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# Implementation of a fetal ultrasound telemedicine service: an evaluation of outcomes, women's views and family costs.

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## Research article

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# Abstract

## Background

The complexity of fetal medicine (FM) referrals that can be managed within obstetric units is dependent on the availability of specialist ultrasound expertise. Telemedicine can effectively transfer real-time ultrasound images via video-conferencing. We report the successful introduction of a fetal ultrasound telemedicine service linking a specialist fetal medicine (FM) centre and a remote obstetric unit.

## Methods

All women referred for FM consultation from the obstetric unit were seen via telemedicine, excluding cases where invasive testing or cardiac anomalies were anticipated. The image quality was rated following each consultation. Women's experiences and family costs were evaluated by a questionnaire completed following the first telemedicine appointment during the first phase of the project.

## Results

Overall, 297 women had a telemedicine consultation during Phase 1 (pilot and evaluation) and Phase 2 (embedding and adoption) of the project, which covered a four year period. There were 154 new and 143 follow-up consultations. Thirty-four women completed questionnaires during the Phase 1 of the study. Travel to the telemedicine consultation took a median time of 20 minutes (4,150), in comparison to an estimated journey of 229.8 minutes (120,450) to the FM centre. Women were generally satisfied with the service and valued the opportunity to have a FM consultation locally.

## Conclusions

We have demonstrated that a fetal ultrasound telemedicine service can be successfully introduced to provide FM ultrasound of sufficient quality to allow fetal diagnosis and specialist consultation with parents. Furthermore, the service is acceptable to parents, has shown a reduction in family costs and journey times.

## Background

Ultrasound screening and diagnosis of fetal abnormality and wellbeing is universally offered with the aim of providing parents with accurate information to inform timely intervention (1). The caseload and complexity of pregnancy complications that can be managed locally in obstetric units is largely dependent on the availability of health care professionals with the expertise required to interpret fetal ultrasound images and provide appropriate counselling (2). Women are often referred from their local

obstetric unit to a specialised fetal medicine (FM) centre (within a tertiary referral centre) when a fetal anomaly is suspected or intensive, fetal monitoring is required.

Telemedicine can be used to provide healthcare at a distance thereby overcoming challenges relating to geography and the availability of medical expertise. It has previously been used to provide FM consultations (3) and also to undertake real time fetal echocardiography (4), offering women the option to receive prenatal diagnosis and consultation with a specialist, whilst remaining in their local hospital. Providing ultrasound consultations via a telemedicine link has previously been shown to be highly acceptable to women (5). In addition, telemedicine can be used to provide ultrasound training remotely (5, 6) thereby improving obstetric sonographers' skills in diagnosing fetal anomalies and monitoring fetal wellbeing and reducing the number of cases referred to FM centres. The opportunity to reduce the quantity of face-to-face consultations is particularly relevant in the current COVID-19 pandemic situation (7).

For families living in rural areas, access to a FM centre can involve travelling long distances and incurring costs due to loss of earnings, childcare and travel. As an example, women living in parts of Cumbria, UK need to travel up to six hours to attend the FM centre in Newcastle-upon-Tyne for specialist fetal medicine opinion. Cumbria is affected by significant challenges in the provision of health care due to a predominantly rural and isolated population, (8) with some areas affected by high levels of socio-economic deprivation (9). The combination of these factors means that long journey times are frequently associated with high family costs as well as significant inconvenience for families.

There are recognised challenges to the introduction of telemedicine into routine service provision despite encouraging results from research studies (10–12). This paper reports the implementation of a successful fetal ultrasound telemedicine service, incorporating an evaluation of women's views of the service and a comparison of family costs.

## Methods

The project involved two phases:

**Phase 1** – (12 months, from October 2015 to October 2016) – The pilot and evaluation phase, included establishing the video-conferencing between the FM centre and the obstetric unit, the advanced training of sonographers and collection of participant questionnaire data. Patient experience data was collected throughout the initial 12 month, funded set-up phase (2015–2016).

**Phase 2** (36 months, from November 2016 to October 2019) – The embedding and adoption phase, which involved increasing complexity of cases and the introduction of multidisciplinary consultations.

The service was implemented at a specialist FM centre in North East England, and an obstetric unit situated in the North West of England (~ 1,200 births per annum) in October 2015. The service utilised existing 2 × 100Mbps fibre optic circuits, installed between the hospitals during the pilot phase of the

project to support another clinical service. A codec was installed at both sites together with a Cisco Video Conferencing (VC) unit at the FM centre and a Polycom Group 500 VC unit at the obstetric unit to allow the handling of high quality images using the least bandwidth. A bespoke unit including a monitor, microphone, camera and codec was assembled for use in the clinical ultrasound room. The camera position could be switched (using a remote control) between the ultrasound machine display during scans, to the woman and her family during pre- and post-scan counselling. The FM consultant and the family had a full screen view of each other when discussing the scan findings.

Information Technology (IT) support was provided by a 24-hour help desk at the FM centre and by the local IT team at the obstetric unit. The telemedicine link was available for one session (~ 3 hours) per week requiring the provision of an obstetric sonographer. A midwife was present throughout the consultation to provide support to the woman and family at the obstetric unit.

Referrals from the obstetric unit for FM opinion were assessed for telemedicine suitability by one of the FM consultants or the lead FM midwife. All appropriate cases were offered telemedicine consultation; cases were excluded from telemedicine consultation for the following reasons: (a) anticipated need for invasive diagnostic or therapeutic intervention (b) structural cardiac anomaly [due to presence of separate fetal cardiology clinics] (c) suspected facial clefts [due to the need for 3D ultrasound]. Measurement of nuchal translucency (as part of combined testing for common trisomies in twin pregnancies), previously undertaken at the FM centre, was introduced in June 2016 with scans being viewed by an experienced midwife sonographer. An information sheet, as well as verbal explanation of the process was provided to women prior to the telemedicine consultation. Standard operating procedures were issued to staff, which included guidance on the equipment set-up, patient referral and suitability assessment, consultation process and action in case of link failure.

Three experienced sonographers, each with over eight years' obstetric ultrasound experience, completed a training programme during the first four weeks of the pilot phase of the project. The sonographers familiarised themselves with the teleconferencing equipment while undertaking fetal growth scans, supported by the team at the FM centre. This provided the opportunity to test the quality and reliability of the transmitted audio and ultrasound images and to undertake training in the acquisition and interpretation of uterine artery (UAD) and middle cerebral artery (MCAD) Doppler. Sonographers at the obstetric unit did not perform UAD or MCAD prior to the implementation of the telemedicine link and women were previously referred to the FM centre if these investigations were indicated. The sonographers were provided with a pre-training manual and remote guidance via the telemedicine link from an experienced midwife sonographer based at the FM centre.

Ultrasound scans at the obstetric unit were performed ), using a Toshiba Aplio 400 ultrasound machine. During the ultrasound consultation, a FM consultant provided verbal guidance to the sonographer via the telemedicine link to ensure that the necessary images and measurements were obtained. Following the scan, the FM consultant discussed the findings and implications with the woman and her

partner/supporting person. A scan report was sent to the referring clinician via a secure email service (NHS Mail) immediately following the telemedicine consultation.

Sonographers completed a training programme during the first four weeks of the pilot phase of the project. The sonographers familiarised themselves with the teleconferencing equipment while undertaking fetal growth scans, supported by the team at the FM centre. This provided the opportunity to test the quality and reliability of the transmitted audio and ultrasound images and to undertake training in the acquisition and interpretation of uterine artery (UAD) and middle cerebral artery (MCAD) Doppler. Sonographers at the obstetric unit did not perform UAD or MCAD prior to the implementation of the telemedicine link and women were previously referred to the FM centre if these investigations were indicated. The sonographers were provided with a pre-training manual and remote guidance via the telemedicine link from an experienced midwife sonographer based at the FM centre.

All women undergoing their first telemedicine appointment during pilot of the project were invited to complete a questionnaire following their consultation. The aim was to evaluate respondent's perceptions of the experience of the consultation, including whether they felt involved in their care, knew who to contact with concerns and whether they would choose to use a telemedicine consultation in the future. The questions were based on items used in a previous study (13) and responses were recorded using a five-point Likert scale. Respondents were asked to record the actual costs incurred to attend the telemedicine appointment (for example, travel and childcare costs) and estimated costs of travel and other associated expenses to the FM centre (supplementary file 1). The FM consultants completed a Likert-scale to assess the quality of the image and audio for both the ultrasound scan and subsequent discussion following each consultation. Descriptive analysis of data was performed using SPSS version 21.0 for Windows.

## Results

During the pilot and evaluation (phase 1) and embedding and adoption (phase 2), a total of 297 consultations (ultrasound scan and counselling) were undertaken via the telemedicine link; 154 new and 143 follow-up consultations (Table 1).

Table 1  
Indication for new referrals to telemedicine service

Primary Indication	Sub-group indication	Number of new referral appointments	Number of follow-up appointments
Suspected fetal anomaly	Renal, urinary & genitalia	25	11
	Central nervous system	12	9
	Heart	2	2
	Musculoskeletal	7	0
	Thorax and diaphragm	1	8
	Abdominal wall and gastrointestinal	14	4
	Tumour	1	2
Small-for-gestational age	Singleton	12	40
Multiple pregnancy	Twin-to-twin transfusion syndrome screening and management	1	5
	Small-for-gestational age	3	2
	Combined testing	24	0
	Other e.g. single demise	0	3
Placenta	Abnormally invasive placenta screening and management	26	7
	Praevia and other (e.g. antepartum haemorrhage)	11	8
Amniotic fluid	Oligo/anhydramnios	2	2
Fetal infection		6	15
Combined testing	High risk result	1	0
Alloimmunisation		2	21
Previous history	Structural or genetic anomaly	4	6
	<b>Total</b>	<b>154</b>	<b>143</b>

Figure 1 shows the total number of new referrals from the obstetric unit and the number of those who received a consultation via telemedicine during the pilot phase.



Data from the pilot phase showed that the mean duration of telemedicine ultrasound scans was 16 minutes (SD 7.3). For all scans undertaken via the link (pilot and embedding phases), the median gestational age at the time of the consultation was 28 + 3 weeks (200 days gestation) (153–230).

Imaging and audio quality were rated highly by four FM consultants and one midwife sonographer (twin combined screening only) with an image median rating of 4 out of 5 (4–5) and the audio median rating of 5 out of 5 (5–5). There was only one case (possible abnormally invasive placenta) where the FM consultant was unable to make a definitive prenatal diagnosis due to the quality of the colour Doppler imaging. The link failed to connect three times and disconnected on three other occasions after completion of the ultrasound scan; the post scan consultation was undertaken by telephone.

### **Patient evaluation of the service**

Questionnaires were completed by 34/40 (85%) women following their first telemedicine consultation during the pilot phase. Table 2 shows the demographic characteristics of the respondents.

**Table 2: Demographic information**

<b>Participant characteristics</b>	<b>Survey (%) n=34</b>
<b>Age</b>	
16-25	9 (26.6)
26-35	16 (55.9)
35+	6 (17.6)
<b>Education</b>	
No formal qualifications	4(11.8)
GCSE	6 (17.6)
A Level	2 (5.9)
Vocational	14 (41.2)
Undergraduate	6 (17.6)
Postgraduate	2 (5.9)

Overall, women expressed high levels of satisfaction with the telemedicine consultation (Table 3). Only two women returned responses of ‘Strongly Disagree’, one in relation to the quality of the ultrasound image and another to the question of whether she would be willing to use telemedicine to monitor her baby’s health in the future.

**Table 3: Patient evaluation of telemedicine consultation (Likert scores)**

Questionnaire items	Mean Likert score/5 (SD)	% patients agreed or strongly agreed
I was satisfied with the picture quality	4.71 (0.78)	96.7
I was satisfied with the sound quality	4.84 (0.37)	100
I was satisfied with my discussion with the doctor after the scan.	4.90 (0.30)	100
I was able to talk about my concerns openly	4.87 (0.34)	100
I know who to contact with any questions	4.77 (0.50)	97.1
I was involved as much as I wanted to be in decisions about what happens next	4.87 (0.43)	96.7
After the consultation, I have a good understanding of the next steps in my care	4.90 (0.30)	100
I was satisfied with the quality of care received overall	4.90 (0.30)	100
I would be willing to use telemedicine to monitor my baby's health in the future	4.84 (0.73)	96.7

## Journey times and costs

The majority of women (28 [82.3%]) travelled to attend the telemedicine consultation at the obstetric unit by car, the remainder by public transport. The median travel time to the obstetric unit was 20 minutes (4,150) in comparison to an estimated median journey of 229.8 minutes (120, 450) to the FM centre. The additional costs that would have been incurred by respondents if they had travelled to the FM centre included leave from paid employment (n=16, 47%), childcare costs (n=8, 23.5%) and partner taking time off paid employment (n=25, 73.5%).

## Discussion

### 1. Summary of results

The project demonstrated that a fetal ultrasound telemedicine service can be successfully implemented in the UK NHS between a remote obstetric unit and a FM centre to provide women with high quality FM consultation and reduce the need for travel. The transfer of ultrasound images is reliable and of sufficiently high quality to achieve fetal diagnosis and consultation in almost all cases.

### Indications for telemedicine

The telemedicine link was effectively utilised to provide ultrasound prenatal diagnosis when a fetal anomaly was suspected and for monitoring the wellbeing of fetuses at risk of compromise, including pregnancies affected by preterm small-for gestational age, preterm premature rupture of membranes, twin-to-twin transfusion syndrome and red cell alloimmunisation. The link was particularly beneficial to parents requiring regular monitoring where multiple journeys to the specialist centre would have otherwise been necessary.

Women were excluded from a telemedicine consultation if there was a suspected fetal cardiac anomaly because of an existing, separate fetal cardiology service. Previous studies have shown that fetal cardiology by telemedicine is achievable (4, 14-16) and the telemedicine service could be extended to include such cases in the future. This would require additional training for sonographers and the availability of one of the fetal cardiology team.

It has been previously stated that telemedicine has the potential to increase the number of consultant referrals (17). It is our experience that sonographers and obstetricians at the obstetric unit are more likely to refer patients for FM review when they are unsure of the diagnosis (rather than repeat a scan themselves). However, the telemedicine link also offers the opportunity for obstetricians and sonographers to discuss uncertainties around ultrasound findings or management of care directly with a specialist consultant, thereby reducing inappropriate referrals. This was also a finding in a previous study of fetal telemedicine (3).

## **2. Benefits to women and acceptability**

Women valued the opportunity to receive specialist FM expertise by telemedicine and expressed high levels of satisfaction with the service. These findings are consistent with the findings of previous studies, which showed high levels of patient satisfaction and confidence with telemedicine consultations (3, 5, 13, 18). The majority of women stated that they would be willing to use the telemedicine service again. Feedback from local staff indicated that some women specifically requested a telemedicine consultation, a finding reported in a previous study (5). A detailed discussion of the findings from semi-structured interviews undertaken with stakeholders and women who had telemedicine consultations is reported in a separate paper (19). Total travel times were reduced by more than two and a half hours in comparison to journeys that would be required to a FM centre and costs to attend the telemedicine appointments were lower than estimated costs for attendance at the FM centre.

The value of a fetal ultrasound telemedicine service is highlighted further by the current COVID-19 pandemic(20); the use of telemedicine reduces the need for face-to face visits while maintaining access to FM consultations, as recommended by current guidance (21). The pandemic situation has emphasised the opportunities that telemedicine offers when travel needs to be minimised while continuing to provide fetal diagnosis (22).

## **3. Challenges of establishing the service**

Difficulties were encountered during the initial stages of the project in establishing a reliable teleconferencing link. Prior attempts to utilise an existing Internet-based video conferencing infrastructure (based on N3 [Wide Area IP Network] and Integrated Services Digital Network (ISDN) telephone lines) were unsuccessful; a connection capable of achieving high quality real-time image transfer was not possible using N3 and direct internet access was unsuccessful as a result of existing firewalls.

There were significant challenges for stakeholders responsible for managing staff in the obstetric unit; managers expressed concerns relating to the increased need for sonography and midwifery staff time to support the telemedicine clinic. This was counterbalanced by the opportunity to increase sonographer skill levels and to substantially reduce travel and associated costs for women and families.

Sonographers expressed worries about their clinical ultrasound practice being observed by the fetal medicine consultant during consultations and being unable to achieve the images required (19). There was also a need to ensure that there was IT support at both the obstetric unit and FM centre in case of technical problems with the link or equipment. These concerns were overcome through extended engagement with clinical staff, senior managers and IT managers at both sites for 12 months prior to the pilot phase of the project and throughout the embedding phase. The training undertaken with sonographers was fundamental to ensuring that they were confident in their ultrasound skills and use of the telemedicine equipment. Previous studies have shown that successful engagement with clinicians and other stakeholders is a significant factor in the success of telemedicine services, particularly beyond the initial set-up period (12, 23, 24).

### **Limitations of study**

The findings are limited by the relatively small number of referrals from a single, small obstetric unit. It is difficult therefore to determine whether the findings are generalisable to other obstetric units and a broader range of clinical specialities. The project was designed to evaluate the implementation and adoption of a fetal telemedicine service but does not provide data on the accuracy of prenatal diagnosis by telemedicine and does not seek to compare telemedicine and non-telemedicine image quality.

## **Conclusions**

Telemedicine provides a reliable and feasible option for the delivery of FM consultations to women in a small obstetric unit without the need to travel to a FM centre. The service is valued by women and staff and reduces family costs. There is clear scope to develop the use of the telemedicine link within the provision of specialist maternity, neonatal and paediatric care, which would have significant benefits for families, particularly during a pandemic situation. Future work will focus on extending the provision to neighbouring obstetric units and to other clinical specialities, particularly in areas where there are challenges to sustaining clinical expertise.

## **Abbreviations**

AHSN - Academic Health Science Network

FM – Fetal Medicine

MCAD – Middle cerebral artery Doppler

OSATS – Objective Structured Assessment of Technical Skill

UAD – Uterine Artery Doppler

VC – Video Conferencing

## **Declarations**

## **Ethics approval and consent to participate**

Ethical approval was granted by the NHS National Research Ethics Service, NRES Committee London-Hampstead (REC reference: 14/LO/1671).

## **Consent for publication**

Not applicable.

### **Availability of data and materials**

The dataset used in the present study is available from the corresponding author upon reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

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Phase 1 of the project was funded by the Academic Health Science Network (AHSN), North East and North Cumbria. The funding body was not involved in the design of the study, data collection, analysis and writing of the manuscript.

## **Authors' contributions**

All authors were involved in design of the study. SCR, AM, and VS were the Project Leads. ML and VS conducted the data collection and performed the data analyses. VS wrote the first draft of the manuscript; SCR, ML, EB, EvO and BB reviewed, edited and contributed to subsequent drafts. All authors have approved the final manuscript.

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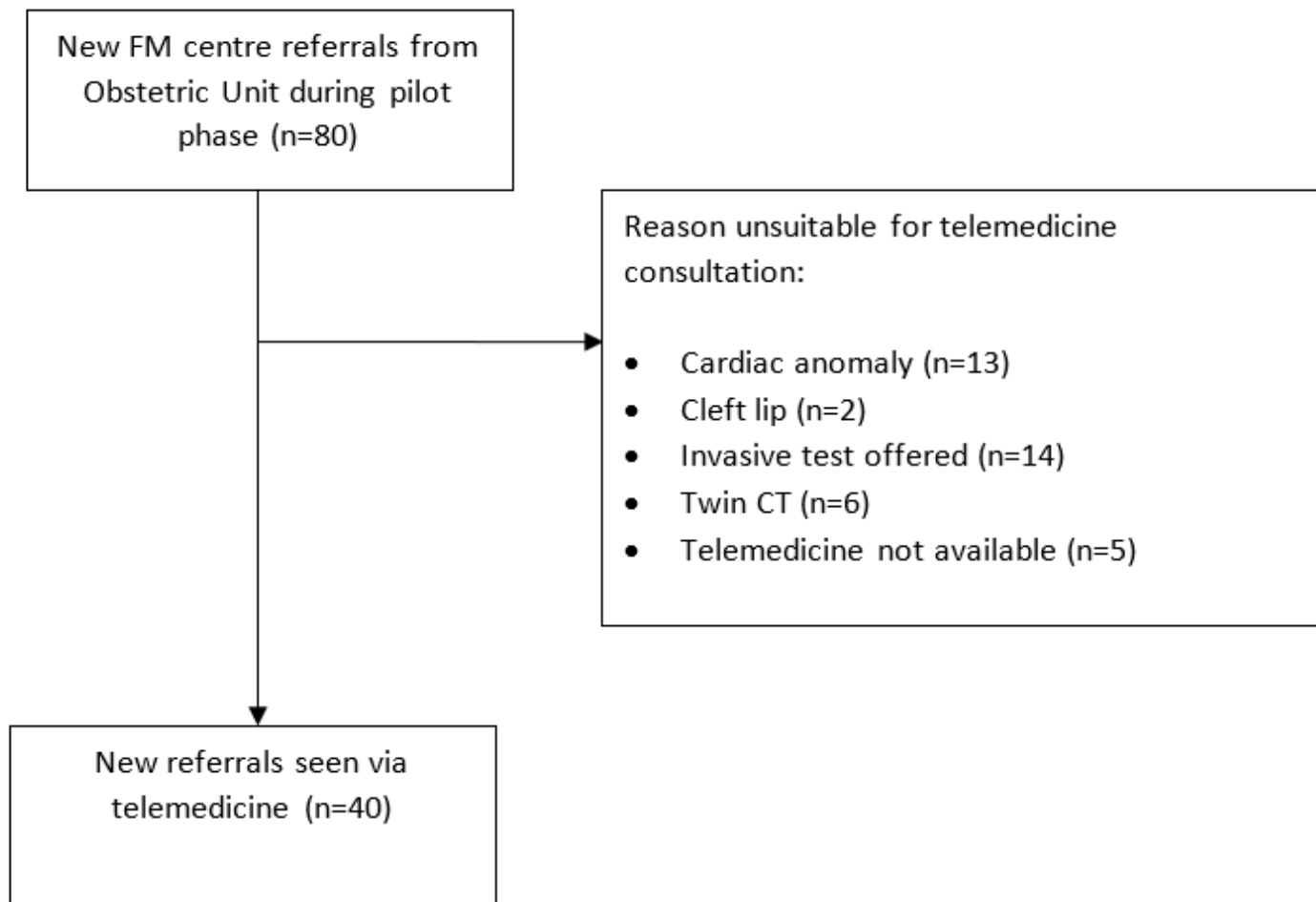
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## Figures



**Figure 1**

Telemedicine referrals

## Supplementary Files

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