options in the questionnaire.

How often do you perform obstetric ultrasound examinations? \(^a\)

<table>
<thead>
<tr>
<th>How do you rate your skills in ultrasound in relation to the assessment/evaluation of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal presentation (^b)</td>
</tr>
<tr>
<td>Localisation of the placenta (^b)</td>
</tr>
<tr>
<td>Fetal heart rate (^b)</td>
</tr>
<tr>
<td>Amniotic fluid amount (^b)</td>
</tr>
<tr>
<td>Gestational age estimated by CRL (crown-rump length) (^b)</td>
</tr>
<tr>
<td>Gestational age estimated by biparietal diameter, femur length and abdominal diameter (^b)</td>
</tr>
<tr>
<td>Cervical length (^b)</td>
</tr>
<tr>
<td>Fetal heart: 4 chamber view (^b)</td>
</tr>
<tr>
<td>Fetal heart: aorta and pulmonary artery (^b)</td>
</tr>
<tr>
<td>Doppler: umbilical artery (^b)</td>
</tr>
</tbody>
</table>

Do you have a role in decision-making regarding clinical management on the basis of obstetric ultrasound examinations? \(^c\)

What do you believe would improve the utilisation of ultrasound at your clinic/workplace? 

<table>
<thead>
<tr>
<th>Statements on ultrasound resources and training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant women in my country have access to dating ultrasound (i.e. estimation of gestational age) (^e)</td>
</tr>
<tr>
<td>Pregnant women in my country have access to fetal anomaly screening (^e)</td>
</tr>
<tr>
<td>Pregnant women in my country have access to obstetric ultrasound independent of area of living (^e)</td>
</tr>
<tr>
<td>Pregnant women in my country have access to obstetric ultrasound independent of income (^e)</td>
</tr>
<tr>
<td>There are enough resources in my country to provide medically indicated obstetric ultrasound examinations to pregnant women who need it (^e)</td>
</tr>
<tr>
<td>At my workplace, there is always access to obstetric ultrasound when it is needed (^e)</td>
</tr>
<tr>
<td>At my workplace, lack of ultrasound training of the ultrasound operator sometimes leads to suboptimal pregnancy management (^e)</td>
</tr>
<tr>
<td>Maternity care in my country would improve if midwives were qualified to perform basic ultrasound examinations (^e)</td>
</tr>
</tbody>
</table>

Statements on the role of ultrasound in the clinical management of pregnancy

| Ultrasound is decisive in pregnancy management \(^e\) |
| Every woman should undergo ultrasound examination in pregnancy to determine gestational age \(^e\) |
| It is irresponsible of a pregnant woman to decline a dating scan \(^e\) |
| Ultrasound is safe to use for the pregnant woman and the fetus irrespective of the number of examinations \(^e\) |
| Ultrasound is important for expectant parents to bond with their fetus during pregnancy \(^e\) |

\(^a\) Response options: Never, On a daily basis, On a weekly basis, On a monthly basis, More seldom than on a monthly basis.
\(^b\) Response options: No skills, Low skill-level, Intermediate skill-level, High skill-level.
\(^c\) Response options: No, Yes a minor role, Yes a moderate role, Yes a major role.
\(^d\) Response options: Not at all, Not very much, A fair amount, A great deal, Don’t know.
\(^e\) Response options: Strongly agree, Agree, Neutral, Disagree, Strongly disagree.
Paper III

Data collection and sample

Data were collected through focus group discussions (FGDs) with midwives working in maternity care in the Hanoi area of Vietnam. Purposive sampling was used for selecting health facilities at different levels of health care and geographic area. Three hospitals were chosen: one national hospital in an urban part of Hanoi, one provincial hospital in a semi-urban part of Hanoi and one district hospital in a rural part of Hanoi. Data collection were performed at the selected hospitals over two weeks in March 2013. One of the co-authors (PTL) with local knowledge of the setting and health system contacted the heads of the department at the selected hospitals who assisted in the recruitment of participants. Midwives working on the day scheduled for the FGD were eligible to participate in the study. Potential participants were verbally informed about the study and the voluntary nature of participation. No midwife declined to participate. Before the start of each FGD, participants were encouraged to provide verbal information about their age, education and work experience as a midwife. A thematic interview guide was used as a data collection tool in the FGDs (Table 2). The co-author (PTL) moderated the FGDs in Vietnamese and two other co-authors (IM and SG) attended as observers and wrote field notes. Both IM and SG had a Vietnamese interpreter who translated the discussion in the FGDs concurrently. A Vietnamese English-speaking interpreter working as a medical doctor also participated in the FGDs. The FGDs were digitally recorded and lasted approximately 60-70 minutes. The participants received a small remuneration for the time they spent in the FGD. A total of 25 midwives participated in four FGDs, each comprising 6–7 participants. Data saturation was assessed as being achieved after the fourth FGD.

Data analysis

The data were transcribed verbatim and translated from Vietnamese into English by staff at the Hanoi Medical University. The moderator (PTL) was both proofreading the Vietnamese transcriptions and checking the quality of the translation into English while simultaneously listening to the recordings. Qualitative manifest and latent content analysis, inspired by Graneheim and Lundman (141), was used as the analysis method. The transcribed text was initially read several times by the first and the last author (SH and IM), and meaning units and codes were then identified by SH with support from IM. The codes were sorted into sub-categories and categories and the findings were discussed by SH, IM and PTL. Parts of the transcribed text in Vietnamese were read again by PTL to clarify certain parts of the English statements. At the end of the analysis phase, all authors were given a chance to discuss the findings until consensus was achieved and a final theme emerged.
Paper IV

Data collection and sampling

The fourth study used a cross-sectional study design with questionnaires directed at health professionals working in maternity care in the Hanoi area of Vietnam. Purposive sampling was used when selecting the health facilities in order to obtain a representative sample of health professionals working in maternity care. A total of 29 health facilities were included in urban, semi-urban and rural areas of Hanoi: one national hospital, one provincial hospital, 24 district hospitals and three maternity homes. Because of a lack of studies within this research area, the power calculation was based on plausible estimations of prevalence of sociodemographic characteristics and outcome variables. The outcome assessed as requiring the largest sample was: *Every woman should undergo ultrasound examination in pregnancy to determine gestational age* and the sociodemographic variable *Work experience over and under 5 years*. A sample size of 290 obstetricians/gynecologists and a corresponding number of midwives were calculated in order to detect a difference in proportion of 0.10 with a power of 80% and a significance level of 5%.

The Vietnamese co-authors (PTL and PHD) contacted the directors at the selected health facilities and they all agreed to facilitate with recruitment of participants. The aim was to include obstetricians/gynecologists, other physicians and midwives/nurses with different experiences in relation to obstetric ultrasound. Eligible participants were health professionals working at the maternity wards on the day scheduled for data collection. Four local data collectors were trained by the research team and conducted the entire data collection. The data collection was performed in April 2017. Before the start, eligible participants received both written and verbal information about the study and were informed that their participation was voluntary and anonymous. The participants signed a consent form before answering the questionnaire. No eligible health professional declined to participate in the study. The primary sample included 890 participants although 60 sonographers and six radiology technicians were excluded since they constituted a small part of the sample, and further did not contribute to clinical management of pregnant women. The final sample of 824 participants was included in the study. Data were entered into SPSS by two experienced data clerks working at Hanoi Medical University. To evaluate the quality of the entered data, every 10th questionnaire was re-entered into SPSS by the first author (SH). Data from all 107 variables in 89 questionnaires yielded a total error rate of 1.4%. The identified errors were then corrected in the SPSS file.
Data analysis

For this study, 45 (N=105) questions and statements were analysed. For categorical variables, frequency and prevalence (n and %) were used as well as Pearson’s chi-square test. The significance level was set to <0.05%. Univariate logistic regression was used for analysis of sociodemographic characteristics, i.e. independent variables, as well as different opinions related to obstetric ultrasound, i.e. dependent variables. Forward stepwise regression analysis was used in the multivariable logistic regression model. Odds ratios (OR) and their 95% confidence interval (CI) were calculated in the regression analysis. Mean values and their standard deviations (SD) were calculated for continuous variables.

For independent variables, some response options were categorised into larger groups. The variable health profession initially included the following options: obstetrician/gynecologist, general practitioner, resident physician, other type of physician, midwife, radiologist/sonographer and “other”. The groups of general practitioners, resident physicians and other type of physician (one anaesthesiologist working in maternity care) were then merged with the group of obstetricians/gynecologists. One nurse working in maternity care was categorised as a midwife. The final variable health profession included the two groups: obstetricians/gynecologists and midwives. The variable health facilities was dichotomised in the analysis into national hospital/provincial hospital and district hospital/maternity home. For the variable area of health facility, the health facilities were categorised into urban (n=7), semi-urban (n=5) and rural areas (n=17) of Hanoi. The variable number of ultrasound examinations indicated in an uncomplicated pregnancy was categorised as 3 examinations or less and 4 examinations or more, based on the Ministry of Health’s recommendation of three ultrasound examinations during a normal pregnancy. The response options for the variable role in decision-making regarding clinical management on the basis of obstetric ultrasound examinations were in some analyses dichotomised into yes and no although the original response options were: yes a minor role, yes a moderate role, yes a major role and no (Table 4). For dependent variables related to participants’ opinions of the role of and access to ultrasound, the response options disagree and strongly disagree in some analyses were merged together, as well as the response options agree and strongly agree. The statements about what could improve the utilisation of ultrasound, the response options not at all and not very much were merged together, as well as the response options a fair amount and a great deal. The response options neutral and don’t know were removed from some of the analyses.
Ethical approval and ethical considerations

Study I and Study II (Rwanda) were granted ethical approval by the University of Rwanda, College of Medicine and Health Sciences Institutional Review Board, on behalf of the Rwandan National Ethics Committee (Study I: reference 001/UR/CMHS/SPH/2015A, Study II: reference No/310/CMHS IRB/2016). Approval was also obtained from the Ministry of Health, Rwanda (Study I: reference 20/320, Study II: reference 20/5779/DGPHFIS/MPP/2016). Ethical approval for Study III and Study IV (Vietnam) was obtained from the Hanoi Medical University Review Board in Bio-Medical Research (reference 141/HMU IRB; same for both studies). All participants included in Studies I–IV were provided with information about the study, were informed that their participation was voluntary and that they could withdraw their participation at any time during the research process. The selected participants also signed a consent form before the start of all FGDs (Study I & Study III). Consent for participation was considered to be achieved when the participants agreed to respond to the questionnaire they had received (Study II and Study IV).

The research team was aware that some of the issues under study could be perceived as being ethically sensitive. In the FGDs, (Study I & Study III), it was anticipated that participants would not express their thoughts if the questions were too sensitive. However, the researchers were prepared to ensure participant integrity and respect during the FGDs. For the questionnaires, (Study II & Study IV), the participants could refuse to respond to a question if they perceived it as being too sensitive. To ensure confidentiality, all results from the FGDs (Paper I & Paper III) were presented on an aggregated level and quotations did not include any personal details. For the cross-sectional studies (Paper II & Paper IV), the questionnaires were administered and collected by the data collectors in order to protect the participants’ confidentiality. The questionnaires did not include any personal details. Instead, the questionnaires were labelled with a unique code representing each participant and a number representing each health facility. All questionnaires have been stored in a secure, lockable location at the University of Rwanda and at Hanoi Medical University.
RESULTS

The results are presented through different themes evolving from the main findings of the different studies in this thesis (Papers I–IV; Table 7).

Participant characteristics: Rwanda

In Paper I, 23 midwives participated in the study – all female. The mean age was 32.6 years (range 25–47 years). The participants reported a mean work experience of 6.5 years (range 1 month to 19 years). Two of the participants reported special training in ultrasound.

In Paper II, a total of 907 health professionals were included in the study with the following distribution: obstetricians/gynecologists 3.2%, other physicians 24.5%, midwives 29.7% and nurses 42.7%. The majority of participants were female (60.5%). The mean age was 35.0 years (range 21–68 years) and the mean work experience in the profession was 6.3 years (range 0–44 years). One third of the sample (32.3%) performed ultrasound examinations. However, almost all obstetricians/gynecologists (96.6%) and other physicians (95.9%) performed ultrasound examinations while a small number of midwives (16.4%) and nurses (2.8%) reported that they performed ultrasound examinations. A majority of ultrasound operators performed examinations on a daily basis (60.1%).

Participant characteristics: Vietnam

In Paper III, 25 midwives participated in the study – all female. The mean age was 34.4 years (range 25–47 years) and the mean work experience was 12.1 years (range 1.5–24 years). 20 midwives reported having a college education and five reported having a university education. No participants reported performing ultrasound or had received formal ultrasound training. In Paper IV, 824 health professionals were enrolled in the study: obstetricians/gynecologists 35.1% and midwives 64.9%. Most participants were female (85.1%). The mean age was 34.8 years (range 21–60 years) and the mean work experience in the profession was 10.5 years (range 0–36 years). Almost one third of the sample performed ultrasound examinations (28.1%). A majority of the obstetricians/gynecologists performed ultrasound examinations (78.9%) while only a few midwives (0.6%) reported likewise. A few participants at all levels of health care (8.3%) reported that midwives performed ultrasound examinations at their workplace. The majority of ultrasound operators performed ultrasound examinations on a daily basis (66.5%) and the mean estimated number of ultrasound examinations per day was 15.7 (range 1–100, median 10.0, SD 17.4).
The role of obstetric ultrasound in pregnancy management

Obstetric ultrasound was reported to be a very important tool in maternity care in both Rwanda and Vietnam. Midwives in Rwanda described the changes they had seen in recent decades when ultrasound became more available to healthcare services (Paper I). The midwives reported that the introduction of ultrasound in pregnancy management had decreased the number of fetal deaths and increased the number of prenatally detected fetal anomalies, e.g. fetal malformations (Paper I). The majority (95.9%) of health professionals working in maternity care in Rwanda reported that ultrasound is decisive in pregnancy management (Paper II). Most midwives and nurses working at hospitals (84.3%) and nurses and midwives working at health centres (79.9%) in Rwanda agreed or strongly agreed that all women should undergo ultrasound examination in pregnancy to determine gestational age. Most obstetricians/gynecologists (79.3%) and other physicians (80.6%) working at hospitals in Rwanda also agreed or strongly agreed with this statement. A majority of physicians (90.0%), midwives and nurses working at hospitals (78%), nurses and midwives working at health centres (72.4%) and obstetricians/gynecologists (65.5%) agreed or strongly agreed that “Ultrasound is safe to use for a pregnant woman and the fetus irrespective of the number of examinations” (Paper II).

“I believe it [ultrasound] can help me go beyond what I hear with my ear or what I can normally check based on my knowledge”. (Midwife, Study I)

In Vietnam, obstetric ultrasound was reported to be a widespread and commonly used examination for most pregnant women in the Hanoi area (Paper III & Paper IV). As reported by midwives in Rwanda, Vietnamese midwives also experienced a reduced number of babies born with anomalies that had previously been undetected before birth (Paper III). Two thirds of the Vietnamese sample of health professionals (66.2%) agreed or strongly agreed with the statement “ultrasound is decisive in pregnancy management” (Paper IV). However, obstetricians/gynecologists reported significantly lower agreement (55.7%) with this statement than midwives (71.8%; p<0.001). The majority of health professionals (87.5%; midwives 87.3% and obstetricians/gynecologists 87.8%) agreed or strongly agreed that “every woman should undergo ultrasound examination in pregnancy to determine gestational age” (Paper IV). A comparison between health professional’s views of the role of ultrasound in Rwanda and Vietnam are presented in Table 5. Analyses using Pearson’s chi-square test showed that there was a significant difference (p<0.001) in opinion between health professionals in Rwanda and Vietnam for all statements in Table 5. There was also a significant difference in opinion on the statements in Table 5 between physicians in Rwanda and Vietnam, as well as for midwives/nurses in Rwanda and Vietnam (results not presented in Paper II or Paper IV).
“Ultrasound is the leading factor for the science and advanced techniques in obstetrics”. (Midwife, Study III)

Table 5. The role of ultrasound in the clinical management of pregnancy.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Health professionals</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rwanda</td>
<td>Vietnam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total=907</td>
<td>Total=824</td>
<td></td>
</tr>
<tr>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
</tr>
</tbody>
</table>

Ultrasound is decisive in pregnancy management

- Strongly agree: 662 (73.1) 153 (18.7)
- Agree: 206 (22.8) 389 (47.5)
- Neutral: 12 (1.3) 135 (16.5)
- Disagree: 20 (2.2) 135 (16.5)
- Strongly disagree: 5 (0.6) 7 (0.9)

Every woman should undergo ultrasound examination in pregnancy to determine gestational age

- Strongly agree: 414 (45.7) 243 (29.6)
- Agree: 327 (36.1) 476 (57.9)
- Neutral: 32 (3.5) 70 (8.5)
- Disagree: 113 (12.5) 30 (3.6)
- Strongly disagree: 19 (2.1) 3 (0.4)

It is irresponsible of a pregnant woman to decline a dating scan

- Strongly agree: 298 (33.1) 203 (24.9)
- Agree: 240 (26.6) 408 (50.1)
- Neutral: 145 (16.1) 136 (16.7)
- Disagree: 161 (17.9) 60 (7.4)
- Strongly disagree: 57 (6.3) 8 (1.0)

Ultrasound is safe to use for the pregnant woman and the fetus irrespective of the number of examinations

- Strongly agree: 434 (48.0) 177 (21.7)
- Agree: 276 (30.5) 412 (50.6)
- Neutral: 111 (12.3) 121 (14.8)
- Disagree: 62 (6.9) 97 (11.9)
- Strongly disagree: 21 (2.3) 8 (1.0)

Ultrasound is important for expectant parents to bond with their fetus during pregnancy

- Strongly agree: 409 (45.2) 85 (10.4)
- Agree: 306 (33.8) 277 (33.9)
- Neutral: 102 (11.3) 230 (28.1)
- Disagree: 54 (6.0) 202 (24.7)
- Strongly disagree: 33 (3.7) 24 (2.9)
Unequal access and distribution of obstetric ultrasound resources

Access to obstetric ultrasound in Rwanda was often described as poor, especially for pregnant women living in rural areas (Paper I). Most women in Rwanda received ANC at health centres, however, ultrasound examinations were mainly performed at hospitals. Women with uncomplicated pregnancies were not referred from health centres to hospitals for an ultrasound examination unless it was included in their health insurance or if they could pay for it (Paper I).

“She [the pregnant woman] asks you ‘How can I proceed to get checked with ultrasound? …. What can we do if our health centre does not give us a transfer? We need it’. You can realise that they [pregnant women] are not happy about the fact that the [health] centre does not give them a transfer for ultrasound”. (Midwife, Paper I)

In Paper II, health professionals employed at public hospitals in Rwanda were less likely to report sufficient access to obstetric ultrasound when needed compared to health professionals employed at private hospitals (OR 0.16; 95% CI 0.07–0.37). There was also a difference in access to obstetric ultrasound between geographical areas. Health professionals at health facilities outside Kigali were less likely to report sufficient access to obstetric ultrasound when needed than those working in the Kigali area (OR 0.53; 95% CI 0.39–0.73, Paper II). Further results are presented in Figure 1.
In Vietnam, midwives reported that there was easy access to obstetric ultrasound, particularly at private clinics (Paper III). It was reported that overcrowded public hospitals was one reason for pregnant women to seek ultrasound examinations at private clinics. Pregnant women could be dealt with more quickly at private clinics and the ultrasound examinations were said to have higher imaging quality, including access to video images (Paper III).
“The ultrasound scans at private clinics are more accurate thanks to the 3D or 4D ultrasound scan techniques. The image is clearer than that in hospitals, as in hospitals only black and white ultrasound scans are available”. (Midwife, Paper III)

Midwives reported that private clinics commonly planned for further visits from pregnant women in order to increase their profits. Although the cost of ultrasound examinations was reported to be higher at private clinics than at public health facilities, the generally low cost of these examinations did not significantly impact pregnant women’s economy. Most pregnant women could afford several ultrasound examinations, although midwives recognized that women of low socio-economic status living in rural areas could not access ultrasound examinations to the same extent (Paper III). In the cross-sectional survey from Vietnam (Paper IV), most health professionals (95.6–100%), regardless of health facility level, agreed or strongly agreed with the statement “there is always access to obstetric ultrasound when needed at my workplace”. There was a difference in opinion between health professionals, where midwives were more likely to agree or strongly agree with the statement “pregnant women in the country have access to ultrasound independent of area of residence”, compared with obstetricians/gynecologists (OR 2.54; 95% CI 1.60–4.02). For the statement “pregnant women in my country have access to ultrasound independent of income”, participants in national and provincial hospitals reported significantly lower agreement than participants in district hospitals and maternity homes (OR 0.39; CI 0.27–0.58, Paper IV).

**Demand for ultrasound examination**

Rwandan midwives reported that pregnant women generally wanted more ultrasound examinations than they received (Paper I). In the sub-category “Pregnant women demand ultrasound”, it was explained that pregnant women asked for ultrasound examinations in order to become informed about fetal well-being and fetal sex. Midwives reported that information about fetal sex was often provided during an ultrasound examination as it was important to expectant parents for their preparations before birth. It was stated that some pregnant women believed they would avoid pregnancy risks if they had an ultrasound examination and that ultrasound could even be considered to be a form of treatment. It was also reported that pregnant women were not satisfied with an ANC examination at the hospital if an ultrasound was not conducted (Paper I).
“Some women take it as a routine examination, she thinks that she has to have it every time that she comes, and it is here that we as midwives have to play our role of showing them the importance of ultrasound and make them understand that having an ultrasound examination every day is not adding any value”. (Midwife, Paper I)

Pregnant women in Vietnam were commonly perceived as being very attracted to obstetric ultrasound examinations (Paper III). Pregnant women were reported to request ultrasound examinations whenever they came for ANC and this attractiveness was linked to the possibility of seeing an image of the fetus. It was also stated that ultrasound examinations made pregnant women feel secure about fetal well-being. The ultrasound image was also assessed as affecting pregnant women on a psychological level. Having repeated ultrasound examinations were also reported as a means for pregnant women to show that they really cared about their pregnancy (Paper III). Health professionals in both Rwanda (79%) and Vietnam (44.3%) also agreed or strongly agreed that ultrasound is important for expectant parents in order to bond with the fetus during pregnancy (Paper II & Paper IV).

Midwives stated that obstetric ultrasound was commonly considered to be a harmless examination by the Vietnamese community (Paper III). The general opinion was that pregnant women could choose to have as many ultrasound examinations as they wanted, particularly at private clinics. Some public hospitals had also implemented a “service area” to meet pregnant women’s demand for ultrasound examinations.

“Here [in the hospital] it is divided into two areas, one for routine checks and another for service. The service is to serve all requests of patients. But in the routine check area, they have to comply to the doctors’ recommendations”. (Midwife, Paper III)

In Paper IV, a mean number of 5.9 ultrasound examinations was reported by health professionals in Vietnam to be medically indicated during an uncomplicated pregnancy (obstetricians/gynecologists: SD 2.7, range 2–15, and midwives: SD 2.6, range 2–20). An association was demonstrated between the perception that four or more ultrasound examinations were medically indicated in an uncomplicated pregnancy and a higher level of agreement with the statement “Ultrasound is important for expectant parents to bond with the fetus during pregnancy”, compared to participants who assessed that three ultrasound examinations or less are medically indicated in a normal pregnancy (OR 1.61; 95% CI 1.03–2.50; adjusted for health profession and whether performing ultrasound or not, Paper IV). Vietnamese midwives also reported that antenatal surveillance normally included at least ten scans for a normal pregnancy.
“...the routine antenatal surveillance has at least 10 or more ultrasound scans. Apart from that, they [pregnant women] also have ultrasound scans in other clinics to know the sex of the baby”. (Midwife, Paper III)

Obstetric ultrasound in relation to other clinical examinations during pregnancy

Midwives in Rwanda reported that ultrasound was very useful in pregnancy surveillance and management. However, it was stated that ultrasound should not overshadow other clinical examinations in ANC (Paper I). The midwives felt that pregnant women relied more on ultrasound than on other examinations during pregnancy. When a Pinard horn was used, i.e. a trumpet-shaped horn to monitor fetal heart rate, participants felt that pregnant women did not trust the examination because they could not hear or see the fetal heart rate (Paper I).

“Psychologically she [the pregnant woman] feels well and knows that her child is healthy [when examined by ultrasound]. However, when we use the fetoscope [Pinard horn], they do not trust it and question its result .... They trust results provided by ultrasound”. (Midwife, Paper I)

Midwives in Vietnam explained that an ultrasound examination could provide information about the fetus that was not available through other pregnancy examinations, for example, information on fetal anomalies and fetal development (Paper III). However, midwives stressed that it was important to use obstetric ultrasound when indicated and as a complement to other examinations during pregnancy. It was reported that some pregnant women replaced ANC surveillance with ultrasound examinations and the midwives found this very troubling. Situations were described in which pregnant women had developed a serious illness or even died because of undiagnosed pre-eclampsia, a condition that could have been easily detected using routine ANC surveillance. It was reported that midwives attempted to inform pregnant women about the importance of examinations other than obstetric ultrasound, for example, checking blood pressure, blood tests and urine samples. However, factors such as long waiting times for ANC at public hospitals and pregnant women viewing ultrasound examinations as being more trustworthy than other examinations, were believed to be explanatory factors for why some pregnant Vietnamese women did not prioritise ANC. It was also reported that pregnant women who had many children, resided in rural areas, had no health insurance or only visited private clinics were at a higher risk of not receiving adequate ANC (Paper III).
“Private clinics just conduct ultrasound scans for patients, but no [pregnancy] examinations or tests. Therefore, they don’t know in what state their patients are.... In our department, some patients had surgery and died because they were in serious states of multi-organ dysfunction [upon arrival]”. (Midwife, Paper III)

“People think that ultrasound scans can replace the role of antenatal examinations”. (Midwife, Paper III)

Obstetric ultrasound skills

Midwives in Rwanda reported that neither physicians nor midwives attended formal ultrasound training (Paper I). Physicians learned to perform ultrasound examinations from their colleagues, but the midwives believed that there was also a need for physicians to undergo formal training.

“Maybe we cannot have gynecologists at all hospitals, but [ultrasound] training for doctors is needed....”. (Midwife, Paper I)

In Rwanda, the majority of participants (65%) reported that they agreed or strongly agreed with the statement “at my workplace, lack of ultrasound training of the ultrasound operator sometimes leads to suboptimal pregnancy management” (Table 4, Paper II). Approximately one third of all health professionals in Vietnam (37.1%) reported that they agreed or strongly agreed with the same statement (Paper IV). Health professionals performing ultrasound in Rwanda were asked to rate their skills in relation to different ultrasound examinations. Fetal heart rate was the examination for which most participants reported having high or intermediate level skills. However, the group of obstetricians/gynecologists and other physicians reported having a high skill level (78.2%) to a greater extent than midwives and nurses (29.1%; p<0.001). Obstetricians/gynecologists and other physicians’ self-rated skills are presented in Figure 2 (Paper II).
For all participants performing ultrasound examinations in Vietnam, fetal heart rate examination, like Rwanda, was the examination for which most participants reported a high skill level. Examination of the fetal heart: aorta and pulmonary artery was the examination for which the least number of Vietnamese participants reported a high skill level (Paper IV). Vietnamese obstetricians/gynecologists’ self-rated skills are presented in Figure 3 (Paper IV).
The initial sample of health professionals in Study IV also included the category of sonographers (n=60). However, this category was finally removed since sonographers constituted a small part of the sample, and further did not contribute to clinical management after their obstetric ultrasound examination. These results (unpublished) showed that there were no significant differences in self-reported skill level between obstetricians/gynecologists and sonographers, except for the examination of the fetal heart: aorta and pulmonary artery, and umbilical artery Doppler ultrasound, for which sonographers reported higher skill levels (p<0.001). Self-rated skills in umbilical artery Doppler examination are presented in Table 6 (results not previously presented in Papers).
Table 6. Vietnam: Univariate\textsuperscript{a} and multivariable\textsuperscript{b} logistic regression analysis for intermediate or high level self-reported skills in relation to low level self-rated skills in umbilical artery Doppler for specified background characteristics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Crude OR \textsuperscript{a} (CI 95%)</th>
<th>Model 1 \textsuperscript{b} (n=204)</th>
<th>Model 2 \textsuperscript{b} (n=204)</th>
<th>Model 3 \textsuperscript{b} (n=204)</th>
<th>Model 4 \textsuperscript{b} (n=203)</th>
</tr>
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<tbody>
<tr>
<td>Health profession</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Obstetricians/Gynecologists</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sonographers</td>
<td>3.13\textsuperscript{c} (1.43-6.87)</td>
<td>3.17 (1.42-7.06)</td>
<td>2.92 (1.27-6.68)</td>
<td>2.91 (1.27-6.67)</td>
<td>3.00 (1.29-6.97)</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>≤34</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>≥35</td>
<td>2.00 (1.10-3.64)</td>
<td>2.11 (1.14-3.90)</td>
<td>1.88 (0.99-3.59)</td>
<td>2.13 (0.56-8.10)</td>
<td>2.18 (0.57-8.37)</td>
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<td>Frequency of performing ultrasound</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>On a daily basis</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>On a weekly basis</td>
<td>0.46 (0.22-0.97)</td>
<td>0.49 (0.22-1.09)</td>
<td>0.49 (0.22-1.09)</td>
<td>0.49 (0.22-1.08)</td>
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<tr>
<td>On a monthly basis/More seldom</td>
<td>0.17 (0.07-0.40)</td>
<td>0.20 (0.08-0.47)</td>
<td>0.20 (0.08-0.47)</td>
<td>0.20 (0.08-0.48)</td>
<td></td>
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<tr>
<td>than on a monthly basis</td>
<td></td>
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<tr>
<td>Years in profession</td>
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<tr>
<td>≤8</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
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<tr>
<td>≥9</td>
<td>1.78 (0.99-3.22)</td>
<td></td>
<td></td>
<td>0.87 (0.23-3.30)</td>
<td>0.86 (0.22-3.29)</td>
</tr>
<tr>
<td>Level of health facility</td>
<td></td>
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<tr>
<td>District hospital/Maternity home</td>
<td>1</td>
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<tr>
<td>National hospital/Provincial hospital</td>
<td>1.06 (0.58-1.92)</td>
<td></td>
<td></td>
<td></td>
<td>1.18 (0.60-2.30)</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Crude odds ratio and its 95\% confidence interval
\textsuperscript{b}Adjusted odds ratio and its 95\% confidence interval
\textsuperscript{c}Bold numbers represent significance; \(p<0.05\)

Improving the utilisation of obstetric ultrasound

To improve the quality of maternity care in Rwanda, midwives argued for the provision of obstetric ultrasound at health centres (Paper I). Insufficient access to ultrasound at health centres was sometimes perceived as delaying a referral to a hospital because of unknown pregnancy complications. Midwives thought that the high workload of physicians at hospitals would probably decrease if ultrasound was available at health centres. However, it was reported that no physicians permanently worked at health centres but, instead, they saw the potential for midwives and nurses to be trained in ultrasound. Midwives reported that there was a major need for more health professionals to perform ultrasound and they suggested that it could form part of the midwives’ duties. It was stated that performing ultrasound was generally considered to be a physician’s task, although the midwives stated that maternity care would improve if midwives could learn to perform basic ultrasound examinations.

“We perceive that it is not out our job, but our wish as midwives is to be able to perform ultrasound so that we can play a role in the mother’s care and make decisions without necessarily waiting for the availability of the doctor”. (Midwife, Paper I)
“….We need training and ultrasound machines in order to help [pregnant] women in rural areas, especially those who are very far away and it is not easy for them to reach a district hospital where they can find doctors. So it would be good if there were a nurse or midwife trained in ultrasound use at the health centre level as there are no doctors at that level”. (Midwife, Paper I).

A few participants in Rwanda reported that midwives performed ultrasound at their workplace: 14.7% of midwives and nurses working at hospitals, 13.2% of physicians working at hospitals, 6.9% of obstetricians/gynecologists working at hospitals and 1.3% of nurses and midwives working at health centres (Paper II). However, the great majority of all health professionals (91.3%) agreed or strongly agreed that maternity care in Rwanda would improve if midwives were qualified to perform basic ultrasound examinations (Figure 4).

**Figure 4.** Statement from the questionnaire: Maternity care in Rwanda would improve if midwives were qualified to perform basic ultrasound examinations (N=903). Different opinions are presented with proportions (%) Paper II.
When health professionals in Rwanda were asked about what factors might improve the utilisation of ultrasound, a majority answered “a fair amount” or “a great deal” to the following suggestions: more training for health professionals currently performing ultrasound (94.5%), more physicians trained in ultrasound (92.9%) and better quality of ultrasound machines (92.2%) (dichotomised answers “not at all” or “not very much” compared with “a fair amount” or “a great deal”, Table 5, Paper II). Participants employed in public hospitals were more likely to agree that more ultrasound machines would help improve the utilisation of ultrasound than those employed at private hospitals (OR 3.25; 95% CI 1.85-5.70). Participants who did not perform ultrasound were also more likely to agree that better quality ultrasound machines (OR 1.79; 95% CI 1.08–2.95) and more midwives trained in ultrasound (OR 2.65; 95% CI 1.74-4.04) would help improve the utilisation of ultrasound in their workplace, compared with participants who performed ultrasound (Paper II).

In Vietnam, radiologists/sonographers and other physicians were mainly reported as being ultrasound operators (Paper III). Vietnamese midwives did not discuss the possibility of learning to perform ultrasound examinations to the same extent as Rwandan midwives (Papers III and I). However, a majority of Vietnamese health professionals (69%) reported that they agreed or strongly agreed with the statement “maternity care in my country would improve if midwives were qualified to perform basic ultrasound examinations” (Paper IV). Midwives were more likely to agree or strongly agree with this statement than obstetricians/gynecologists (OR 5.09; 95% CI 3.41–7.61). There was also a difference in opinions between participants working at hospitals in different geographical areas, where participants working in rural hospitals (79.6%) and semi-urban hospitals (78.3%) were more likely to agree that “maternity care in my country would improve if midwives were qualified to perform basic ultrasound examinations” than those working in urban areas (60%, Paper IV). As in Rwanda, Vietnamese health professionals also agreed that more training for health professionals currently performing ultrasound (92.8%), more physicians trained in ultrasound (93.2%) and better quality of ultrasound machines (94.0%) were the best strategies for improving the utilisation of ultrasound (the dichotomised answers “not at all” or “not very much” compared with “a fair amount” or “a great deal” are presented, Table 3, Paper IV). Obstetricians/gynecologists were more likely to agree with the statement that “more training for health professionals currently performing ultrasound would improve the utilisation of ultrasound” than midwives (OR 2.60; 95% CI 1.24–5.46) (Paper IV).
### Table 7. Overview of main results Papers I–IV.

<table>
<thead>
<tr>
<th>Results</th>
<th>Paper I</th>
<th>Paper II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus groups discussions; Rwanda</td>
<td>Cross-sectional Questionnaire Study; Rwanda</td>
</tr>
<tr>
<td>The role of obstetric ultrasound in pregnancy management</td>
<td>Important role for decreasing risks in pregnancy and improving pregnancy outcomes</td>
<td>The majority (95.9%) of participants reported that they agreed or strongly agreed that ultrasound is decisive in pregnancy management</td>
</tr>
<tr>
<td>Unequal access and distribution of obstetric ultrasound resources</td>
<td>The distribution of obstetric ultrasound services was reported to be unequal across the country and between different socio-economic groups</td>
<td>Participants employed at public health facilities were less likely to report access to obstetric ultrasound when needed compared to participants from private health facilities (OR 0.16; 95% CI 0.07–0.37)</td>
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<tr>
<td>Demand for ultrasound examination</td>
<td>Pregnant women in general were perceived as requesting more ultrasound examinations than they received</td>
<td>Participants employed at health facilities outside the Kigali area were less likely to report sufficient access to obstetric ultrasound when needed than participants employed at health facilities in the Kigali area (OR 0.53, 95% CI 0.39–0.73)</td>
</tr>
<tr>
<td>Obstetric ultrasound in relation to other clinical examinations during pregnancy</td>
<td>Although ultrasound was considered to be very useful, midwives noted that it should not overshadow other clinical examinations in ANC</td>
<td>Suboptimal pregnancy management because of lack of ultrasound training of operators was reported by the majority of health professionals (55.2%–72%)</td>
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<tr>
<td>Obstetric ultrasound skills</td>
<td>Midwives reported that neither physicians nor midwives attended formal training in ultrasound</td>
<td>Fetal heart rate was the ultrasound examination for which most health professionals reported having high or intermediate skill levels</td>
</tr>
<tr>
<td>Improving the utilisation of obstetric ultrasound</td>
<td>Providing obstetric ultrasound services at health centres was regarded as one way of improving the quality of maternity care</td>
<td>Most midwives/nurses (98.2%) and obstetricians/gynecologists/other physicians (76.8%) reported low or no skills regarding their ability to examine the fetal aorta and the fetal pulmonary artery</td>
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Insufficient access to ultrasound sometimes resulted in a delay of referral to a hospital | The majority of health professionals (91.3%) agreed or strongly agreed that “maternity care in Rwanda would improve if midwives were qualified to perform basic ultrasound examinations” |

The participants identified a major need for more health professionals to perform ultrasound examinations and suggested that it could become part of midwives’ work tasks | More training for health professionals currently performing ultrasound (94.5%), more physicians trained in ultrasound (92.9%) and better quality of ultrasound machines (92.2%) were seen as the most important factors for improving the utilisation of ultrasound |

Participants working in public hospitals were more likely to agree that more ultrasound machines would help to improve the utilisation of ultrasound in their workplace, compared with participants at private hospitals (OR 3.25; 95% CI 1.85–5.70) |  |
<table>
<thead>
<tr>
<th>Results</th>
<th>Paper III</th>
<th>Paper IV</th>
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<tr>
<td>The role of obstetric ultrasound in pregnancy management</td>
<td>A very important role in maternity care</td>
<td>Most participants (66.2%) agreed or strongly agreed that ultrasound is</td>
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<td></td>
<td>Highly valuable for determining gestational age, detecting ectopic</td>
<td>decisive in pregnancy management</td>
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<td>pregnancy and miscarriage</td>
<td>Obstetricians/gynecologists reported significantly lower agreement with</td>
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<td>Before ultrasound was introduced, it was more frequent for babies to be</td>
<td>the statement “ultrasound is decisive in pregnancy management” (65.7%)</td>
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<td></td>
<td>born with anomalies that neither health professionals nor parents</td>
<td>than midwives (71.8%; p&lt;0.001)</td>
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<td>had been aware of</td>
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<td>Unequal access and distribution of obstetric ultrasound resources</td>
<td>To meet pregnant women’s demand, some public hospitals had</td>
<td>Most participants (95.6%–100%), regardless of level of health facility,</td>
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<td>implemented a “service area” close to the ordinary ANC where pregnant</td>
<td>agreed or strongly agreed with the statement “there is always access to</td>
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<td>women could pay to receive ultrasound examinations whenever they wanted</td>
<td>obstetric ultrasound when needed at my workplace”</td>
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<td></td>
<td>Most pregnant women could afford several ultrasound examinations,</td>
<td>Midwives were more likely to agree or strongly agree that pregnant</td>
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<td>although midwives recognized that women with low socio-economic status</td>
<td>women in the country have access to ultrasound independent of area of</td>
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<td>living in rural areas could not access ultrasound examinations to the</td>
<td>residence, compared with obstetricians/gynecologists (OR 2.54; 95% CI</td>
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<td></td>
<td>same extent</td>
<td>1.60–4.02)</td>
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<td>Demand for ultrasound examination</td>
<td>Descriptions of pregnant women’s attraction to obstetric ultrasound</td>
<td>Participants in national hospitals (68.9%) and provincial hospitals (76.4%)</td>
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<td></td>
<td>were common; pregnant women were perceived as requesting ultrasound</td>
<td>reported significantly lower agreement with the statement “pregnant</td>
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<td>examinations whenever they attended ANC</td>
<td>women in my country have access to ultrasound independent of income”</td>
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<td>Midwives reported that pregnant women were having unnecessary ultrasound</td>
<td>than participants in district hospitals (67.2%) and maternity homes (68.5%)</td>
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<td></td>
<td>examinations; at least ten scans for normal pregnancies</td>
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<td>An ultrasound image was thought to affect pregnant women positively on</td>
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<td>a psychological level which, according to the midwives, explained why</td>
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<td>they wanted repeated examinations</td>
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<td>Midwives also described pregnant women worrying about their pregnancies</td>
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<td>and ultrasound examinations made them feel secure about fetal well-being</td>
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<td>Having repeated ultrasound examinations was a means for pregnant women</td>
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<td>to show that they really cared about their pregnancy</td>
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<td>Obstetric ultrasound in relation to other clinical examinations during</td>
<td>An ultrasound examination was said to provide information about the</td>
<td>A mean number of 5.9 ultrasound examinations was reported to be</td>
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<td>pregnancy</td>
<td>fetus not available through other examinations, for example, fetal</td>
<td>medically indicated during an uncomplicated pregnancy (obstetricians/</td>
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<td>anomalies and fetal development</td>
<td>gynecologists: SD 2.7, range 2–15, and midwives: SD 2.6, range 2–20)</td>
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<td>Important to use obstetric ultrasound when indicated and as a complement</td>
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<td>to other examinations</td>
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<td>Pregnant women who replaced ANC surveillance with ultrasound examinations</td>
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<td>were perceived as troubling</td>
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<td>Ultrasound examinations were reported to be viewed as more trustworthy</td>
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<td>than clinical examinations, and receiving an ultrasound examination was</td>
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<td>sometimes seen as a sufficient form of pregnancy control</td>
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<td>Obstetric ultrasound skills</td>
<td>Suboptimal pregnancy management because of lack of ultrasound training</td>
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<td>of operators was reported by approximately one third of all health</td>
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<td>professionals (37.1%)</td>
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<td>For all obstetricians/gynecologists performing ultrasound (n=227), fetal</td>
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<td>heart rate was the examination for which most participants reported a</td>
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<td>high skill level (70%)</td>
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<td>Examination of the fetal heart, aorta and pulmonary artery was the</td>
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<td>examination with the lowest proportion of self-rated high skill level</td>
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<td>(22.5%)</td>
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<td>Improving the utilisation of obstetric ultrasound</td>
<td>The majority of participants (69.0%) agreed or strongly agreed with the</td>
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<td>statement “maternity care in my country would improve if midwives were</td>
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<td>qualified to perform basic ultrasound examinations”</td>
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<td>Participants working in rural hospitals (79.6%) and semi-urban hospitals</td>
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<td>(78.3%) were more likely to agree with the previous statement than those</td>
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<td>working in urban hospitals (80.0%) (p=0.001).</td>
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<td>More training for health professionals currently performing ultrasound</td>
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<td>(92.8%), more physicians trained in ultrasound (92.3%) and better</td>
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<td>quality of ultrasound machines (94.0%), were reported as the most</td>
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<td>important factors for improving the utilisation of ultrasound</td>
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<td>Obstetricians/gynecologists were more likely to agree that “more</td>
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<td>training for health professionals currently performing ultrasound would</td>
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<td>improve the utilisation of ultrasound” compared to midwives (OR 2.60;</td>
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<td>95% CI 1.24–5.46).</td>
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DISCUSSION

Rwanda and Vietnam represent low-income and lower middle-income settings with different characteristics, cultures, religions and healthcare systems. This thesis provides new knowledge about the experiences and views of Rwandan and Vietnamese health professionals on obstetric ultrasound. Overall, obstetric ultrasound was reported to be an appreciated pregnancy surveillance tool by health professionals working in maternity care in both countries. The increasing demands of pregnant women for ultrasound examinations were described by midwives in both settings and may be considered to represent an increasing ethical dilemma in health care. Access to ultrasound was described as being very limited in some geographical areas and in health centres in Rwanda, whereas ultrasound was described as being readily available at most health facilities in the Hanoi area of Vietnam. Pregnant women in Rwanda were commonly not offered an ultrasound examination if their pregnancy was assessed as being normal, while pregnant women in Vietnam were reported to often undergo repeated ultrasound examinations, sometimes replacing ANC examinations. Vietnamese ultrasound operators reported satisfying self-reported skill-levels for different obstetric ultrasound examinations when compared with Rwandan ultrasound operators. However, ultrasound operators in both countries reported a need for additional in-service training and education on the safety aspects of ultrasound use. Training of midwives in performing basic ultrasound examinations was also considered to be a feasible solution in Rwanda for increasing pregnant women’s access to ultrasound examinations.

Should obstetric ultrasound be prioritised in low-income settings?

The reduced cost of ultrasound machines in recent years has made the provision of ultrasound feasible in some resource-poor settings. However, the benefits, trade-offs and potential drawbacks of the large-scale implementation of obstetric ultrasound in low- and middle-income countries are still being discussed (110). In Paper I, midwives in Rwanda stated that the lack of routine dating ultrasound could make it difficult to manage pregnant women as there was little information available about a pregnancy, such as gestational age, number of fetuses and localisation of the placenta. This resulted in some hospitals performing ultrasound examinations on all pregnant women in order to obtain significant additional information about a pregnancy. It has been proven that the proper measurement of gestational age supports the management of complicated pregnancies such as pre-eclampsia and preterm labour and birth. Earlier detection of pregnancy complications could lead to timely and appropriate health care (67). A Cochrane review from 2015 that included 37,505 women in high-income countries found that routine ultrasound examinations before 24 weeks of
gestation versus selective ultrasound examinations increases the detection of multiple pregnancy and improves gestational dating, which may reduce the number of inductions for post-term pregnancy. There is also some evidence that fetal abnormalities are detected earlier in pregnancy when routine ultrasound examinations are performed rather than selective ultrasound examinations. However, routine ultrasound examinations were not associated with reduced adverse outcomes for babies or use of the health service for mothers and babies (83). Although the use of ultrasound has been reported to not directly reduce maternal, perinatal or neonatal mortality in high-income countries (83, 108), it has been speculated that it may impact mortality in low-or-middle-income countries. In the 2016 WHO ANC model, one early ultrasound examination is recommended before 24 weeks of gestation. The examination can be performed either at first contact, up to 12 weeks of gestation, or at the second contact at around 20 weeks of gestation. WHO does not recommend a routine ultrasound examination after 24 weeks’ gestation for women who have already had an early ultrasound examination (66, 67), as this has been demonstrated to not provide any further benefits for the mother or baby in low-risk or unselected pregnancies (102). However, stakeholders may consider a late pregnancy ultrasound for pregnant women who have not been dated in order to identify the number of fetuses, the presentation, as well as placental location (67). The 2016 WHO ANC guidelines acknowledge that the use of early pregnancy ultrasound has not been proven to reduce perinatal mortality. However, other benefits as for example increased accuracy of gestational age assessment would assist the clinical management of suspected preterm birth and reduced labour induction for post-term pregnancies (67). A cluster randomised trial published in 2018 assessed the impact of two ultrasound examinations during ANC with standard ANC without ultrasound in five low-and middle-income countries. The trial found no increase in pregnant women’s use of ANC and rate of hospital births for pregnant women with complications. Nor did the routine use of ultrasound in ANC reduce maternal, fetal and neonatal mortality (159). This cluster randomized trial had started but had not been finalised when the 2016 WHO ANC recommendations were presented and was mentioned in the WHO ANC guidelines as contributing to further evidence of ultrasound use in rural, low-resource settings (66). Although this multicentre study does not demonstrate any health outcome improvements in the routine use of ultrasound in ANC in low-to-middle-income countries, obstetric ultrasound will probably be implemented in several countries in accordance with the 2016 WHO ANC recommendations. However, prior to implementation of routine ultrasound examinations in ANC, several measures must be taken into account, such as cost of equipment and other expenses, national policies, regulations and standards of practice, equitable access and service delivery of ANC and ultrasound for pregnant women, as well as training of ultrasound operators. In addition, reliable referral pathways are also important to outline as specialised health care will be required in the event of abnormal findings in a routine ultrasound examination (67).
Task shifting and skills among ultrasound operators

Many developing countries are experiencing an extreme shortage of ultrasound operators, such as sonographers and physicians (112). The WHO Guideline Development Group has noted that ultrasound in ANC can potentially be task shifted from sonographers and physicians at hospitals to midwives, nurses and clinical officers in rural health facilities, as long as there is appropriate training, mentoring, staffing and with a good quality referral system in place (66). With this task shifting, more pregnant women in remote areas would be able to access ultrasound and this would also serve to notify pregnant women about giving birth at appropriate health facilities in relation to their own health status and fetal health status (160). In Paper I (Rwanda), midwives stated that there was an explicit shortage of physicians in maternity care. Midwives sometimes performed emergency ultrasounds at hospitals because of the unavailability of physicians, although they had no formal ultrasound training and had not actually been appointed to perform this task. Physicians who permanently worked at health centres were described as being very rare. Midwives also reported that many pregnant women in rural areas did not have access to obstetric ultrasound as this was unavailable at the health centres where most pregnant women in Rwanda give birth. Participants saw the potential for increased access to ultrasound at health centre level if midwives could be trained to perform ultrasound examinations. Currently, there are very few midwives at health centre level as most of them are employed at district hospitals or at higher level hospitals. Several studies have concluded that it is feasible to train midwives or other health professionals without prior ultrasound training to perform basic ultrasound examinations in rural settings in Africa (112, 161, 162). In our study from Rwanda, most health professionals agreed or strongly agreed that maternity care would improve if midwives were qualified to perform basic ultrasound examinations (Paper II). It has been suggested that pre-service training for midwives or nurse/midwife students could reduce costs and may be a more sustainable option than training already employed midwives to perform ultrasound examinations (160). In the cross-sectional study from Vietnam (Paper IV), the majority of participating midwives were positive to the idea of training midwives in ultrasound. Health professionals working at rural and semi-urban hospitals in Vietnam were also more positive to the idea of training midwives to perform ultrasound examinations than participants working at urban hospitals. However, when compared with the results from Rwanda, it appears that the idea of training health professionals other than physicians to perform ultrasound is not as appreciated in Vietnam as it is in Rwanda. Another option in Rwanda for task shifting could be to train the new cadre of clinical officers to perform ultrasound examinations at rural health facilities. Clinical officers are intended to strengthen the workforce in health care, particularly at health centre level in rural areas. In neighbouring countries such as Uganda, Tanzania and Kenya, the use of clinical
In a study from Kenya, the specially trained “clinical officer-reproductive health” was found to increase access to emergency reproductive health care and played a significant role in performing caesarean sections and other obstetric and gynecological procedures (163). In Paper I (Rwanda), midwives reported that physicians almost exclusively learnt from each other in practicing ultrasound. Thus, there was a need for physicians to undergo formal ultrasound training. It has also been reported that most of the ultrasound operators in Africa are insufficiently trained (164). Our results support this finding as more than half of all participating health professionals in Paper II (Rwanda) reported that the lack of training of ultrasound operators sometimes led to suboptimal pregnancy management. More than one third of the participating health professionals in Vietnam also agreed or strongly agreed with this statement (Paper IV). Teaching and training in ultrasound are crucial as ultrasound is an operator-dependent technique (109, 164). The ISUOG education committee has proposed recommendations for formal basic ultrasound training which can be used as a framework for managers when planning ultrasound training of health professionals. The proposal for ultrasound training includes both theoretical and practical training, as well as an examination as a final step. Evidently, the time required to adequately perform an ultrasound without supervision varies. However, the ISUOG has recommended that a minimum of 100 hours of supervised scanning covering a wide range of obstetric conditions could serve as a general indication for being certified in ultrasound use (109). These recommendations are probably not feasible for compliance in low-income countries, where there is an explicit shortage of health professionals.

Pregnant women’s autonomy in health care

Since the introduction of the 2016 WHO ANC recommendations, there has been greater focus on the value that pregnant woman place on ANC. The WHO recommendations aim to empower all pregnant women to access the type of person-centred ANC they prefer and request and for health professionals to provide health care in accordance with a human rights approach (67). A review of what pregnant women want during ANC (165) informed this specific WHO recommendation. Pregnant women were reported to value having a positive pregnancy experience, including the following domains: clinical practices (tests and interventions), timely and relevant information, together with emotional and psychosocial support. Each of these domains should be provided by health professionals equipped with good clinical and interpersonal skills in a high quality health system (165). The 2016 WHO ANC recommendation of an ultrasound examination before 24 weeks of gestation emphasized that one of the aims of the ultrasound recommendation is to improve women’s pregnancy experience. Prior to an ultrasound examination, the ultrasound operator should counsel the pregnant woman on the potential limitations and benefits of the examination. The ultrasound provider should also share the results of the examination with the pregnant woman after the examination (67).
qualitative evidence synthesis from 2019 reports that pregnant women use ANC if they find it positive and that it coincides with their values and beliefs, if it is accessible, affordable, and if they are treated as individuals. Pregnant women also want to feel that they and their baby are safe and that health professionals are caring, flexible, kind, culturally sensitive and respectful. Pregnant women also want tests and treatments when necessary, as well as relevant information and advice. The findings suggest that this kind of care is also what health professionals want to provide to their patients. Further, health professionals in ANC want proper training, education, support and proper payment for their work (166).

Most people would say that “having a choice” is what all human beings want. Choice is closely linked to the individual autonomy of freedom and giving patients choices has been linked to patient’ satisfaction with health care. However, the opportunity to make a choice may not necessarily be a good thing. Patient autonomy also depends on knowledge and informed consent (167). In our studies from Vietnam, pregnant women were reported to have repeated obstetric ultrasounds and sometimes also replaced routine ANC examinations with ultrasound examinations. It is well known that ultrasound examinations are attractive to pregnant women and their families, but pregnant women often lack information about the purpose and limitations of obstetric ultrasound examinations (168). If pregnant women do not receive sufficient information to make decisions regarding what kind of health care is adequate and relevant during pregnancy, it is understandable that they may prefer repeated ultrasound examinations instead of attending routine ANC. It has also been argued that the concept of informed choice and consent is highly dependent on the surrounding context and culture and is not an independent, value-neutral decision (169). The use of technology overall in society normalises its use during pregnancy and birth. Processes and skills outside “the technology umbrella” are increasingly being seen as old-fashioned in health care, which may also marginalise pregnant women’s knowledge and health professionals’ clinical skills (169, 170). Participating midwives in Rwanda described how pregnant women did not trust other kinds of pregnancy examinations, for example, Pinards horn, as much as ultrasound examinations. Participating midwives in Vietnam also reported that having several ultrasound examinations during pregnancy could be a way for pregnant women to show that they cared a lot about the pregnancy. The trust and status of technology in maternity care have also been reported in another study from Vietnam (171). Many urban-dwelling pregnant women, particularly those who are well-off in the population, overuse technology during pregnancy and birth by having repeated ultrasound examinations, delivery at high-level health facilities and caesarean section (171). Ultrasound is also used as a common tool for sex determination and to facilitate sex-selective abortion in Vietnam (60). However, the root of this problem lies in the strong preference for sons. This strong preference in Vietnam is linked to a kinship system in which gender inequality is inherent (172). Gender-biased sex selection, to the disadvantage of female fetuses, has been considered an abuse of human rights. However, it has
been argued that prohibition of ultrasound examinations is a restriction of a woman’s reproductive right to make autonomous decisions (173).

Participating midwives in Vietnam reported that pregnant women preferred to have ultrasound examinations at private clinics because of the higher image quality. Ultrasound imaging is promoted as a joyful moment that increases the bonding between the parents and the fetus. The clarity and quality of 3D and 4D ultrasound is a selling point for ultrasound (174). The CROCUS research team (155) and other researchers (80) have previously reported that physicians in Vietnam may have a financial incentive to perform repeated ultrasound examinations as a way of increasing their own profits. Health insurance and service fees create strong incentives for health providers in Vietnam to overprovide services that can be provided faster, for example, ultrasound examinations instead of clinical examinations and caesarean section rather than waiting for a spontaneous, vaginal delivery (39). As reported in our studies and in previous studies (171), pregnant women’s exclusive use of private ANC in Vietnam is associated with inadequate ANC content. Although the vast majority of Vietnamese women receive ultrasound examinations during pregnancy (79, 171), almost half of all women in 2014 did not have their blood pressure taken, or urine and blood samples taken during their last pregnancy (54). This is of great concern as proper content of ANC is of crucial importance to the health of pregnant women and their fetuses (175). The 2016 ANC guidelines from WHO emphasise the importance of the quality of different components provided at ANC contacts. It also intends to encourage health professionals not only to prevent morbidity and mortality but also to prioritize person-centred health and well-being (67). The improved continuity of health care during pregnancy could be one way of increasing proper ANC content. Generally, continuity of health care provided by physicians is associated with lower mortality rates, increased patient satisfaction, greater adherence to medical advice, increased adaptation of health promotion and less use of hospital services (176). In Vietnam, private clinics tend to have better continuity of health care during ANC than public hospitals. However, private clinics’ continuity of care is sometimes associated with financial incentives relating to overuse of ultrasound instead of having proper ANC examinations (39). Lack of information among pregnant women is a problem in Vietnam since nearly one quarter of pregnant women do not receive health education during ANC (79). Little continuity of care combined with pregnant women’s lack of information regarding essential components of ANC could explain why some pregnant women prefer ultrasound examinations in favour of routine ANC. Midwife-led continuity models, in which the midwife is the lead professional and follows the pregnant woman from her first ANC contact until the early days of parenting, has been shown to decrease interventions during birth and increase satisfaction among women in high-income countries (177). To further improve the content of ANC and to reduce the amount of non-medical ultrasound examinations in Vietnam, a midwife-led continuity model could be an opportunity to improve maternity services.
Although it could be argued that additional ultrasound examinations may not place any major risks on pregnant women and their fetus, it could be questioned whether public health care should provide ultrasound examinations without medical indication. Some public hospitals in Vietnam were reported to have implemented a “service area” in which pregnant women could pay to receive ultrasound examinations whenever they wanted (Paper III). Overprovision of ultrasound services may be excluding other important components of ANC and also wasting human resources in an already strained health care system such as the one in Vietnam (39). Providing non-medical ultrasound examinations could perhaps be viewed as less problematic in high-income settings with greater resources, although ultrasound entails energy exposure and should not be used without adequate indications of medical benefits (95). The 2009 WHO systematic review concludes that exposure to diagnostic ultrasound during pregnancy is not associated with adverse maternal, perinatal or childhood effects. However, harmful effects may be subtle and may appear many years after exposure. Thus, the ALARA principle should be respected with the least amount of ultrasound energy over the minimum required time (94). The great majority of health professionals in both Rwanda (Paper II) and Vietnam (Paper IV) reported that they agreed or strongly agreed that ultrasound is safe to use for a pregnant woman and the fetus irrespective of the number of examinations. Health professionals in Vietnam also reported that a mean number of 5.9 ultrasound examinations could be considered medically indicated during an uncomplicated pregnancy (Paper IV). Health professionals in Vietnam appear to disagree with the Ministry of Health’s recommendation of three ultrasound examinations during a normal pregnancy as being an appropriate number of examinations. In our CROCUS Study from Norway it was also reported that 52% of the participating ultrasound operators wanted to offer more ultrasound examinations than the one recommended in the Norwegian guidelines (178) and Norwegian obstetricians reported that one to five ultrasound examinations should be routinely performed in an uncomplicated pregnancy (158). It can be assumed that many health professionals in both low and high-income countries have not been updated about the current evidence of the benefits and non-benefits of ultrasound use during pregnancy. Globally, health professionals may also need to be updated about the safety aspects of ultrasound examinations during pregnancy.

Methodological considerations

An overall strength of this thesis is the use of both qualitative and quantitative methods providing results using different methodological approaches. The FGDs and the individual interviews in the CROCUS Study were initially performed to capture a broader understanding of the research questions under study. After completion of the qualitative phase in all six countries of the CROCUS Study, the research team, with representatives from the six countries, convened and discussed the most important findings. As the topics of interest in the CROCUS Study are previously largely unexplored, we were unable to find already existing
and validated questions that would fit our research questions and the selected settings in which our research was to be undertaken. The second phase was therefore initiated by formulating a questionnaire that was almost entirely based on the main findings and issues that emanated from the qualitative studies. The same questionnaire was then used in all six countries included in the CROCUS Study in order to facilitate comparisons between the countries. The six countries have various health systems and other differing characteristics. Thus, a number of questions could then be less applicable to a specific setting. In order to increase internal validity, the questionnaire was pilot tested in the respective country with participants from different health professions. During the pilot test, the participants answered the questionnaire and were then interviewed in order to capture any misunderstandings about the questions in the questionnaire. One omission in the questionnaire content was that there was no question about whether the participant had received any formal ultrasound training. This may be considered a limitation of the study. However, in the Rwandan setting there is no additional ultrasound training available for health professionals except those who specialised as obstetricians/gynecologists. Thus, it is highly unlikely that participants other than obstetricians/gynecologists had received formal ultrasound training. The questionnaire included some potentially sensitive items relating to the participants’ professional competence and perceptions. For example, ultrasound operators were requested to assess their own competence in performing and evaluating different ultrasound examinations. In order to enable as truthful answers as possible, we chose anonymous participation. This approach made it impossible to perform a test-retest that evaluated individual consistency, although it could be argued that a test-retest may have strengthened the reliability of the study. Another strength of this thesis is that the entire research group represents multiple health professional disciplines, different genders, cultural competence relating to the investigated settings, experiences from the clinical field of a number of countries and differing research traditions. Thus, the range of experiences in the research group may have increased the trustworthiness and validity of the research.

In Paper I, i.e. the FGDs with Rwandese midwives, purposive sampling of health facilities was used to capture a broad understanding of midwives’ experiences and views on working in both rural and urban areas, as well as in health facilities of different sizes and levels of health care. Additionally, a strength of this study was that all available midwives working on the day of data collection participated. This included midwives with different kinds of experience of ultrasound and length of work experience. A possible limitation may have been the different sizes of the focus groups. In the Rwandan study, two to six midwives were included in the focus groups although a more stable number had been suggested and had been anticipated, since five to eight participants are considered to be the ideal number of participants in a focus group (179). Because of the high workload at some study sites it was not possible to include more midwives on the day planned for data collection. However, data saturation i.e. the point when new data repeat
what was previously expressed (180), was assessed to have been reached after six FGDs and the inclusion of further focus groups was therefore not needed. A possible limitation in Rwanda was that the moderator for the FGDs was a physician and not a midwife, like the participants. Because of this, the midwives could theoretically have been inhibited from fully expressing their opinions. However, the results do not indicate such a restraining situation since the midwives appeared to discuss the different issues freely. Another strength of this study was that the FGDs were held in the midwives’ native language, Kinyarwanda. The participating midwives were therefore free to express their thoughts in full. The FGDs were transcribed and translated into English, which might increase the risk of misinterpretation and the loss of some important findings. To decrease this risk, the moderator initially control read the transcriptions while simultaneously listening to the recordings. Secondly, a person independent of the research group back-translated parts of all FGDs from English into Kinyarwanda. Although some words differed, the content of the text remained intact. During the analyses, the first and last author (SH and IM) worked closely on the process of coding and performing categories and theme. The other co-authors provided additional perspectives on interpretation, which increased the trustworthiness of the findings. A possible limitation of this study may have been that nurses, who are the main health professionals to provide most maternity care in Rwanda at health centre level, were not included in this study. However, this was a well-reflected decision that was made in advance as obstetric ultrasound is not provided at health centre level, at which most nurses are employed, with a few exceptions.

In Paper II, i.e. the cross-sectional study from Rwanda, one strength is the large number of health facilities included at hospital level (n=43) corresponding to 57% of all district hospitals and 100% of all provincial and referral hospitals. The results from this study are probably representative of health professionals working at hospitals in Rwanda as all provincial and referral hospitals and 57% of all district hospitals were included in the study. Health professionals working at health centre level were also included in the study in order to collect additional experiences. However, the total sample cannot be considered to be fully representative for Rwanda as the proportion of health professionals in the study sample is much higher at hospital level than at health centre level. A possible limitation could also be the uncertainty of the required study sample size calculated in the power calculation. Because of a lack of previous studies in this research field, the power calculation was based on assumptions of the proportions of one background variable and one outcome variable. The power calculation did not include health professionals working at health centre level since ultrasounds are rarely available on this level. Another strength of this study is that no health professional invited to the study declined to participate. Such a high participation rate is uncommon in many European countries in which health examination surveys generally have a response rate of 45–66%. A significant reduction in the response rate overall has also been noted in recent decades (181). In line with our
study, the Rwanda Demographic and Health Survey (19) had a response rate of nearly 100%. The high response rates in Rwanda could be a sign that Rwandan people put great trust in authorities such as the Ministry of Health, as the country has rapidly improved in several health outcomes. The data collectors visited the selected health facilities and informed all eligible health professionals about the study, which may also have contributed to the high response rate. The use of face-to-face surveys has been reported to increase the response rate and increase participants’ tolerance of longer surveys (182). However, the high response rate may also be potentially evaluated as an expression of the authoritarianism that is a characteristic of Rwanda. Another presumed limitation is that the questionnaire was translated from English into Kinyarwanda and French. Although the questionnaire was checked several times and back-translated into English to avoid linguistic pitfalls, there may have been a risk that some questions were not identically translated in the three different questionnaires. However, the content of the questionnaires was the same.

In Paper III, i.e. the qualitative study from Vietnam, credibility was achieved through purposive sampling of midwives working at different levels of the health system, as well as in urban, semi-urban and rural areas of Hanoi. The Vietnamese co-author, who is also a physician, part of the research group and familiar with the Vietnamese healthcare system, moderated the FGDs. This contributed to the additional strength of the study. However, health professions are organised hierarchically in the Vietnamese system, which may have limited the midwives’ willingness to freely express their opinions. However, this potential limitation was not recognised since the material was assessed to be both rich in content and also included sensitive statements from the participating midwives. Continuation of data collection until saturation was achieved, as well as a thorough description of the study context and the data collection and analysis procedure, contributing to increased transferability. In order achieve dependability, notes on informal communication were made by one of the observers and an interview guide was used in the FGDs to ensure that the main topics of the study were discussed. The FGDs were transcribed and translated from Vietnamese into English. This could have been a potential limitation due to the risk of misinterpretation and losing significant content in the data. To reduce this risk, the Vietnamese moderator control read the English transcriptions and checked the Vietnamese transcriptions in case of uncertainty relating to interpretation. Finally, all co-authors discussed the preliminary findings until consensus was reached, which increased the confirmability of the result.

In Paper IV, i.e. the cross-sectional study from Vietnam, one strength was that participants were recruited from health facilities at different health levels in urban, semi-urban and rural areas of Hanoi. This contributed to increasing the representativeness of the study results. As the power calculation was based on assumptions of proportions for one background variable and one outcome variable, the required study sample might have been insufficient. However, the results of the study showed several significant associations, which indicate that
the study sample was probably adequate. Four local and experienced data collectors collected all data, which increased the strength of data collection. The research team also included two Vietnamese researchers who facilitated data collection and strengthened the interpretation of the data. One limitation might have been the translation of the questionnaire from English into Vietnamese. To reduce the risk of losing the intended meaning of statements and questions, back-translation of the questionnaire from English into Vietnamese was performed. The back-translation indicated that the content of the questions was intact although some words differed. No eligible health professional declined to participate in the study, which can be seen as a strength. Other studies in Vietnam also show high response rates, for example, the Viet Nam Multiple Indicator Cluster Survey 2014, including 9,979 households and with a response rate of 99.6% (54). However, it could be discussed whether the high response rate in Vietnam is a result of a hierarchical society in which citizens are used to complying with the directives of the authorities. An incentive provided to participants for their contribution to studies is generally recognized in Vietnam. Thus, the participants in this study were given a small sum for spending their time on answering the questionnaire. This payment could also have influenced the willingness to participate in the study.
CONCLUSIONS AND IMPLICATIONS FOR PRACTICE

A main finding from Rwanda is that obstetric ultrasound plays a very important role in surveillance during pregnancy, although Rwanda is a low-income setting. Most health professionals believed that ultrasound is decisive in pregnancy management. However, access to obstetric ultrasound was described as being unequal between urban and rural areas, between public and private health facilities, and also between different socio-economic groups. Access to obstetric ultrasound at health centres was described as being very low, as physicians rarely worked at health centre level. Participants reported that maternity care in Rwanda would improve if midwives were allowed and trained to perform ultrasound examinations, particularly at health centres. Most participants agreed with the 2016 WHO recommendation that all pregnancies should be dated through an ultrasound examination before 24 weeks of gestation. However, such a measure cannot be implemented in Rwanda at present as the number of physicians who also request formal ultrasound training is limited. Thus, there is an opportunity for the Rwandan health system to train midwives to perform basic ultrasound examinations in order to further improve the quality of maternity care. Surprisingly, most participating Rwandan health professionals agreed that obstetric ultrasound is safe, regardless of the number of examinations. Taking the ALARA principle into account, health professionals must increase their knowledge of ultrasound safety principles. Although ultrasound was mainly undertaken during pregnancy complications, healthy pregnant women were perceived as often requesting an ultrasound examination when attending ANC. The increasing demand for ultrasound examinations from pregnant women must be balanced in relation to ultrasound examinations based on medical indication, especially in a low-income country with limited financial and human resources, as well as limited access to obstetric ultrasound.

In the lower middle-income country of Vietnam, obstetric ultrasound is well integrated into maternity care. Obstetricians/gynecologists reported a satisfactory self-reported skill level regarding different ultrasound tasks. However, insufficient ultrasound training was also reported to result in suboptimal pregnancy management. Health professionals reported a mean number of 5.9 ultrasound examinations to be medically indicated during an uncomplicated pregnancy. Overall, pregnant women were perceived as undergoing more ultrasound examinations than the three examinations recommended during pregnancy by the Vietnamese Ministry of Health. Pregnant women were perceived as expressing a high level of trust in ultrasound examinations and that they sometimes might replace routine ANC contacts with ultrasound examinations. The preference for, and reliance on ultrasound surveillance in favour of medical examinations, is of concern since it may increase
the non-detection of potentially dangerous symptoms and signs in pregnant women. To further improve maternal and fetal health outcomes, pregnant women must be better informed about the purpose of adequate ANC and that repeated ultrasound examinations in a healthy pregnancy are of no benefit. Additionally, overcrowded hospitals are a well-known problem in Vietnam, and non-medical ultrasound examinations consume limited healthcare resources that need to be better allocated.

Both Rwanda and Vietnam have made remarkable improvements in health care in recent decades. Although both settings are struggling to further improve the health of pregnant women and children, there is great diversity between the countries in their challenges regarding the appropriate use of obstetric ultrasound. Rwanda needs to increase access to obstetric ultrasound. In contrast, Vietnam needs to limit its overuse of ultrasound during pregnancy for non-medical purposes. Finally, additional training for ultrasound operators appears to be a key component in both settings in order to perform high quality ultrasound examinations during pregnancy to benefit pregnant women and their fetus.
PERSPECTIVES FOR FUTURE RESEARCH

• To determine whether increased access to obstetric ultrasound by midwives at health centres in Rwanda would affect the clinical management and the number of adequate referrals to hospitals for obstetric complications

• To explore the experiences and views on ultrasound during pregnancy of nurses who provide maternal health care at health centres in Rwanda

• To explore whether a general routine ultrasound examination during the second trimester of pregnancy could result in better maternal and fetal health outcomes in Rwanda

• To investigate indications and number of ultrasound examinations that pregnant women in Vietnam undergo during an uncomplicated pregnancy

• To explore pregnant women’s views of obstetric ultrasound in both Rwanda and Vietnam
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