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Influences on safety of intrapartum electronic fetal heart rate monitoring practices: a scoping review

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ABSTRACT

Objectives Suboptimal intrapartum electronic fetal heart rate monitoring using cardiotocography has remained a persistent problem (EFM-CTG). We aimed to identify the range of influences on the safety of using EFM-CTG in practice.

Design Scoping review to identify influences related to the practice of intrapartum EFM.

Data sources MEDLINE, Embase, CINAHL, Web of Science, Scopus, British Nursing Index, Cochrane Library, from 1 January 2001 to 25 August 2024, and grey literature.

Eligibility criteria Articles that reported potential influences on the clinical practice of intrapartum EFM-CTG in hospital-based intrapartum maternity care settings, including primary studies, secondary analyses, reviews, reports, conference abstracts and investigations relevant to maternity and obstetrics, in English. Evaluations of technological modifications to traditional EFM-CTG monitoring and analysis were excluded.

Data extraction and synthesis We extracted influences on EFM-CTG from the included studies. Findings were synthesised using a best-fit framework approach, structured using an existing 19-domain framework of contributory factors for patient safety incidents in hospitals.

Results 142 articles and 14 reports were included. Our synthesis identified influences on EFM practice across all 19 domains of the contributory factors framework, including those relating to cognitive, social and organisational factors and interactions between professional work and tools used for fetal monitoring.

Conclusion Reducing avoidable harm associated with electronic fetal monitoring requires a systems approach based on a sound understanding of the full range of influences on practice.

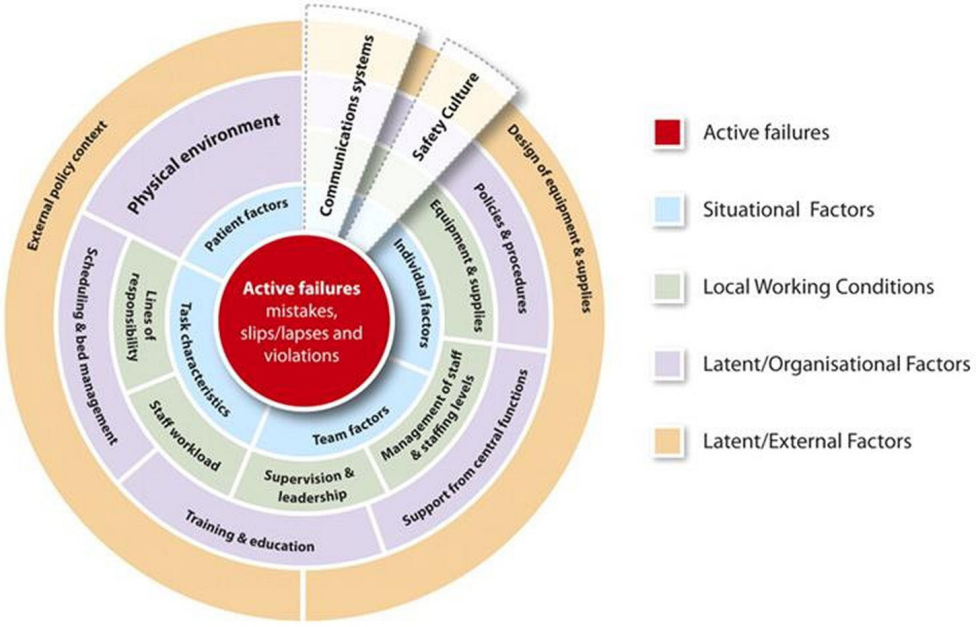
STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The review collates influences on fetal safety from electronic fetal heart rate monitoring using cardiotocography from a comprehensive body of literature, including journal articles and reports from clinical and professional organisations.
⇒ The findings have been organised into a clear explanatory framework using an existing evidence-based patient safety framework.
⇒ Findings may be less relevant to lower- and middle-income countries as studies from these countries were excluded.

INTRODUCTION

Intrapartum electronic fetal monitoring using cardiotocography (EFM-CTG) is the recommended method for monitoring the fetal heart rate during labour for high-risk births in England,[1 2] and in many other countries.[3–6] However, suboptimal monitoring, detection and response to fetal deterioration using intrapartum EFM-CTG has remained a stubborn challenge, implicated in a large share of obstetric malpractice claims[7–13] and reports of maternity service failures.[14–17] Despite the relevance to safety of systems issues as diverse as work system design, availability of senior support, equipment and professional boundaries,[11 18–20] efforts to address EFM-CTG problems have largely focused on training to improve individual clinical behaviour and competencies, such as improving clinicians' EFM-CTG interpretation skills.[21–23] More recently there has also been an emphasis on consideration of clinical context and triggers for escalation, but the evidence that training on its own can deliver improvement is weak.[7 23 24] Current evidence also suggests that electronic decision support for fetal monitoring does not improve clinical outcomes.[25]

It is likely that a systems approach to fetal safety would offer valuable targets for improvement in the practice of EFM-CTG. Such an approach recognises the need to understand the effects and interactions of crucial influences, such as work system design, tasks, equipment, workspace, teamwork, culture and organisation.[26 27] A key insight of systems approaches is that 'active failures'—unsafe acts by people in direct contact with the patient or system—tend to have a causal



Factor	Definition
Active failures	Any failure in performance or behaviour (eg, error, mistake, violation) of the person at the 'sharp-end' (the health professional)
Communication systems	Effectiveness of the processes and systems in place for the exchange and sharing of information between staff, patients, groups, departments and services. This includes both written (eg, documentation) and verbal (eg, handover) communication systems
Equipment and supplies	Availability and functioning of equipment and supplies
External policy context	Nationally driven policies / directives that impact on the level and quality of resources available to hospitals
Design of equipment and supplies	The design of equipment and supplies to overcome physical and performance limitations
Individual factors	Characteristics of the person delivering care that may contribute in some way to active failures. Examples of such factors include inexperience, stress, personality, attitudes.
Lines of responsibility	Existence of clear lines of responsibility clarifying accountability of staff members and delineating the job role
Management of staff and staffing levels	The appropriate management and allocation of staff to ensure adequate skill mix and staffing levels for the volume of work
Patient factors	Those features of the patient that make caring for them more difficult and therefore more prone to error. These might include abnormal physiology, language difficulties, personality characteristics (eg, aggressive attitude).
Physical environment	Features of the physical environment that help or hinder safe practice. This refers to the layout of the unit, the fixtures and fittings and the level of noise, lighting, temperature etc.
Policy and procedures	The existence of formal and written guidance for the appropriate conduct of work tasks and processes. This can also include situations where procedures are available but contradictory, incomprehensible or of otherwise poor quality
Safety culture	Organisational values, beliefs, and practices surrounding the management of safety and learning from error
Scheduling and bed management	Adequate scheduling to manage patient throughput minimising delays and excessive workload
Staff workload	Level of activity and pressures on time during a shift
Supervision and leadership	The availability and quality of direct and local supervision and leadership
Support from central functions	Availability and adequacy of central services in support the functioning of wards/ units. This might include support from Information Technology and Human Resources, portering services, estates or clinically related services such as radiology, phlebotomy, pharmacy.
Task characteristics	Factors related to specific patient related tasks which may make individuals vulnerable to error
Team factors	Any factor related to the working of different professionals within a group which they may be able to change to improve patient safety
Training and education	Access to correct, timely and appropriate training both specific (eg, Task related) and general (eg, Organisation related)

Figure 1 Yorkshire Contributory Factors framework (reproduced from Lawton R, McEachan RRC, Giles SJ, et al. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *BMJ Quality and Safety* 2012; 21(5):369-80, with permission from BMJ Publishing Group Ltd, 2024)

history at multiple levels of the system, including the 'latent conditions' that translate into error-providing conditions or system weaknesses.[28] To fully understand how safety incidents occur requires an understanding of the complex interactions between the elements of the system, at different levels, while recognising the role of internal and external factors.[29]

The evidence on what is known about the influences on the safety of electronic fetal monitoring practices has neither been systematically collated nor organised.

Accordingly, we aimed to identify the full range of influences on the safety of EFM-CTG practices through a scoping review of the available literature, structured using an evidence-based framework for classifying contributory factors to patient safety incidents.[30]

METHODS

Review questions and objectives

Our specific review question was: what are the influences on fetal safety in relation to intrapartum EFM-CTG in hospital-based maternity care settings?

Given the broad scope of our review, a scoping review approach was used because of its value for exploring concepts and mapping the nature and type of a wide range of evidence.[31 32]

Conduct and reporting

Methods for the conduct and reporting of the scoping review followed the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews statement[31] (online supplemental appendix S3). The protocol is publicly available (https://doi.org/10.17863/CAM.51072).

Information sources and search strategy

We searched the following databases: MEDLINE, Embase, CINAHL, Web of Science, Scopus, British Nursing Index and Cochrane Library from 1 January 2001 to 25 August 2024. Full search strategies, developed with an experienced medical librarian and clinical professionals are shown in online supplemental appendix S1.

The search strategy combined keywords and MeSH terms (1) related to safety concerns in medical and maternity care and to good or poor practice, fetal outcomes and other issues related to maternity care, and (2) related to the use of EFM-CTG in labour. Additional targeted searches, hand-searching, and forward and backward citation searching were also conducted as appropriate using a flexible, iterative approach consistent with scoping review methodology to identify any further potentially relevant studies.[33 34]

We also searched for grey literature, including through websites relating to obstetrics, midwifery and patient safety to identify key reports and investigations (online supplemental appendix S2), and conducted searches of OpenGrey and Google Scholar using the main search terms and concepts as the database searches.

Eligibility criteria

The inclusion/exclusion criteria were developed through initial exploratory searches, piloting of title and abstract screening, an iterative learning process and research team discussion about areas of uncertainty. Such iterative development has been shown to be necessary for complex scoping reviews covering a broad range of literature.[33–35]

Studies were eligible for inclusion if they reported potential influences on the clinical practice of intrapartum EFM-CTG in hospital-based intrapartum maternity care settings. We took a broad perspective on such influences, including, for example, team roles, wider organisational, environmental and systems influences, maternal and fetal factors. We aimed to report all potential influences reported in the literature, even if these were sometimes conflicting.

As the scope of the review was broad, we included primary studies and secondary analyses that had the potential to inform our research question, if they were published in English from 2001 onwards, including conference abstracts. We also included reviews of all types (a change from protocol), first because some provided useful findings and second to be consistent with the structure of the many national and international reports in this area that used an overview of a range of evidence. Findings before 2001 were deemed less likely to be relevant to current practice as UK and US guidelines on EFM-CTG practice were introduced after this date.[36 37] Studies that focused on intermittent monitoring (intermittent auscultation (IA)) were included if they reported factors that influenced the initiation or performance of EFM-CTG.

Although we aimed to identify potential influences on fetal safety relating to EFM-CTG practices, we did not seek to assess the effectiveness of interventions to address these factors. We therefore, for example, included studies examining training as an influence, but excluded studies examining the effectiveness of training[23] and evaluations of technological modifications to traditional EFM-CTG monitoring and analysis (eg, analysis of EFM-CTG traces augmented with artificial intelligence). We also made no assumptions about the outcomes of different types of fetal monitoring, for example, EFM-CTG or IA. Studies from lower- or middle-income countries (LMICs) (as defined by the World Bank[38] were excluded owing to their very different contexts.

Selection of evidence

Titles and abstracts were screened independently by two reviewers to identify any studies potentially relevant for inclusion. Disagreements about inclusion were resolved by a third experienced reviewer and/or discussion within the review team.

Studies were retained for full-text checking if it was unclear from the title/abstract if information about influences on safety in relation to EFM-CTG was reported—for example, studies reporting on perinatal mortality audits that did not mention EFM or CTG in the title or abstract. For some topics, many studies reported similar findings; for example, there were several studies reporting interobserver or intraobserver variability of EFM-CTG trace interpretation or confusion between maternal or fetal heartbeat. As our aim was to scope the literature, rather than include an exhaustive set of studies, we chose the most clearly relevant and recent studies for full-text evaluation.

Full-text screening, data extraction and synthesis

To organise the evidence relating to potential influences on fetal safety, we were guided by a best-fit framework synthesis approach[39 40] structured around the Yorkshire Contributory Factors framework (the 'YCF framework')[30] (figure 1), an evidence-based conceptual framework of 19 domains that may contribute to patient safety incidents in hospitals.[30]

The YCF framework is based on synthesis of 95 reports of 83 studies conducted in multiple healthcare settings. The 19 domains range from the situational (eg, individual or team factors) to the external, such as national policies. A particularly welcome feature of the framework is that it seeks to avoid excessive focus on proximal causes of incidents (active failures) and instead broadens to a more systems-based approach that considers how working conditions and latent factors may have impacts. This kind of framework is likely to be of considerable value in helping to characterise the full range of influences on intrapartum EFM-CTG safety in maternity units.

Full-texts were screened by two reviewers in a sequential process concurrently with the data extraction. Those full texts that had no relevant data for extraction were excluded. We created a coding framework based on the 19 domains of the YCF framework. One experienced reviewer imported the studies into NVivo software and extracted and coded relevant findings directly into the framework domains. Some findings fitted into more than one domain, so multiple coding was used as required. To ensure all relevant findings were identified, data were also extracted independently by another reviewer into an Excel spreadsheet and cross-checked against the extracted and coded data in NVivo. Any additional findings identified from this cross-check were also coded into the YCF framework domains. Disagreements were resolved by discussion within the review team. Regular project team meetings facilitated close scrutiny of coding decisions and the mapping to the framework. Within each domain, where several studies reported similar findings, results and studies were further grouped together and organised thematically.

We focused on extracting relevant findings that related to incidents or practice that specifically related to EFM-CTG, with the YCF framework used as a structured framework to organise the findings. Although the YCF framework is based specifically on contributory factors to patient safety incidents, we included a broader range of influences in this review, including issues that could influence the conduct, interpretation or response to EFM-CTG, not solely those based on patient safety incidents. For example, interobserver and intraobserver variability in trace interpretation are influences on the safety of EFM-CTG, even if they do not directly contribute to a particular incident. A small number of studies discussed findings in relation to fetal safety in general that were indirectly relevant to EFM-CTG (eg, need for examination of root causes in the incident investigation), so were included but marked as indirect influences.

A formal quality assessment was not conducted; it is not usually included in scoping reviews.[31]

Patient and public involvement

None.

RESULTS

We included 142 journal articles and 14 major reports in the review (flowchart, figure 2). Full details and references of included studies are in online supplemental table S1. The majority of included studies were from the US (n=42) and the UK (n=31), while 18 were from Australia, 8 each from Norway and Canada, 7 from the Netherlands, 5 from Italy, 4 from France, 3 from Sweden and 2 from Belgium, with the remainder from other countries (full details in online supplemental table S1). The studies and reports were diverse, including journal articles examining litigation or malpractice, clinical audits and reviews of adverse events, qualitative studies, reviews, surveys, observational studies, case studies, secondary analyses of trial data and key reports from obstetric and midwifery organisations and investigations.

Findings on numerous potential influences on safety in relation to EFM-CTG reported in the literature were extracted and mapped to the YCF framework. Where information was extracted from the papers, we used the terminology employed by the authors themselves as the basis of findings reported in online supplemental table S1. What we could extract from the studies depended on the potential influences on fetal safety and the level of detail as reported by the study authors. The information presented in papers was sometimes limited, with little detail, for example, on what type of fetal monitoring (eg, IA or EFM-CTG) was under discussion. Unless the context suggested otherwise, we considered EFM-CTG to be included in the terms used to describe fetal monitoring. Views on best practice relating to CTG varied across studies. Similarly, most studies reported from a clinical or professional viewpoint, with little reporting on whether the views of those giving birth had been taken into account in the decision. To stay faithful to the underlying findings, we extracted all potential influences reported, even if these were sometimes conflicting.

We found that, in general, it was possible to categorise study findings about influences on EFM-CTG safety using the 19 domains of the YCF framework (figure 1).

Due to space restrictions, only key findings are summarised in box 1. To fully demonstrate the huge range and diversity of system influences on fetal safety, online supplemental table S2 shows the full scope of findings mapped to the domains of the Yorkshire contributory factors framework.

'Active failures' are defined in the YCF framework as 'any failure in performance or behaviour (eg, error, mistake, violation) of the person at the "sharp-end" (the health professional)'.[30] Many studies and reports in our review reported active failures such as 'errors in CTG

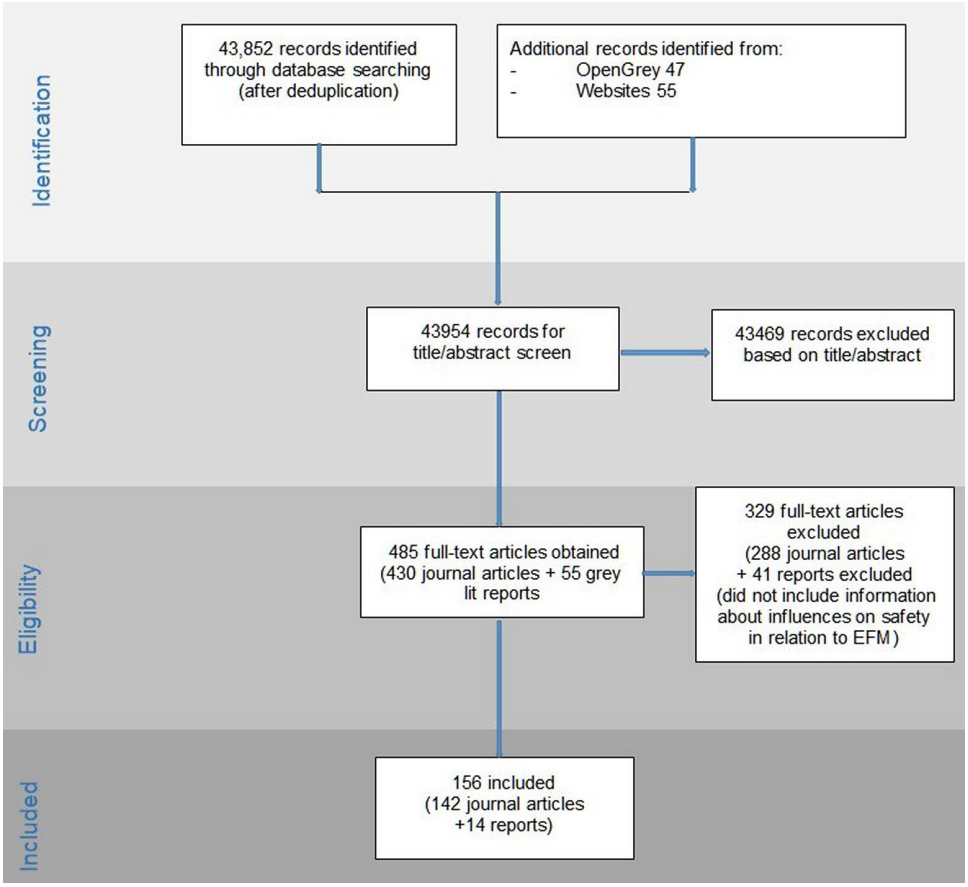


Figure 2 PRISMA flow diagram. EFM, electronic fetal monitoring; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

interpretation' or 'no response to abnormal CTG trace', but little accompanying investigation or analysis of why it happened, and minimal accompanying information (full detail of 'active failures' is reported in online supplemental table S2). We mapped potential influences on 'active failures' to the other domains of the YCF framework (online supplemental table S2). Selected examples are shown in box 1 and include situational factors, local working conditions, organisational factors, external factors, and communication and culture.

Many studies reported structural issues such as high staff workload and staff shortages as influences on suboptimal EFM-CTG performance (box 1, online supplemental table S2), for example, by contributing to cognitive overload, attention strains and perception deficits that result in abnormal EFM-CTG traces being missed or escalation delayed. Equipment-related issues were also repeatedly identified, including availability and maintenance, the potential for machines to confuse the maternal and fetal heart rate, difficulties in obtaining adequate tracings and chart speed variations. Several studies reported the potential for maternal or fetal characteristics to affect the EFM-CTG signal or trace or to make it more difficult to obtain a good trace.

Under the 'external policy context' domain, influencing factors identified in the literature include the volume and diversity of clinical guidelines and recommendations from different national and international organisations in relation to EFM-CTG (eg, Royal College of Obstetricians and Gynecologists (RCOG), American College of Obstetricians and Gynecologists (ACOG), International Federation of Gynaecology and Obstetrics (FIGO), National Institute for Health and Care Excellence (NICE)). These directions are not always consistent and may conflict or fail to cohere. Lack of local or departmental guidelines, poor quality of local guidelines and non-compliance with national guidelines, including procedures for response and escalation were all identified.

The studies we included emphasised the importance of EFM-CTG interpretation training, but also reported that lack of standardisation of guidelines and/or training may lead to different procedures and systems in different units which may contribute to inconsistencies when staff move between different units. They highlighted the importance of experience for effective EFM-CTG interpretation, suggesting that on-the-job training and supervision is also required. Studies also identified a need for training in EFM-CTG practices beyond interpretation, for example, in relation to escalation procedures and wider systems and human factors (box 1).

We found two areas of findings that were not fully accounted for in the YCF framework. First, studies reported fear of litigation as an influence because of its tendency to encourage defensive practice and the

Box 1 Examples of influences on active failures in the practice of electronic fetal heart rate monitoring using cardiotocography (EFM-CTG), based on the Yorkshire Contributory Factors framework (for the full range of influences identified see online supplemental table S2)

Domain 1: situational factors

Team factors

⇒ Absence of interdisciplinary teamwork and under-appreciation of all roles in the team. Existence of hierarchies of power and fear of speaking up in situations of disagreement with colleagues.

Individual staff factors

⇒ Variations in beliefs about the accuracy and safety of EFM-CTG. Variations in experience and confidence. Fatigue, stress, cognitive overload and biases, attention and perception deficits and intentional violations.

Task characteristics

⇒ Complexity of EFM-CTG interpretation, with high inter and intraobserver error.

Patient factors

⇒ Potential factors influencing EFM-CTG including maternal obesity, fetal gestational age and fetal growth restriction.

Domain 2: local working conditions

Workload and staffing issues

⇒ High staff workload. Staff shortages and inability to recruit appropriate staff. Reliance on locum midwives or unskilled workforce (eg, students). EFM-CTG used to monitor low-risk women to cope with high workload. Staff not empowered to escalate when workload becomes difficult to manage. Inappropriate deployment, for example, spending time on tasks that could be done by administrative or support staff.

Leadership, supervision and roles

⇒ Lack of strong institutional, midwifery and obstetric leadership. Tensions between midwifery and obstetrics in boundaries of work in relation to EFM-CTG. Senior staff not attending escalation requests. Lack of, poor quality or non-adherence to local guidelines for EFM-CTG including response and escalation procedures.

Equipment and supplies

⇒ Poor availability and maintenance of equipment, including lack of knowledge and defined roles in maintenance. Technical difficulties in obtaining adequate EFM-CTG traces. EFM-CTG systems need to be interoperable with other technology and information technology systems.

Domain 3: organisational factors

Physical environment

⇒ Cluttered spaces or designs impeding visibility or access to critical information (not CTG specific: evidence from wider maternity safety concerns). Frequency of EFM-CTG checking impacted by maternity care setting (eg, single room vs maternity ward). Non-actionable alarms causing sensory overload.

Support from central functions

⇒ Lack of organisational resources and systems to support escalation and intervention.

Scheduling and bed management

⇒ Lack of beds in labour ward for women whose clinical situation worsens, especially for induction of labour.

Staff training and education

Continued

Box 1 Continued

⇒ Lack of regular, standardised and up-to-date training and opportunities to complete such training. Lack of evidence on optimal mode and content of training.

Domain 4: external factors

Design of equipment and supplies

⇒ Difficult to maintain monitoring when moving around or between wards. Lack of standardisation of alerts and alarms. Confusion between maternal and fetal heart rate.

National policies

⇒ Multiple, inconsistent and unclear guidelines for EFM-CTG interpretation and response. Administrative overload due to a large number of national/governance initiatives.

Domain 5: communication and culture

Safety culture

⇒ Lack of clarity on what constitutes an incident worth reporting; lack of investigation of causes of incidents; fear of the consequences of reporting incidents. Fear of litigation influencing use of EFM-CTG even in low-risk women, and defensive practice.

Verbal and written communication

⇒ Multiple problems of communication including inadequate documentation of EFM-CTG, lack of consistent terminology to describe and communicate fetal heart rate (FHR) patterns and inadequate information at handovers.

ubiquitous use of EFM-CTG. We placed this finding in the 'external policy context' domain after discussion within the review team. Second, we identified that findings mapped to the 'active failures' domain could occur at different stages and time points as labour progressed (eg, at the initial stage of decision-making about the method of monitoring through to response to deterioration), as well as transfer, induction, epidural or preparation to expedite the birth The YCF framework may not sufficiently account for these kinds of changes over time.

DISCUSSION

Main findings

This scoping review offers a comprehensive overview of influences on practice in relation to intrapartum electronic fetal monitoring, mapped against a major patient safety framework. The full range of potential system influences on fetal safety is extensive and diverse (online supplemental table S2). The studies we reviewed suggest that structural issues—such as inadequate staffing levels, high staff workload, equipment defects and variable practice guidance—require attention, but process issues—including tasks and roles, situational factors, communication and culture—also likely to be consequential. These findings suggest that detection and response to fetal deterioration using EFM-CTG occurs in a complex adaptive system in which features of work systems (eg, staffing, resourcing, equipment, training, guidance, cultural norms, professional hierarchies and relations) have the potential to affect behaviours, decisions and actions, and ultimately outcomes. This analysis

is helpful in shifting the focus from proximal causes of incidents (active failures) to a broader and more helpful focus on the influences of latent factors and working conditions on EFM-CTG safety. It adds to the evidence that a whole-systems approach[41] is important to understanding and addressing the effects and interactions of real-world contexts such as teamwork, tasks, equipment, workspace, culture and organisation on clinical performance,[26 27] and provides more clarity about actionable issues that could be targeted by improvement efforts.

Many of the issues identified by our review have been raised previously,[2 13] but the evidence regarding the specific influences on EFM-CTG have neither previously been systematically collated nor organised into a clear explanatory framework. Our findings provide a framework identifying the factors that could be addressed by whole systems approaches.[42] The findings could also support future incident investigations into safety issues in EFM-CTG by providing a structured approach to investigation and support,[29] and avoiding excess focus on 'human error'.[7 8 43]

Interpretation (in light of other evidence)

Reducing avoidable harm linked to sub-optimal practice of EFM-CTG requires a sound understanding of the range of influences on practice. This review has categorised influences into the separate domains of the YCF framework, but it is apparent that these are inter-related and recursive: they are multifactorial, interconnected, and contingent, and dynamically interdependent. Addressing these challenges requires a shift to the system as the unit of analysis.[29] It should be acknowledged that EFM-CTG cannot be considered in isolation. In complex systems, understanding the behaviour of individual components is not enough; performance emerges from dynamic interactions across the entire system.[44]

Our review confirms that detecting and responding to fetal deterioration using EFM-CTG requires structures, systems, culture and processes that support a reliable and safe care pathway that is personalised and responsive to individuals. Only in this way will we be able to grasp how individual decisions and actions are made, and how they are subject to multiple and sometimes contradicting pressures, standards and influences.[44] In these conditions, dynamic trade-offs are commonplace and inevitable.[45] Understanding these trade-offs, and how to influence them, requires targeting the range of systems in which EFM-CTG is nested: the team, the maternity unit, and the hospital, each with its individual and collective working conditions, workload and culture; the healthcare system, with its policies and incentives; a scientific and professional environment, with evolving recommendations and debates; and the wider society, with often diverse expectations.[46]

This study was conducted concurrently with a recently published qualitative study conducted across three maternity units in the UK,[47] examining the everyday practice of CTG monitoring and the work systems within which it takes place. This review reinforces and expands many of the findings of the qualitative study, highlighting the importance of a socio-technical approach to understanding influences on safety and the need for systems principles to address issues in EFM-CTG practice. The use of systems principles would help to minimise the use of interventions unlikely to be effective, and to design and implement those more likely to work.[29] The science of human factors and ergonomics offers methods, frameworks and models to support this endeavour.[48] Improvement will require high-quality human-factors-guided design that is attentive to how people, technology, procedures, and local and wider environment interact together to generate outcomes.[49] Work system design should therefore be a priority and is likely to require: understanding people's needs and capabilities; considering tools, equipment and environments; describing explicitly the tasks that people will need to do and assigning them to roles; developing clear, consensually agreed protocols and associated instructions; and a system for continuous learning and improvement.

Accordingly, our review suggests that training is indeed essential, but individual training in EFM-CTG interpretation alone is not enough.[23] Current recommendations that EFM-CTG training should promote team-working and consider non-clinical skills such as clinical risk factors, situational awareness and human factors are likely to benefit from improved specificity to ensure relevance and usability.[50 51] Further, our review identified some 'active failures' associated with EFM-CTG relate to changing circumstances as labour progresses, and more focus may be needed on ensuring that care pathways are sufficiently flexible to allow for women's changing needs and input from multiple professionals.[52]

Strengths and limitations

A scoping review attempts to capture the breadth of the research rather than aim for exhaustivity. As such, we did not obtain full papers for every study identifying a theme but instead chose the most recent or most relevant. The review was limited to 2001 onwards and to studies from higher-income countries, so the findings may be less relevant to LMICs. Although the review highlights that delays in adequate responses concerning EFM-CTG are an 'active failure' influence on fetal safety, full reasons for the lack of a timely response were seldom investigated or reported in the studies.

A strength of this review is the comprehensive range of literature examined, and the mapping to an existing evidence-based framework in patient safety. Although some of the findings have previously been reported in the broader maternity and patient safety literature,[14 15 50] this review collates and presents together, the range of issues across a very broad range of literature. The YCF framework provided a useful structure to organise the large amount of evidence identified. A particularly valuable feature of the framework is that it seeks to avoid excessive focus on proximal causes of incidents (active

failures), instead offering a more systems-based approach that considers working conditions and latent factors, embedded behind the apparent 'active failures', to understand the root causes of safety errors. However, we recognise that the YCF framework describes contributory factors for identified patient-safety incidents and that the potential 'influences' identified in this review may not be identical.

Conclusions

Influences on patient safety in EFM-CTG are multifactorial. Given the scale of harm and litigation claims associated with intrapartum fetal monitoring, improvement strategies should consider the range of influences identified by this review. Tackling the full range of potential contributory factors will require fresh thinking about the problems to be solved, the targets for intervention and the design of solutions.

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Competing interests MD-W, JB, SK, GL, EL and IK report funding from The Health Foundation to THIS Institute. TJD is the obstetrical lead for NHS Resolution. TJD and CW were members of an RCOG/RCM national fetal monitoring group. HK, HD, AE, ZQK, KJ and XNZ report no competing interests.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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