

A feasibility study to assess the acceptability of point of care ultrasound as an adjunct to routine scanning.

Routine Use of Focussed Point-of-Care Ultrasound in Antenatal Fetal Imaging (RUFUS-AFI)

V6.0 16/07/2026

Research Reference Numbers

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Signature Page

The undersigned confirm that the following protocol has been agreed and accepted and that the Chief Investigator agrees to conduct the study in compliance with the approved protocol and will adhere to the principles outlined in the Declaration of Helsinki, the Sponsor's SOPs, and other regulatory requirement.

I agree to ensure that the confidential information contained in this document will not be used for any other purpose other than the evaluation or conduct of the investigation without the prior written consent of the Sponsor

I also confirm that I will make the findings of the study publicly available through publication or other dissemination tools without any unnecessary delay and that an honest accurate and transparent account of the study will be given; and that any discrepancies from the study as planned in this protocol will be explained.

For and on behalf of the Study Sponsor:

Signature: Date: ...../...../.....

.....

Name (please print):

Mrs Karen Jennings-Wilding

Position:

Senior Clinical Research Governance Manager

Chief Investigator:

Signature: Date:

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Sponsor	The University of Liverpool is the research Sponsor for this Study. It is recognised that as an employee of the University the Chief Investigator has been delegated specific duties, as detailed in the Sponsorship Approval letter. For further information regarding the sponsorship conditions, please contact: Mrs Karen Jennings-Wilding Senior Clinical Research Governance Manager Sponsor@liverpool.ac.uk
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Committees	Trial Steering Committee members: Prof Asma Khalil (CI/MD Supervisor) Dr Abi Merriel (University of Liverpool) Dr Kelsey Lennox (PI)

Study Summary

Study Design	Feasibility study involving mixed methodology including quantitative and qualitative components
Study Participants	Pregnant patients
Planned Size of Sample (if applicable)	180 patients split into three cohorts 200 patients undergoing exploratory data collection 400 maternity healthcare professionals survey respondents 10-20 healthcare professionals and implementation scientists to interview
Follow up duration (if applicable)	N/A
Planned Study Period	24 months: 10/10/2025 to 10/10/2027
Research Question/Aim(s)	To assess the feasibility and acceptability of conducting a randomised controlled trial (RCT) of hand-held point-of-care ultrasound versus standard ultrasound for routine antenatal care Is antenatal point-of-care ultrasound assessment of the fetus acceptable to doctors, midwives, and allied maternity healthcare professionals as part of their routine care of patients?

Funding and Support in Kind

FUNDER(S)	**FINANCIAL AND NON-FINANCIAL SUPPORT GIVEN**
Liverpool Women's Hospital are providing the salary of Dr Lennox. This study is otherwise not funded.	The salary of Dr Lennox contributes to her providing time and PI activities

Roles and Responsibilities of Study Management Committees/Groups & Individuals

This group have jointly designed the study and will have responsibility for study management and interpretation of findings. This group is independent from the sponsor and funders.

Study Steering Groups

Study Steering Group	
Chair	Prof Asma Khalil
Member	Dr Kelsey Lennox
Member	Dr Abi Merriel

Protocol Contributors

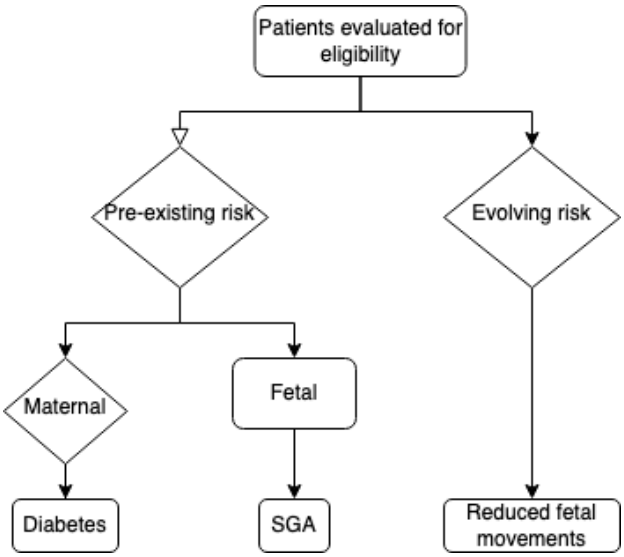
This protocol has been written by Dr Kelsey Lennox and edited by Dr Abi Merriel, Dr Angharad Care, Dr Laura Goodfellow, Dr Andrew Sharp, Prof Asma Khalil, and Dr Steven Lane. The sponsor and funder do not control the final decision regarding any of these aspects of the study.

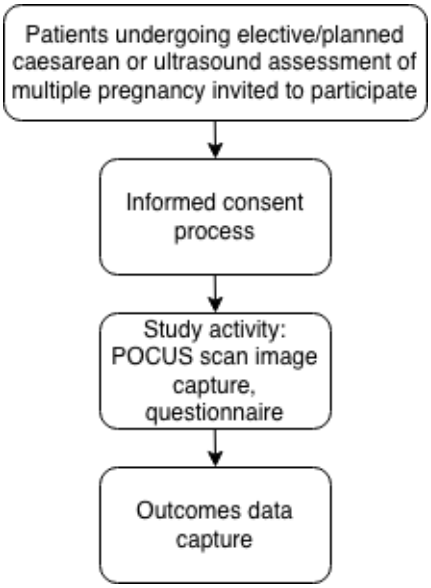
Patient and Public Involvement and Engagement

Service users and staff members have been consulted about the study concept and ultrasound device. The device is currently in use for other purposes within the trust.

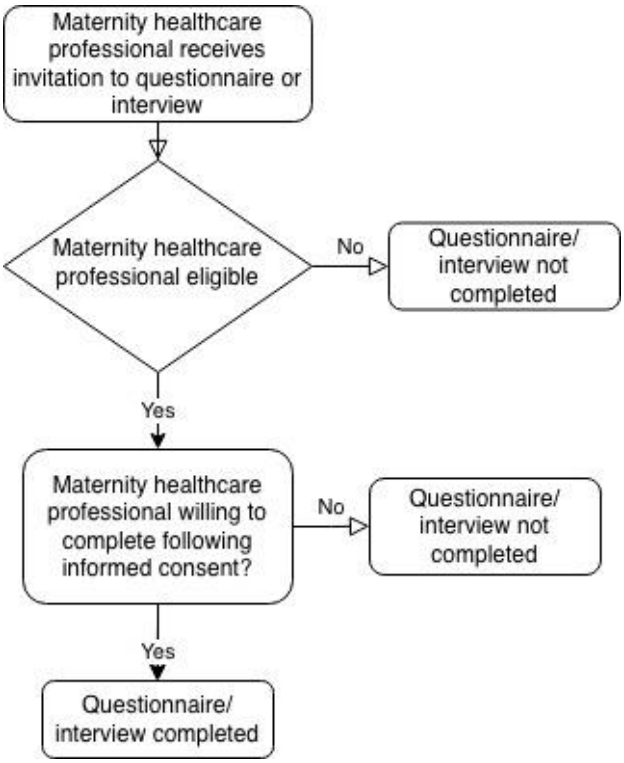
Key Words: POCUS, Antenatal fetal imaging, fetal biometry, obstetrics

Study Flow Charts – patient participants



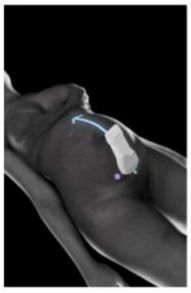


Study Flow Chart – healthcare professionals survey and interviews

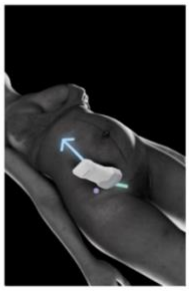


Ultrasound Sweeps

Sweep 1



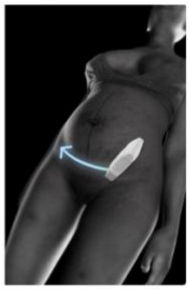
Sweep 2



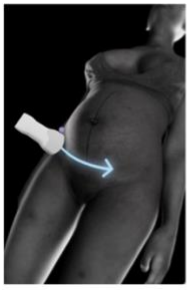
Sweep 3



Sweep 4



Sweep 5



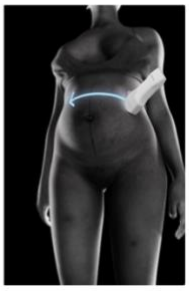
Sweep 6



Sweep 7



Sweep 8



Glossary of Abbreviations

ABBREVIATIONS	
AC	Abdominal Circumference
AE	Adverse Event
AI	Artificial Intelligence
AR	Adverse Reaction
BPD	Biparietal Diameter
CI	Chief Investigator
CRF	Case Report Form
cCTG	Computerised Cardiotocograph (Dawes-Redman analysis)
EDF	End-diastolic flow
EFW	Estimated Fetal Weight
EPR	Electronic Patient Record
FGR	Fetal Growth Restriction
FL	Femur Length
GCP	Good Clinical Practice
HC	Head Circumference
HHPUD	Hand-held portable ultrasound device
HRA	Health Research Authority
HTA	Health Technology Assessment
ICF	Informed Consent Form
ISF	Investigator Site File

LWH	Liverpool Women's Hospital
MAU	Maternity Assessment Unit
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health Research
PI	Principal Investigator
POCUS	Point of care ultrasound
REC	Research Ethics Committee
RFM	Reduced Fetal Movements
SAE	Serious Adverse Event
SFH	Symphysis-Fundal Height (measurement)
SGA	Small for Gestational Age
SSG	Study Steering Group
SUM	Standard Ultrasound Machine
UA (PI)	Umbilical Artery (Pulsatility Index)
UoL	University of Liverpool

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1. INTRODUCTION

This protocol describes the RUFUS-AFI study and provides information about procedures for entering participants, study procedures, safety reporting and governance requirements. Every care was taken in its drafting, but corrections or amendments may be necessary. These will be circulated to investigators in the Study following receipt of required approvals.

Queries relating to this Study should be referred, in the first instance, to the study PI, Dr Kelsey Lennox.

This study will adhere to the principles outlined in the UK Policy Framework for Health and Social Care Research. It will be conducted in compliance with the protocol, the Data Protection Act 2018 and the UK GDPR as amended from time to time and any successor legislation in the UK and any other directly applicable regulation relating to data protection and privacy as well as any other regulatory requirements as appropriate.

2. BACKGROUND

In 2021, the UK Government announced its goals to reduce stillbirth rates (1). This led to the promotion of the Saving Babies' Lives Care Bundle (v2 at the time), a strategy by NHS England to provide a framework of assessment and management of pregnancies by risk factor, with the aim of reducing stillbirth. One of its five key interventions is risk assessment and surveillance for fetal growth restriction (2). With the introduction of the Saving Babies' Lives Care Bundle v2 in the National Health Service (NHS), there has been an increase in the demand for antenatal ultrasound, (3) which leads to increased costs for trusts due to increased need for ultrasound machines and technicians. The total cost of implementation of the Saving Babies' Lives Care Bundle is estimated at around £27m, with ultrasound scans comprising around £9.8m of this (3).

Three million obstetric ultrasounds are performed annually in the UK, (4) representing a significant and rising cost to the health service. Standard ultrasound imaging is currently the gold-standard for diagnosing common clinical complications such as fetal malpresentation, abnormal placentation, in-utero demise, growth disorders, and abnormalities in amniotic fluid volume. Standard ultrasound imaging requires a high-specification machine, the cost of which can be around £15 000-£60 000 (5). Specialised probes may increase the cost, as well as maintenance and software updates. Due to the complexity of these machines, suitably

qualified sonographers are needed to operate them and perform the examinations. Training and retaining higher numbers of these professionals due to an increase in demand for ultrasound has associated costs.

Point-of-care ultrasound (POCUS) is an ultrasound examination performed by the clinician attending the patient that directly affects immediate management. Indications vary across specialties, but POCUS is most used in imaging-critical specialties where emergencies can be fast-paced. Obstetrics is one such specialty. POCUS has traditionally been provided through use of portable cart-based ultrasound machines, but recent developments in microtechnologies have brought about a new era of hand-held devices which fit into the clinician's pocket, increasing portability and availability.

Due to the compact design and diagnostic limitations, point-of-care ultrasound (POCUS) devices are often cheaper than a standard ultrasound, and examinations performed with them may be more time efficient as well (6). These devices are small and allow for ultrasound imaging to be performed rapidly, increasing their utility for emergency scenarios. Due to their lower cost when compared with standard ultrasound machines, there is an interest in their potential to be used for focussed routine examinations in antenatal care, such as growth scans. Following the COVID-19 pandemic, the use of hand-held devices specifically as opposed to larger cart-based models is of additional interest because their compact design makes them easier to clean between patients, reducing the risk of cross-contamination.

Point-of-care ultrasound (POCUS) examinations have been shown to be faster to perform than standard ultrasound (6). When used for focussed examinations, POCUS does not require years of specialist training. Vinayak et al. trained midwives intensively for five weeks to identify common pregnancy complications with accuracy of 99.63%(7). Shah et al. devised a brief but reliable training programme to enable emergency physicians to perform third trimester POCUS examinations quickly and reliably (8).

POCUS machines, if reliable and acceptable, could become a means of delivering focussed ultrasound in antenatal care for specific indications. Evidence by Knights et al. demonstrated that a policy of either facility-based ultrasound by sonographers or POCUS used by midwives was effective in reducing the incidence of undiagnosed breech presentations in labour and an improvement in short-term neonatal outcomes (9). Some initial data report reliability and validity of these devices, but their quality is not explicitly examined in relation to varying patient characteristics (such as maternal body mass index, uterine fibroids, or diabetes, or fetal risks such as SGA) (10-14). There has not yet been a systematic approach to assessing these devices for use in

high-risk patient groups in a routine antenatal care setting. Although a variety of approaches have been developed to bring POCUS to antenatal care settings – mostly in low- and middle- income countries (15, 16) – POCUS implementation has not been assessed in high-income settings such as the UK. It is crucial to assess potential barriers and facilitators to this technology prior to its introduction into care pathways and complements acceptability assessments.

If it is reliable to utilise POCUS devices to conduct these antenatal ultrasounds, there is potential cost-saving for trusts as well as timesaving for service users attending antenatal appointments. Additionally, development of Artificial Intelligence (AI) technologies for image analysis may reduce ultrasound measurement error, reduce the need for time- and labour-intensive care provider ultrasound training, and contribute to training by providing real-time user feedback. This is a developing area of research and is currently experimental (17, 18). This project can contribute to this area of research by providing image sets and ultrasound scan data to train and develop AI models in image analysis specific to point-of-care settings.

In this feasibility study, we aim to ascertain the acceptability and validity of POCUS in different patient groups.

3. RATIONALE FOR CURRENT STUDY

Increasing demand for ultrasound-based fetal growth surveillance is driven by the growing body of evidence implicating fetal growth restriction (FGR) and small for gestational age (SGA) as common causes of stillbirth, and a significant policy-based push toward reducing stillbirth rates at a national scale.

Patients at higher risk of FGR are identified following a risk assessment based on maternal characteristics and previous pregnancy outcomes, and are invited to undergo ultrasound assessment of fetal growth at regular intervals throughout the pregnancy (usually three to four weeks apart) (19). A cohort of these patients have risk factors that can make ultrasound assessment more challenging, including increased maternal body mass index (BMI) and diabetes leading to excess of amniotic fluid. Around one in 20 women who give birth in the UK have diabetes in pregnancy, either pre-existing or developed during the pregnancy (20). Patients with diabetes and diagnosed SGA fetuses are required to attend more frequent scan appointments to ensure the fetal growth and wellbeing remains satisfactory (every two weeks or more if FGR is suspected) (21). Point-of-care devices are attractive to NHS services as they are more affordable than standard ultrasound machines, however it is unclear at present whether this is acceptable and feasible to deliver with training and image quality.

Patients presenting to the Maternity Assessment Unit (MAU) at or after 26 weeks of gestation with concerns regarding reduced fetal movements (RFM) in pregnancy represent a group with evolving risk for FGR. These patients are routinely offered a computerised CTG (cCTG) and an ultrasound scan assessment of fetal wellbeing comprising biometry, amniotic fluid volume assessment, and umbilical artery doppler studies. In our hospital, patients presenting with RFM at 39 weeks of gestation or greater are offered delivery via induction of labour or caesarean section and will only undergo ultrasound assessment in the event they decline delivery. As such, patients at 39 weeks or greater presenting with RFM will not be approached for this study.

Pilot and feasibility studies are not limited to trials or interventional research. The aim of this study is as a preliminary assessment of the feasibility and acceptability of the Vscan for different indications across different groups. We aim to explore practical aspects such as the potential for wide-scale implementation and engagement from patients. This study will provide a guide to the design of future studies and will provide information about appropriate statistical methodologies for the development of an intervention or full-scale study.

4. THEORECTICAL FRAMEWORK

We have designed the RUFUS-AFI study in accordance with the CONSORT 2010 Statement: Extension to Randomised Pilot and Feasibility Trials (22). This guideline provides a structured framework for reporting feasibility studies, and outcomes for the study will be reported in line with the recommendations.

The Theoretical Framework of Acceptability outlines the seven component constructs used in the assessment of acceptability (23).

1. Affective attitude: How an individual feels towards the intervention
2. Burden: The amount of effort required to participate in the intervention
3. Ethicality: The extent to which an intervention has a good fit within the individual's value system
4. Perceived effectiveness: The extent to which an intervention is thought to have achieved its intended purpose
5. Intervention coherence: The extent to which an individual understands how the intervention works
6. Self-efficacy: The individual's confidence in their ability to perform the intervention
7. Opportunity costs: The benefits, profits, or values that were given up to engage in the intervention
8. General/overall acceptability

5. RESEARCH QUESTION/AIM(S)

To assess the feasibility and acceptability of conducting a randomised controlled trial (RCT) of hand-held point-of-care ultrasound versus standard ultrasound for routine antenatal care

5.1. Objectives

Feasibility objectives:

1) To determine if an RCT to assess the reliability of hand-held point-of-care ultrasound assessments in high-risk pregnancy groups is feasible

2) To determine the acceptability of hand-held POCUS to patients

3) To determine if the outcome measures are suitable to assess reliability and acceptability

4) To determine if it is possible to remain blinded to measurements while conducting the study activity

5) To determine if antenatal point-of-care ultrasound assessment of the fetus acceptable to doctors and midwives as part of their routine care of patients

Exploratory Objectives:

1) To evaluate the intraclass correlation (reliability) of hand-held POCUS for the assessment of second and third trimester fetal biometry
2) To assess the validity of hand-held POCUS in patients with different antenatal risk factors (SGA, Diabetes, and RFM)
3) To examine the efficiency of hand-held POCUS for second and third trimester assessment of fetal biometry
4) To determine the minimum sufficient sample size to detect a difference in measurements taken with POCUS versus SUM
5) To observe the maternal and neonatal clinical outcomes in included patients to determine if there is a relationship between POCUS and clinical outcomes
6) To determine if there is an association between the level of ultrasound training reported by the participant and confidence to perform antenatal point-of-care ultrasound assessments of the fetus

7) To determine what, if any, examinations of the fetus are practitioners currently comfortable providing with point-of-care ultrasound
8) To determine if there are any examinations of the fetus practitioners would not be comfortable providing with point-of-care ultrasound and why
9) To obtain a dataset of images and ultrasound scan data points for future research and development of analytical AI technology
10) To determine barriers and facilitators to POCUS implementation in maternity healthcare settings in the UK

5.2. Outcome

The primary outcomes will be the acceptability and feasibility of point-of-care ultrasound to patients. This will be assessed as:

1) The number of patients approached who agree to participate (objective 1)
2) The response rate to the questionnaire (objectives 2 and 3)
3) The number of patients willing to undergo POCUS scans in the future as determined by the questionnaire responses (objective 2)
4) The number of unblinding episodes that occur (objective 4)

The exploratory outcomes will investigate the reliability and validity of the point-of-care ultrasound device, as well as identify implementation barriers and facilitators. This will be assessed as:

1) For categorical data, Kappa coefficients demonstrating 90% agreement or greater (objectives 1 and 2)
2) For numerical data, ICC 0.9 or greater (objectives 1 and 2)
3) For continuous data (fetal biometric measurements), high level of agreement with Bland Altman, defined as ≥95% of the differences between the two measurement methods fall within the clinically acceptable range of ±3 to ±7 mm, depending on gestational age (objectives 1 and 2)
4) The difference in the mean time taken to perform each type of scan (POCUS and SUM) (objective 3)
5) The number of patients in whom fetal assessment could not be performed (objective 2)
6) Data from the feasibility study will inform the sample size calculation for the full randomized controlled trial by providing estimates of outcome variability, effect size, and recruitment parameters necessary for a power analysis (objective 4)

7) Maternal and neonatal clinical outcomes. For enrolled participants who are booked at LWH, we will extract the following routinely collected outcomes from the EPR after delivery:

    a. **Maternal:** 3rd- or 4th-degree tear; postpartum haemorrhage; shoulder dystocia; prolonged stay (>3 days); intrapartum fever; clinical chorioamnionitis; postnatal antibiotics; caesarean birth; instrumental birth; episiotomy; failed instrumental delivery; readmission.
    b. **Neonatal:** 5-min Apgar; arterial pH ≤7; neonatal trauma; NICU admission; base excess; neonatal antibiotics; meconium aspiration.

8) A list of barriers and facilitators to POCUS implementation in maternity healthcare

The outcome for the survey of healthcare professionals will be the acceptability of POCUS (exploratory objectives 6-8). We will define acceptability along a scale, from not acceptable (<25% practitioners would be happy to provide POCUS), moderately not acceptable (25-50%), acceptable (50-75%) and very acceptable (>75%) (feasibility objective 5). This will be reported per each examination indication (i.e. fetal presentation, viability, biometry etc.) (exploratory objectives 7 and 8) and level of ultrasound training (exploratory objective 6). Similarly, counts of examinations practitioners are not comfortable with performing with POCUS will be compiled. Reasons for these will be listed and ranked by proportion of responses.

Exploratory objective 10 and exploratory outcome 8 will be addressed through semi-structured qualitative interviews of maternity healthcare professionals and implementation scientists.

6. STUDY DESIGN AND METHODS OF DATA COLLECTION

This will be a feasibility study involving both qualitative and quantitative data developed in line with current guidance (24, 25). This feasibility study has been designed to establish the feasibility and acceptability of a future randomised controlled trial (RCT). It will involve pseudo-anonymised data collection from pregnant patients. This study will not involve an alteration to the standard care of enrolled patients.

Participants will undergo ultrasound with POCUS with a probe frequency of 3-5 MHz. The same probe model (Vscan Air CL, GE Voluson, available for routine clinical use for presentation scanning at LWH) will be used for all POCUS scans to limit variability in image quality. This model utilises a personal mobile device or tablet for image display and saves images which can be uploaded to a secure server. Measurements of fetal head circumference (HC), abdominal circumference (AC), and femur length (FL) will be taken with both devices and

incorporated into the Hadlock EFW calculation (26). Patients in the RFM, SGA, multiple pregnancy and Diabetes cohorts will also undergo ultrasound with a standard ultrasound machine (standard care). While performing the standard ultrasound, the PI will be blinded to the measurement value by covering the area of the screen where the measurement number appears with an opaque card. Both scans will be performed by the same sonographer (study PI) to limit inter-observer variability. The results of these scans will be examined using the statistical analysis as detailed below. Time taken to obtain measurements will be obtained for both methods and compared. Patients undergoing planned caesarean or induced labour birth will not undergo a standard ultrasound, as this is not indicated in routine clinical care, and the result of the POCUS scan will not be used to alter or influence their care in any way. While the current iteration of the Vscan Air app does not include an algorithm allowing for assessment of fetal weight for more than one fetus simultaneously, collection of cine loops from these pregnancies can help with the database development to achieve Exploratory Objective 9.

Standardised cine loop acquisition: In addition to still images, a predefined transverse abdominal sweep cine loop (duration ≤15 seconds) will be acquired during the POCUS examination using the Vscan Air CL and the device's native cine functionality. The sweep protocol (positioning, depth, gain, sweep speed) will be specified in the SOP to support reproducibility. Cine loops will be captured opportunistically during the study scan and will not alter clinical management. The additional time is anticipated to be ≤1–2 minutes per scan. Patients in the multiple pregnancy cohort will only have cine loops captured as part of the study activity.

Image/video handling: Still images and cine loops will be captured without on-screen patient identifiers; any embedded metadata containing identifiers will be removed prior to upload. Files will be stored in a pseudonymised form during the study (key held separately with restricted access) and fully anonymised at study close by destroying the linkage key after verification and QA. The resulting anonymised datasets may be retained for future ethically approved research under Sponsor governance (see Sections 11.2 and 13).

Outcomes ascertainment: For participants booked to give birth at LWH, routine maternal and neonatal outcomes will be extracted from the EPR after delivery by delegated, trained research staff. No additional visits or procedures are required. Data items are listed in Appendix 1; the timing is shown in Appendix 3.

Clinical data will also be collected. This will consist of maternal and fetal details including maternal body mass

index (BMI), antenatal risk factors, and the gestational age at the time of the scan.

Ultrasound findings and clinical measurements to be collected prospectively are illustrated in *Appendix 1.*

The qualitative component will address the primary objective and secondary objective 4. Participants will be asked to fill in an experience questionnaire following the ultrasounds. This questionnaire will evaluate their perception/satisfaction with the POCUS scan. Data for the qualitative component assessing acceptability will be obtained from the responses to the questionnaire. Participants will be provided either a paper-based or online questionnaire hosted at RedCap.

Outcomes will be summarised descriptively to guide feasibility and design of future studies. No change to clinical care or follow-up is introduced.

The survey of healthcare professionals will recruit any practicing UK healthcare professionals providing antenatal or intrapartum care for women/birthing people.

- Doctors (e.g. obstetricians)
- Nursing Staff
- Midwives / health visitors
- Allied health professionals (e.g. physician associates/ pharmacists)

Inclusion Criteria:

Any health professional providing maternity care to women/birthing people in the UK.

Exclusion Criteria:

- Healthcare practitioners who have not provided care to women/birthing people in the last 5 years
- Not providing clinical care in the UK

Sample Size and Rationale:

- We will aim for a sample size of 400 survey responses from a variety of geographical locations. This should provide us with an overview of the opinions of maternity healthcare professionals

Recruitment methods

- Recruited online through advertisement in NHS hospitals, social media and email.
- A hyperlink and QR code will be provided on the advertisement, directing participants to the survey.
- Participants will be offered the opportunity to participate in a prize draw for one of four £10 tokens.

Consent

- Potential participants will be provided with a short introduction to the study and a link to the participant information sheet and asked to consent by ticking the consent boxes before beginning the online survey, in accordance with the University of Liverpool research ethics guidance

Survey structure

The survey will be carried out using REDCap software. It will ask for demographic details (where in the country the participant is, their age, ethnic background and job role). The survey is designed to take no longer than 10 minutes to complete. (See appended staff survey).

Data Analysis

- Descriptive Statistics:
  Utilise for quantitative data captured (frequencies, percentages).
- Thematic Analysis:
  Analyse free-text responses thematically to identify common themes

Qualitative interviews of health care professionals and implementation scientists

The qualitative interviews will use semi-structured interview techniques to explore and identify barriers and facilitators to POCUS implementation in maternity care settings.

Sample

Between 10 and 20 professionals. For breadth of representation potential participants will be identified by a combination of professionals who complete the national survey and those who have been identified through literature searching of relevant publications in both POCUS studies and healthcare implementation science. A sampling frame will be developed based on purposive maximum variation sampling for representation across

groups of obstetricians, primary care clinicians, midwives, implementation scientists, and allied maternity care staff.

In-depth interviews will take place using MS TEAMS. An interview schedule has been designed specifically for the purposes of the study (see appended interview schedule). All interviews will open and close with the same question. Relevant issues emerging from the discussion that are not on the interview schedule may also be explored. Interviews will last approximately 45-60 minutes. Having provided participants with a participant information sheet, we will gain consent via an online form which can be emailed or provided in-person to participants before the interview using REDCap software. The interviews will be conducted via Microsoft Teams by the study PI. The interviews will last up to 60 minutes and be recorded and transcribed using the auto-transcribe function. The transcriptions will be checked for accuracy by the study PI. The interviews will be semi-structured and use a topic guide.

As it is not feasible for clinical staff to undertake interviews during clinical hours, interview will be conducted out of hours. A £10 thank-you voucher will be provided to each participant for their time.

In the event of a participant expressing distress during the interview, protocol will be followed as per the distress policy.

7. STUDY SETTING

This study will be a single-site study undertaken at LWH NHS Foundation Trust.

8. SAMPLE AND RECRUITMENT PARTICIPANT ENTRY

8.1 Eligibility Criteria

8.1.1 Inclusion Criteria

Pregnant patients attending Liverpool Women's Hospital for one or more of the following indications:

Routine assessment of the fetus due to maternal diabetes

Routine assessment of SGA fetus

Assessment of suspected SGA fetus on symphysis-fundal height measurement (SFH)

Reduced fetal movements

Attendance for elective (planned, category 3 or 4) caesarean birth or planned birth via induction of labour for any indication

Routine assessment of multiple pregnancy

Booked to give birth at Liverpool Women's Hospital (or receiving intrapartum/postnatal care at LWH) to enable outcomes ascertainment from the EPR.

Able and willing to provide informed written consent for participation in the study

Aged 18 years or above

8.1.2 Exclusion Criteria

- Inability to provide informed consent
- Patients who have an abnormal CTG necessitating urgent delivery, or in established preterm labour

8.2 Recruitment

8.2.1 Sample identification

We will publicise the study with posters and leaflets in the clinical waiting areas and we will encourage clinical staff interacting with these patients to offer participation in the study. Potential participants will be approached by the clinical care team about participation, and if interested and eligible, referred to the research team who also work in the clinical care team.

8.2.2 Informed Consent

The potential participant will be provided with the participant information leaflet, given time to read the leaflet and offered the opportunity to answer questions. If they wish to take part in the study, as the study is observational and will not impact their clinical care, they will be able to participate immediately. Potential participants will be offered a complimentary scan picture of their baby (position-permitting) as incentive to take part in the study.

For the survey and interview groups, having provided participants with a participant information sheet, we will gain consent via an online form which can be emailed or provided in-person to participants before the interview using REDCap software. Participant emails, where provided, will be de-linked from the consent form two weeks after the interview.

9. ADVERSE EVENTS

9.1 Definitions

Adverse Event (AE): any untoward medical occurrence in a patient or clinical study subject, including unfavourable and unintended signs, including abnormal laboratory results, symptoms or a disease associated with treatment.

Serious Adverse Event (SAE): any untoward and unexpected medical occurrence or effect that:

· Results in death

· Is life-threatening – refers to an event in which the subject was at risk of death at the time of the event; it does not refer to an event which hypothetically might have caused death if it were more severe

· Requires hospitalisation, or prolongation of existing inpatients' hospitalisation

· Results in persistent or significant disability or incapacity

· Is a congenital anomaly or birth defect

Medical judgement should be exercised in deciding whether an AE is serious in other situations. Important AEs that are not immediately life-threatening or do not result in death or hospitalisation but may jeopardise the subject or may require intervention to prevent one of the other outcomes listed in the definition above, should also be considered serious.

We do not anticipate any Adverse Events or Serious Adverse events resulting from this study due to its non-interventional nature. Ultrasound in pregnancy is safe and is used routinely. The handheld Vscan Air is used routinely at the Trust. Repeated ultrasounds in pregnancy have not been shown to be harmful to patient or fetus (27).

During routine growth scans performed for the indications given, fetal anomalies may be identified. While this is not an adverse event as its identification does not result from the study itself, any fetal anomalies identified during either the POCUS or standard ultrasound scans will be managed in accordance with LWH policy on reporting fetal anomalies and referral to the Fetal Centre for further assessment to be undertaken, if appropriate.

The risk of equipment failure is low, mainly due to the equipment being purchased within the last 24 months. Should device failure occur, an alternate device will be sought from LWH and repair requested from the manufacturer. There are multiple devices in use at the Trust for other purposes, and these are readily available the clinical research team.

9.2 REPORTING PROCEDURES

All adverse events should be reported. Depending on the nature of the event the reporting procedures below should be followed. Any questions concerning adverse event reporting should be directed to the Chief Investigator in the first instance.

9.2.1 Non-serious Adverse Events (AEs)

Adverse Events (AEs) are any untoward medical occurrence in a patient or clinical study subject, including unfavourable and unintended signs, including abnormal laboratory results, symptoms or a disease associated with treatment.

All such events, whether expected or not, will be recorded on a Case Report Form (CRF) and in the patient's medical notes.

9.2.2 **Serious Adverse Events (SAEs)**

Upon identification of an SAE the Principal Investigator should complete a study specific SAE form and sent to the Chief Investigator/Study Team within 24 hours. Relapse and death and hospitalisations for elective treatment of a pre-existing condition do not need reporting as SAEs.

Contact details for reporting SAEs

Please send SAE forms to: Professor Asma Khalil, asma.khalil@lwh.nhs.uk

Tel: 07795226291 (Mon to Fri 09.00 – 17.00)

All SAEs should be reported to the sponsor and the REC, where in the opinion of the Chief Investigator, the event was:

- 'related', i.e. resulted from the administration of any of the research procedures; and
- 'unexpected', i.e. an event that is not listed in the protocol as an expected occurrence

Reports of related and unexpected SAEs should be submitted within 15 days of the Chief Investigator becoming aware of the event, using the HRA Non-CTIMP safety report to REC form. The Chief Investigator must also notify the Sponsor of all SAEs.

For University of Liverpool Ethics Committee approved studies please refer to https://www.liverpool.ac.uk/intranet/media/livacuk/researchethics/reviewprocedures/Safety,reporting,and,adverse,events,procedure.pdf (Section - Studies which require approval from the University's Sponsorship Committee)

10. STATISTICS AND DATA ANALYSIS

10.1 Sampling

All pregnant patients attending Liverpool Women's Hospital Trust (diabetes antenatal clinic, fetal medicine unit growth clinic, maternity assessment unit with reduced fetal movements, admitted in antenatal ward with reduced fetal movements) will be considered to take part in this study.

As this is an exploratory study and no hypothesis testing is planned a formal sample size calculation has not been performed.

We will aim to include 60 patients per cohort. There will be three cohorts, so the total number of patients will be 180, and the number of scans performed 360. The sample size estimation was determined by the study team including the statistician because this is an exploratory study with a binary primary outcome (acceptable vs non-acceptable). A review of feasibility studies by Totton et al. (28) evaluated three studies of sample size estimations. The most recent of these studies was by Teare et al.(29), who recommend 60 participants per arm for feasibility studies with binary outcomes. 60 participants per cohort will generate sufficient results for

feasibility and acceptability to achieve the proposed outcomes.

This sample size will also provide sufficient data for analysis of the secondary outcomes. As these are concerned with the level of agreement between the two ultrasound modalities, we will use Bland-Altman limits of agreement. Studies using this method rarely include sample size calculations, with an average sample size of 65 (30). The overall assessment of the devices from the combined three groups will involve a total sample of 180 paired scans. Bland-Altman limits of agreement and Intraclass correlation coefficients will also be used to examine the relationship between the birthweight and ultrasound-derived estimated fetal weight of those in the planned birth cohort.

Diabetes: The Diabetes antenatal clinic at LWH runs once a week on Tuesdays and sees between 20-40 patients per week. During a six-month period, this will equate to around 750 patients.

SGA: The Growth clinics at LWH run twice a week on Mondays and Thursdays and see roughly six patients per clinic. During a six-month period, this will equate to around 300 patients.

RFM: Patients present with RFM regularly to MAU at LWH. Around four patients per day will present. In a six-month period, this will equate to around 700 patients. The PI will aim to recruit from this clinical area weekly on Fridays.

Data collection

Data will be obtained from patient records and the scans performed and recorded via a CRF. We will utilize a secure, web-based data entry system accessible at https://redcap.liverpool.ac.uk/ for recording the data. It is the responsibility of the PI to ensure the accuracy of all data entered and documented in the CRFs. Review of the data may occur at the discretion of the other members of the trial steering group.

Data will be collected from participant questionnaires undertaken on paper and transcribed into REDCap. Each response will be coded with the participant's Trial ID number.

10.2 Data Analysis

Data analysis and statistical analysis plan

Data arising from the questionnaires will be analysed in Microsoft Excel and will be reported using descriptive

summary statistics, mean, medians, and counts (i.e. “54% of participants were satisfied with the POCUS scan”).

Acceptability will be assessed using descriptive summary statistics, mean, medians, counts, and corresponding measures of variability.

Data will be analysed using R (R Core Team, 2017).

The statistical methods have been chosen in collaboration with and at the advice of a University of Liverpool statistician (Dr Lane) to ascertain agreement between the two methods of scanning (POCUS and SUM), and to enable appropriate statistical analysis of the proposed sample. Within each group we will use interclass correlation coefficients (ICC) and Spearman correlation coefficients (SCC) to check how closely the two methods agree by looking at the agreement between the paired measurements. Intraclass correlation coefficients measure how similar the measurements from the two methods are, indicating reliability or consistency for continuous variables. As the ICC approaches 1 (0.9 or greater), the greater the level of agreement. For this study, an ICC of 0.9 or greater will be considered a high level of agreement and indicate increased reliability of the Vscan device.

To assess for difference in the scan duration, the mean scan time, median and interquartile ranges will be used. We will examine for correlation between the continuous variables of BMI and scan time with both POCUS and standard ultrasound. Calculation of a correlation coefficient will be performed with Spearman’s correlation test.

Kappa coefficients measure agreement for categorical outcomes, such as assessments of fetal presentation or amniotic fluid levels. Values ≤ 0 indicate no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. These methods will be used to check for similarity within the methods (POCUS or SUM). This will ensure the measurements taken by the methods themselves are consistent.

Calculating the mean difference and 95% confidence intervals will provide estimate of any offset between two devices. Bland-Altman plots with limits of agreement will also provide a visual indication of the level of agreement between the two devices, and between the estimated fetal weight obtained by the POCUS device and the actual fetal weight at delivery in the planned birth cohort.

Clinical outcomes analysis: Maternal and neonatal outcomes will be presented descriptively (counts, percentages, means/medians as appropriate). No formal hypothesis testing is planned. Where feasible, exploratory cross-tabulations will relate outcomes to scan feasibility/quality metrics. Absence and availability of specific outcomes (e.g., cord gases) will be reported to inform future study design.

Data linkage: Outcomes will be linked using the participant Trial ID and NHS/hospital number held in the secure linkage file. At anonymisation, the linkage key will be destroyed and only anonymised analytic datasets retained.

Interview transcripts will be qualitatively analysed using thematic analysis to identify themes.

These methods evaluate both quantitative and qualitative agreement across different types of data (continuous and categorical) and aim to verify if POCUS aligns with SUM in measuring fetal parameters accurately.

Data anonymisation

Patient confidentiality will be maintained by assigning a unique personal identification number to replace any identifiable patient data when sharing study data. For instance, when a new patient is added to the study, they will be assigned a participant ID number. By utilising such identification numbers, the confidentiality of study data is preserved.

In this trial, we will manage six distinct data packages, each with specific storage and security protocols to ensure patient confidentiality and data integrity.

Package 1: Consent Forms

Package 1 consists of signed consent forms, which contain identifiable information, including the participant's name, date of birth, hospital number, NHS number, signature, and Trial ID. These forms will be stored in a locked filling cabinet within the University department at Liverpool Women's Hospital. This will be accessible only to the Study Steering Group (SSG). The secure storage ensures that participant identity is protected, and access is strictly controlled.

Package 2: Clinical Data

Package 2 consists of clinical data, including numerical measurements and descriptive information derived

from the ultrasound scans. These data will be anonymized, with each dataset associated only with the participant's Trial ID. The Trial ID will serve as a unique identifier. Package 2 will be recorded in REDCap, a secure electronic data capture system, which will effectively separate the identifiable information (from Package 1) from the clinical data (in Package 2). This separation minimizes the risk of re-linking the datasets, thereby enhancing participant privacy and ensuring compliance with data protection regulations. Following completion of data collection, the pseudonymised data will be downloaded from REDCap in CSV format and analysed in SPSS.

Package 3: POCUS ultrasound images

Package 3 consists of POCUS ultrasound images obtained for the sole purpose of the study. These are obtained on the device and will be stored on the University Active Data Store in files coded by their personal identification number only. These files will be encrypted. Following the study close, these images and cine sweeps will be fully anonymised and retained for use in future research.

Package 4: Questionnaire responses

Package 4 consists of questionnaire responses generated from REDCap in a CSV file. The responses will be linked to data from Packages 1, 2, and 3 by their participant number. The questionnaire will only be offered to RUFUS-AFI study participants.

Package 5: Healthcare professional survey responses

Package 5 consists of questionnaire responses generated from REDCap in a CSV file. Participants will not be identifiable, and their email address will only be left if they wish to receive the study results enter the prize draw. Their email will be de-linked from their response once the study closes to recruitment and their response to the study will be anonymous.

Data will be stored in REDCap prior to the anonymous data being downloaded onto a University of Liverpool Active Data Store Account for safe storage in addition to the anonymised data being on a working directory in the study's Microsoft Teams space.

Package 6: Interview transcripts

Package 6 consists of interview transcripts. These will be fully anonymised and stored in the University Active Data Store for safe storage in addition to the anonymised data being on a working directory in the study's Microsoft Teams space.

Together, these packages of data will be securely managed to maintain participant confidentiality and to facilitate accurate and efficient data analysis.

At the end of the data collection period, only the pseudonymised data obtained via the REDCAP will be transferred to a comma-separated values (CSV) file and downloaded for statistical analysis. The REDCAP will then be closed, and the data archived for at least 10 years following closure of the study.

All research data will be stored within University of Liverpool data storage infrastructure and will comply with the research data management policy researchdatamanagementpolicy.pdf (liverpool.ac.uk) All data will be password protected and accessible by the necessary members of the research team only. Data which will be used for subsequent analysis will undergo full anonymisation by decoupling of the identifiers from the data. On completion of the study, all study data including consent forms and other participant identifiable information will be stored for a minimum of 10 years. The University of Liverpool Active DataStore provides a centralised, secure, supported data storage facility for electronic data, with ongoing access for the life span of a project. This space, and its underlying technical infrastructure are fully supported by IT Services who continually review and improve security arrangements. The Active DataStore has many layers of protection, with data replicated between two secure physical locations and backed up regularly. Additionally, a regular tape backup is made to a third physical location, and segregated from the public network both physically and logically. The research data will be accessed only by named members of the research team granted password protected access to the Active DataStore by the Chief Investigator.

11.REGULATORY ISSUES

11.1 Ethics Approval

Before the start of the study, a favourable opinion will be sought from the UK Health Departments Research Ethics Service NHS REC for the study protocol, informed consent forms and other relevant documents e.g. advertisements. Health Research Authority (HRA) approval will be obtained where required.

The study will be submitted to Liverpool Women's Hospital for Confirmation of Capacity and Capability. The

study will be conducted in accordance with the recommendations for physicians involved in research on human subjects adopted by the 18th World Medical Assembly, Helsinki 1964 and later revisions.

11.2 Confidentiality

The Chief Investigator will preserve the confidentiality of participants taking part in the study and will abide by the Data Protection Act 2018 and the UK GDPR as amended from time to time and any successor legislation in the UK and any other directly applicable regulation relating to data protection and privacy.

An electronic copy of all consent forms will be saved to the University of Liverpool Active Data Store. This folder will be password protected and accessed only by nominated members of the core research team. It will be kept separate from all other study related information and data. Coded, de-personalised data will be stored on the REDCAP database during data collection. At the end of the data collection period, anonymised data obtained and stored in the REDCAP will be transferred to a comma-separated values (CSV) file and downloaded for statistical analysis. The REDCAP will then be closed, and the data archived for a minimum of 10 years following closure of the study.

Image and video data: POCUS still images and cine loops will be stored in a pseudonymised form during the study with access restricted to delegated staff. On-screen identifiers will not be recorded; metadata will be scrubbed prior to upload. At study close, the image/video datasets will be fully anonymised by destroying the linkage key after QA checks. The anonymised datasets may then be retained and used for future ethically approved research, method development, or training, under Sponsor governance and data access procedures. No identifiable information will be included in any dataset retained for future use.

Participant information and rights: The PIS/ICF inform participants that (a) we will extract routine outcomes from their records at LWH, (b) withdrawal does not affect care, and (c) data already collected up to the point of withdrawal will continue to be used to safeguard research integrity. Participants are informed that anonymised datasets (which cannot be linked back to them) may be used in future research.

11.3 Indemnity

The University of Liverpool holds Indemnity and insurance cover with Newline Insurance Company, which apply to this study.

11.4 Audits

The study may be subject to inspection and audit by the University of Liverpool under their remit as sponsor and other regulatory bodies to ensure adherence to GCP and the UK Policy Framework for Health and Social Care Research (v3.2 10th October 2017).

11.5 Independent Oversight

This study will not convene neither a Steering Committee nor an Independent Safety and Data Monitoring Committee (ISDMC) as this is a low-risk non-interventional study. Oversight will be provided by the study steering group and the Sponsor.

The study with have a study steering group that will be able to review at regular intervals all accumulating data, with the responsibility of reviewing the recruitment of participants, the collection of all essential data and to assess participant safety. Biannual meetings of an advisory group will include all members of the study steering group as well as two independent advisors (Profs David Lissauer and Andrew Weeks, University of Liverpool). The purpose of these independent advisors is to ensure adequate progress of the project in line with the proposed timeline, provide additional clinical expertise, and to address any significant concerns pertaining to its delivery. This advisory group may suggest changes to the study.

12. END OF STUDY

This study will end once the data collection is complete. After the end of study is declared no study activity, other than final report writing (following 'lock' of the study database and completion of statistical analyses), will be undertaken. As there are no formal hypotheses being tested, there are no formal stopping rules (other than safety) or mechanisms defined here to stop the study prior to the planned end of study.

12.1 Dissemination policy

The data from this study will be owned by the University of Liverpool. The findings will be shared at national and international conferences relevant to obstetricians, midwives and paediatricians, infectious disease and public health audiences. We plan to submit the work for publication in peer reviewed journals. The funders will be acknowledged on any publication, and the publication will be made open access (CC-BY) in accordance with University of Liverpool requirements.

Each participant will be asked if they would like a copy of the study findings. The protocol and final study report will be published.

If this study is prematurely discontinued (e.g., due to safety) all participants must be informed and the reason for the discontinuation should be written on the end of study form for each participant.

12.2 Authorship eligibility guidelines and any intended use of professional writers

The authors of this protocol plus any individual who subsequently makes a significant contribution will be eligible for authorship for any publications arising from this study. We will follow The International Committee of Medical Journal Editors recommendations.

13.ARCHIVING

Data and all appropriate documentation will be stored for a minimum of 10 years after the completion of the study, including the follow-up period, unless otherwise directed by the funder/sponsor/regulatory bodies. Anonymised research datasets, including anonymised image and cine-loop datasets generated at study close, may be retained beyond 10 years for future ethically approved research under Sponsor governance. Identifiable data will not be used in future studies.

14. APPENDICES

14.1 Data collection

Demographics

Parity, gestation, scan indication, pregnancy risk factors, Diabetes type, BMI, whether known SGA before the scan, presence of reduced fetal movements, ethnicity.

Measurements

POCUS (during study visit): Fetal heartbeat; presentation; MVP (liquor); HC (mm); AC (mm); FL (mm); Umbilical Artery end-diastolic flow (EDF); placental location; EFW (g); scan duration (HH:MM:SS); cine loop captured (Y/N); cine loop duration (s); sweep protocol compliance (Y/N); operator-rated image quality (Likert).

SUM: Fetal heartbeat, presentation, liquor volume (MVP), HC (mm), AC (mm), FL (mm), Umbilical Artery EDF

& PI, Placental location, EFW (g), Scan duration (HH:MM:SS).

Questionnaire: Patient experience and acceptability (paper/REDCap), coded by Trial ID.

Outcomes (post-delivery, EPR extraction):

- Maternal: 3rd- or 4th-degree tear; postpartum haemorrhage; shoulder dystocia; prolonged stay (>3 days); intrapartum fever; clinical chorioamnionitis; postnatal antibiotics; caesarean birth; instrumental birth; episiotomy; failed instrumental delivery; readmission.
- Neonatal: 5-min Apgar; arterial pH ≤7; neonatal trauma; NICU admission; base excess; neonatal antibiotics; meconium aspiration.

14.2 Appendix 2 - Required documentation

Patient information sheet

GP letter

Participant information leaflet (survey)

Survey of healthcare professionals

14.3 Appendix 3 – Schedule of Research Procedures

Procedures	Visits - 1				
	Screening	Baseline	Data collection point (no study visit required)	Study close – 12 months	24 Months
Informed consent	x	x			
Demographics		x			
Medical history		x			
Performing scans		x			
Post-scan questionnaire		x			
Outcomes (data collection only)			x		

Analysis of data				x	
Publication of results					x

14.4 Appendix 4 – Device details and particulars

Vscan Air CL G1, GE Vingmed Ultrasound AS, Strandpromenanden 45, 3191 Horten, Norway.

Serial number: VA009001765. Assembled in Austria

LWH Reference Equipment asset number: W11990

No-cost training in use of the device is available from the Royal College of Obstetricians & Gynaecologists (RCOG) at: https://elearning.rcog.org.uk/product?catalog=co_pocus

The study PI will have completed this training prior to commencement of the study.

Liverpool Women's Hospital indemnify the Vscan device for theft and loss.

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