ORIGINAL ARTICLE

Professionals’ views of fetal-monitoring support the development of devices to provide objective longer-term assessment of fetal wellbeing

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Abstract

Objective: Continuous longer-term fetal monitoring has been proposed to address limitations of current technologies in the detection of fetal compromise. We aimed to assess professionals’ views regarding current fetal-monitoring techniques and proposed longer-term continuous fetal monitoring.

Methods: A questionnaire was designed and validated to assess obstetricians’ and midwives’ use of current fetal-monitoring techniques and their views towards continuous monitoring. 125 of 173 received responses (72% obstetricians, 28% midwives) were analysed.

Results: Professionals had the strongest views about supporting evidence for the most commonly employed fetal-monitoring techniques (maternal awareness of fetal movements, ultrasound assessment of fetal growth and umbilical artery Doppler). 45.1% of professionals agreed that a continuous monitoring device would be beneficial (versus 28.7% who disagreed); this perceived benefit was not influenced by professionals’ views regarding current techniques or professional background. Professionals have limited experience of continuous fetal monitoring, but most respondents believed that it would increase maternal anxiety (64.3%) and would have concerns with its use in clinical practice (81.7%).

Conclusion: Continuous fetal monitoring would be acceptable to the majority of professionals. However, development of these technologies must be accompanied by extended examination of professionals’ and women’s views to determine barriers to its introduction.

Keywords

Continuous fetal monitoring, fetal monitoring, fetal movements, ultrasound, umbilical artery Doppler

Introduction

Fetal monitoring is employed to detect symptoms and signs that may indicate fetal compromise. Ideally, accurate detection of fetal compromise combined with appropriate intervention would lead to a reduction in perinatal morbidity and mortality without a negative impact on healthy pregnancies. Current methods to assess fetal wellbeing are frequently subjective or can only be used intermittently. They include maternal awareness of fetal movements (FM), cardiotocography (CTG), ultrasound measurement of fetal growth, and Doppler assessment of blood flow though maternal and fetal vessels [1]. However, the National Institute for Health and Care Excellence (NICE) and the Royal College of Obstetricians and Gynaecologists (RCOG) do not advocate the use of many of these techniques, particularly in low-risk pregnancies, due to a lack of evidence of a reduction in perinatal mortality [2–4]. The only practices supported by strong favourable evidence are ultrasound assessment of fetal biometry, and umbilical and uterine artery Doppler in high-risk pregnancies [2,4]. Continuous objective fetal monitoring is proposed as a way to remove the limitations of subjective or intermittent evaluation of fetal wellbeing [5]. When considering the continuous use of current methods of fetal monitoring, the use of Doppler ultrasound is not appropriate due to safety concerns with long-term use [6]. In contrast, FMs and the fetal heart rate (FHR) can be monitored for extended periods using safe techniques, such as accelerometry-based movement detection [7–10] and the electrocardiogram (ECG) [11,12]. Monitoring these parameters has been an area of research interest since the 1930s, although technological advances have led to increased number of publications in the last two decades. However, current devices have not been widely used in clinical practice due to various problems including: issues with signal quality, poor battery life and interference [5]. Continuous objective recording of both FMs and FHR could provide more detailed feedback on fetal health than either in isolation. For clinical utility, a device needs to achieve a suitable sensitivity and not suffer from reliability issues that
have limited other approaches. Although these technological aspects are important, their achievement would be irrelevant if continuous objective antenatal fetal monitoring was not viewed favourably by women and professionals, as this would act as a significant barrier to the implementation of any device. Despite the apparent prior interest in longer-term fetal monitoring, there is little research to assess views of professionals. We aimed to assess professional opinions regarding current fetal-monitoring techniques, the potential utility of continuous objective fetal monitoring and their perceptions about the possible effects resulting from such technologies.

Methods

A questionnaire was developed and validated using the process proposed by Lynn [13]. Objectives were set for areas to explore and questions were designed accordingly. The objectives covered two main areas: (i) current use of various fetal-monitoring techniques by professionals and beliefs about how effectively these reduce perinatal mortality, and (ii) opinions about continuous longer-term fetal monitoring, including objective FM and FHR monitoring and the potential effects the use of this form of surveillance could have.

Twenty-nine questions were generated. These were sent to 10 validators comprising midwives, obstetricians and subspecialists in maternal/fetal medicine. Validators were presented with the questionnaire objectives and, for each question, they were asked to rank the face validity (to what extent the question appeared to relate to the objectives) on a 5-point Likert scale ranging from strongly disagree to strongly agree. Content validity (the clarity and relevance of the question) was ranked on a 4-point scale ranging from not clear to very clear. Space was provided for comments or to document aspects omitted from the question. Nine of the 10 validators provided complete responses. Regarding face validity, all validators agreed or strongly agreed that the question related to the objectives for assessment for 13 questions, eight agreed or strongly agreed for 11 questions, and for five questions, seven agreed or strongly agreed. A question was determined to be valid if it achieved a ranking of 3 or 4 on the clarity and relevance scales [13]; thus for a question to reach the 5% significance level for this question-related to the objectives for assessment for 13 questions, eight agreed or strongly agreed for 11 questions, and for five questions, seven agreed or strongly agreed. A question was determined to be valid if it achieved a ranking of 3 or 4 on the clarity and relevance scales [13]; thus for a question to reach the 5% significance level for this questionnaire, seven of nine validators had to rate it as ‘3’ or ‘4’ on the Likert scale. All questions were valid in terms of clarity. One question was judged as invalid in terms of relevance and was subsequently excluded. Cronbach’s alpha for internal consistency measures the extent to which questions measure the same construct [14]; the score obtained was 0.95 (excellent).

Based on validators’ comments, minor amendments were made the layout and similar questions were combined or grouped into tables to reduce the number of questions (final version in Supplemental File). The survey was made available online and the link publicised by the RCOG and the Royal College of Midwives (RCM) via social media and e-mail newsletter. Responses were collected between April and July 2014. In total, 173 responses were received and reviewed in Microsoft Excel 2010 (Microsoft, Washington, DC). Responses with less than 50% of questions completed were removed, leaving 125 responses. Descriptive and comparative statistical analyses were conducted using SPSS Statistics (version 20.0, IBM, New York, NY). Pearson Chi-square test was used when all test cells had expected frequencies >5, otherwise Fisher’s exact test was applied.

Results

Twenty-eight percent of respondents were midwives and 72% were obstetricians (36.0% consultants, 35.2% trainees and 0.8% subspecialists in maternal/fetal medicine). Of the monitoring methods assessed, maternal awareness of FMs was the technique most often used by clinicians (96.8% low-risk pregnancy and 87.2% high-risk pregnancy), with very few opting to monitor fetal activity more formally with counting strategies such as kick-charts (6.4% low-risk pregnancy and 5.6% high-pregnancy) (Table 1). CTG was used more often in high-risk than low-risk pregnancies, with non-computerised CTG utilised more often than computerised CTG in all pregnancies (Table 1). Ultrasound assessment of fetal growth and umbilical artery Doppler are used by the majority of clinicians in high-risk women (96.6% and 98.3%, respectively), compared with a much smaller proportion of low-risk women (23.1% and 19.7%, respectively) (Table 1).

A comparison of the use of fetal-monitoring methods showed that a significantly greater proportion of midwives than obstetricians currently use non-computerised CTG in low-risk cases; there were no other differences between professions regarding the use of other techniques (Figure 1).

A large majority of professionals believed that there is either strong or some evidence (88.8% low-risk pregnancies and 89.6% high-risk pregnancies) in favour of the use of maternal awareness of FMs to reduce perinatal mortality (Table 2). Formal counting strategies were less supported, with the majority of respondents stating that these have neither evidence in favour nor against preventing stillbirth (56.0% low-risk and 54.4% high-risk) and more respondents falling in the against category than in favour category (Table 2).

| Method of fetal monitoring                        | Number of responses | Low-risk pregnancy (%) | High-risk pregnancy (%) |
|--------------------------------------------------|---------------------|------------------------|-------------------------|
| Maternal awareness of FMs                        | 125                 | 121 (96.8)             | 109 (87.2)              |
| Formal FM counting strategies using kick-charts  | 125                 | 8 (6.4)                | 7 (5.6)                 |
| Intermittent antepartum non-computerised CTG     | 125                 | 41 (32.8)              | 69 (55.2)               |
| Intermittent antepartum computerised CTG         | 125                 | 18 (14.4)              | 61 (48.8)               |
| Ultrasound assessment of fetal growth            | 117                 | 27 (23.1)              | 113 (96.6)              |
| Umbilical artery Doppler                         | 117                 | 23 (19.7)              | 115 (98.3)              |

Table 1. Forms of fetal-monitoring professionals currently use to identify fetal compromise in low-risk and high-risk pregnancies.
Opinions were most varied for CTG; computerised CTG was believed to more effectively reduce PMR than non-computerised CTG in high-risk and low-risk pregnancies. Of all the monitoring methods, CTG in low-risk pregnancy was associated with the most negative views about its value, with 10.4% of respondents stating, there is strong evidence against the use of non-computerised CTG and 8.8% for computerised CTG in reduction of perinatal mortality (Table 2). All but four respondents held favourable views of the evidence supporting the use of umbilical artery Doppler in high-risk pregnancies, with mixed opinions about its evidence in low-risk cases (Table 2).

After arrangement of the data presented in Table 2 into an ‘‘in favour’’ category (strong evidence in favour plus some evidence in favour) and an ‘‘against’’ category (strong evidence against and some evidence against), with exclusion of neutral opinions, a significantly greater proportion of midwives than obstetricians believed that there is favourable evidence for non-computerised CTG reducing the perinatal mortality rate (PMR) in low-risk women (74.1% midwives versus 31.8% obstetricians) and for formal FM counting strategies reducing PMR in both low-risk (57.9% versus 27.8%) and high-risk pregnancies (70.0% versus 35.1%) (Figure 2).

Figure 1. The use of different forms of fetal monitoring (A) in low-risk pregnancies and (B) in high-risk pregnancies broken down by professional group. For midwives, n = 27–35, for obstetricians, n = 90 for all groups (***(p < 0.001)).
Table 2. Professionals’ beliefs about the evidence underpinning the effectiveness of different forms of fetal monitoring in reducing perinatal mortality in low-risk and high-risk pregnancies (n = 125 each row). The modal response to each question is highlighted in bold.

| Pregnancy risk | Maternal awareness of FMs | Strong evidence in favour (%) | Some evidence in favour (%) | Neither in favour nor against (%) | Some evidence against (%) | Strong evidence against (%) | Missing response (%) |
|---------------|---------------------------|------------------------------|-----------------------------|----------------------------------|--------------------------|---------------------------|---------------------|
| Low           | 51 (40.8)                 | 60 (48.0)                    | 12 (9.6)                    | 2 (1.6)                          | 0 (0.0)                  | 0 (0.0)                   | 0 (0.0)             |
| High          | 51 (40.8)                 | 61 (48.8)                    | 12 (9.6)                    | 1 (0.8)                          | 0 (0.0)                  | 0 (0.0)                   | 0 (0.0)             |
| Formal FM counting strategies |                      |                              |                             |                                  |                          |                          |                     |
| Low           | 3 (2.4)                   | 18 (14.4)                    | 70 (56.0)                   | 28 (22.4)                        | 6 (4.8)                  | 0 (0.0)                   | 0 (0.0)             |
| High          | 5 (4.0)                   | 22 (17.6)                    | 68 (54.4)                   | 25 (20.0)                        | 5 (4.0)                  | 0 (0.0)                   | 0 (0.0)             |
| Intermittent antepartum non-computerised CTG |                      |                              |                             |                                  |                          |                          |                     |
| Low           | 12 (9.6)                  | 22 (17.6)                    | 53 (42.4)                   | 24 (19.2)                        | 13 (10.4)                | 1 (0.8)                   | 0 (0.0)             |
| High          | 14 (11.2)                 | 41 (32.8)                    | 56 (44.8)                   | 10 (8.0)                         | 2 (1.6)                  | 2 (1.6)                   | 0 (0.0)             |
| Intermittent antepartum computerised CTG |                      |                              |                             |                                  |                          |                          |                     |
| Low           | 11 (8.8)                  | 24 (19.2)                    | 51 (40.8)                   | 28 (22.4)                        | 11 (8.8)                 | 0 (0.0)                   | 0 (0.0)             |
| High          | 26 (20.8)                 | 59 (47.2)                    | 32 (25.6)                   | 5 (4.0)                          | 1 (0.8)                  | 2 (1.6)                   | 0 (0.0)             |
| Umbilical artery Doppler |                    |                              |                             |                                  |                          |                          |                     |
| Low           | 20 (16.0)                 | 28 (22.4)                    | 47 (37.6)                   | 24 (19.2)                        | 6 (4.8)                  | 0 (0.0)                   | 0 (0.0)             |
| High          | 58 (46.4)                 | 63 (50.4)                    | 4 (3.2)                     | 0 (0.0%)                         | 0 (0.0%)                 | 0 (0.0%)                  | 0 (0.0%)            |

FM, fetal movement; CTG, cardiotocography.

More clinicians agreed than disagreed when asked if they thought a device for the continuous monitoring of FMs and FHR would be beneficial (45.1% versus 28.7%, Table 3). 50.0% said that they believed that the majority of pregnant women would be willing to use such a device, compared with 27.1% who disagreed (Table 3). The majority (51.3%) reserved a neutral opinion about the effectiveness of continuous fetal monitoring in reducing PMR compared with current forms of fetal monitoring (Table 3). However, the majority of professionals believed that a continuous fetal-monitoring device would increase maternal anxiety (64.3%) rather than give reassurance (23.6%). There was no relationship between clinicians’ beliefs about the evidence for current monitoring techniques (as described in Table 2) and views on the possible benefit of continuous fetal monitoring, i.e. those who felt that current methods are supported by strong or some evidence did not necessarily believe that a device would not be of benefit, and vice versa.

Professionals said that they would most often consider the use of continuous fetal monitoring in high-risk pregnancies, such as women presenting with RFM (62.0%), pregnancies known to be complicated by fetal growth restriction (FGR) (68.5%) or a previous stillbirth (63.9%). Women with FGR in a previous pregnancy (11.1%), women over 40 years of age (18.5%), women with significant disease (47.2%) and those with a body mass index (BMI) ≥30 kg/m² (8.3%) would be less often considered. 14.8% of clinicians would not consider continuous monitoring in any women. Some open responses noted that each case would have to be assessed individually, while 39.1% of clinicians said that it would depend on the size and the cost of a device.

Only four clinicians (3.3%) had experience of a device designed for continuous fetal monitoring. Two viewed this as a positive, and two as a negative experience. Of the three that had tested devices, one documented poor patient compliance and poor battery life, two experienced increased antenatal check-up admissions and all three-reported interference from artefacts and poor signal quality. Critically, none reported patient dissatisfaction. One open response noted that recording was particularly difficult in women with raised BMI.

A large proportion of clinicians (81.7%) stated that they would have concerns with the use of continuous fetal monitoring in clinical practice. Subsequent open responses documented their concerns. These can be grouped as follows: *maternal effects* – a reduction in women’s confidence in their bodies, in addition to maternal anxiety as already discussed; *effects on maternity care* – increased unnecessary intervention, increased admissions for check-ups, unnecessary medicalisation of care; *financial implications* – uncertain cost effectiveness, demand may exceed the number who could be provided with monitoring, and *technological issues with the device* – ensuring that the device has sufficient sensitivity, uncertainty about the safety and size of a device, concerns about the time taken to analyse results, difficulties obtaining recordings from women with raised BMI, defining what constitutes normal and abnormal recordings and defining criteria for women requiring continuous monitoring.

**Discussion**

Current use of fetal-monitoring techniques by maternity healthcare professionals largely follows evidence-based guidance from NICE and the RCOG; the largest proportion of professionals report advising maternal awareness of FMs to almost all pregnant women and using ultrasound assessment of fetal growth and uterine and umbilical artery Doppler in high-risk pregnancies [2–4]. Non-computerised CTG in the antenatal period is used more frequently in the antenatal period than evidence recommends. The findings of this survey are supported by their similarity to responses from UK professionals in a previous survey of fetal monitoring by awareness of FMs [15].

Clinicians held some positive views about continuous fetal monitoring; more clinicians than not thought that a device to objectively assess fetal wellbeing by measuring FMs and FHR could be beneficial, that the majority of pregnant women would use a device and that it could reduce hospital attendances with perceived RFM. No professional group would be resistant to continuous fetal monitoring even though midwives were more in favour of some current surveillance techniques. In addition, recognition by professionals that some current monitoring techniques are not based on strong evidence of their value supports the development of novel forms of fetal monitoring. In particular, professionals’ beliefs regarding the lack of evidence for benefit particularly relate to methods that
Figure 2. The proportion of midwives and obstetricians who believe that fetal monitoring techniques are supported by favourable evidence (strong evidence or some evidence in favour from questionnaire responses) for reducing perinatal mortality (A) in low-risk pregnancies and (B) in high-risk pregnancies. For midwives \( n = 19–35 \) and obstetricians \( n = 36–86 \). (Pearson Chi-square test used when all test cells had expected frequencies >5, otherwise Fisher’s exact test was applied. \( *p < 0.05, **p < 0.01 \).)

Table 3. Respondents’ views on the possible benefit and willingness of women to use a continuous fetal-monitoring device and the potential effectiveness of such a device in reducing perinatal mortality.

| Option                                                                 | Strongly agree (%) | Agree (%) | Neither agree nor disagree (%) | Disagree (%) | Strongly disagree (%) |
|------------------------------------------------------------------------|-------------------|-----------|-------------------------------|-------------|-----------------------|
| A device for continuous monitoring of FHR and FMs would be of benefit\(^a\) | 14 (11.5)          | 41 (33.6) | 32 (26.2)                     | 26 (21.3)   | 9 (7.4)               |
| Based on your experience, the majority of pregnant women would be willing to use a 24-h continuous fetal-monitoring device\(^a\) | 10 (8.2)           | 51 (41.8) | 28 (23.0)                     | 28 (23.0)   | 5 (4.1)               |
| 24-h continuous fetal monitoring would be more effective in reducing stillbirth rates than current fetal monitoring\(^b\) | 1 (0.8)            | 36 (30.3) | 61 (51.3)                     | 15 (12.6)   | 6 (5.0)               |

\(^a\)\( n = 122 \).
\(^b\)\( n = 119 \).
continuous monitoring could replace, e.g. non-computerised CTG and formal FM counting. The most frequent negative opinion associated with continuous fetal monitoring was that it would increase maternal anxiety rather than provide reassurance.

A large proportion of respondents indicated that they would have concerns with the introduction of a continuous fetal-monitoring device into clinical practice. Some of these concerns were also raised in studies assessing professional views of continuous intrapartum CTG monitoring, specifically that continuous monitoring can result in unnecessary intervention [16], increased dependence on technology [17,18], causes medicalisation of pregnancy [19] and increases maternal anxiety [16]. Thus, when considering introduction of longer-term fetal-monitoring lessons may be learned from the prior introduction of related technologies in intrapartum care in order that these concerns are addressed by prospective clinical studies.

The largely neutral opinion from professionals regarding the effect a continuous fetal-monitoring device could have on perinatal mortality may be due to a lack of experience of monitoring of this kind; this is supported by the observation that 20% of respondents stated that they needed more information to make judgments on continuous fetal monitoring. This observation may be because there are no continuous monitoring devices in widespread clinical use [5] and only the Monica fetal ECG device (Monica Healthcare, Nottingham, UK) has been tested in robust clinical trials [11,12]. In addition, clinicians’ expectations may also reflect the comparatively modest effects of currently available fetal-monitoring techniques on perinatal mortality.

To extend this work, an exploration of professionals’ views should be undertaken after the provision of more information underpinning continuous longer-term fetal monitoring such as descriptions of the objectives and the attributes required to achieve this. This could result in clinicians altering neutral opinions and give a clearer indication of where opinion lies. This approach should also directly address some concerns documented by clinicians in the open-response section. Subsequent questionnaires could be designed after focus groups or interviews to assess clinicians’ current knowledge. Due to advertisement on social media is it unknown what the questionnaire response rate was, thus it cannot be determined if responses are representative of the population or may reflect the views of an interested group of respondents.

Despite these limitations, this is the first attempt to collect professional views surrounding continuous long-term fetal monitoring. We believe this was a reliable assessment of respondents due to the survey’s high validation score. Although further investigation is necessary, there are sufficient positive responses to support ongoing exploration of continuous fetal-monitoring devices.

An evaluation of women’s views is essential, particularly given the majority view from professionals that continuous fetal monitoring could increase maternal anxiety. As it is known that advising women to monitor FMs can be associated with anxiety [3], women’s views on perceived anxiety levels with the use of continuous monitoring must be examined. An assessment of maternal views has only been previously performed with the use of the Monica fetal ECG device [12]. Although a relatively small cohort was studied, the use of this device was largely associated with high satisfaction levels. Using semi-structured diaries, maternal anxiety was noted by some participants wearing the monitor for a limited period of up to 24 h during home induction of labour. This will not necessarily reflect views of women presented with the proposal of longer-term fetal monitoring in the antenatal period.

In addition to evaluating maternal anxiety, the qualitative responses describe factors which should be included as outcomes in studies of the clinical utility of continuous fetal-monitoring devices. For example, in addition to assessing the validity of data recording in combination with evidence-based analysis (e.g. computerised CTG), evaluation must address the frequency and reasons for antenatal admissions, the incidence of intervention and whether this was deemed necessary. The impact of the device on maternal anxiety can be achieved by validated questionnaires, although the impact on the perception of their own bodies or confidence will likely require individual qualitative assessment. Such a holistic approach will not only be able to identify potential barriers to the implementation of novel technologies but also provide evidence of efficacy to inform the views of professionals and end-users.

Conclusion
Professionals are open to the idea of continuous fetal monitoring due to their appreciation of the limited ability of current fetal-monitoring techniques to reduce perinatal mortality, particularly in low-risk pregnancies. Further exploration requires a more detailed assessment of professional views and an appropriate evaluation of maternal views towards this proposal. This work provides support for the development of devices to continuously monitor FMs and FHR.

Acknowledgements
The authors would like to thank professionals who reviewed the questionnaire during its development.

Declaration of interest
Dr Edward Johnstone and Dr Alexander Heazell are co-investigators on a project to develop non-invasive long-term fetal monitoring in high-risk pregnancies. This has been funded by Manchester: Integrating Medicine and Innovative Technology, Tommy’s – the baby charity and a grant from The University of Manchester EPSRC IAA Concept and Feasibility Study Fund. The authors do not have any personal financial conflicts of interest to report in relation to this manuscript. This study was funded by the Holly Martin Stillbirth Research Fund.

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Supplementary material available online
Supplemental File