



The overuse of intrapartum cardiotocography (CTG) for low-risk women: An actor-network theory analysis of data from focus groups

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ABSTRACT

Background: There is an overuse of cardiotocography for intrapartum fetal monitoring for low-risk women in high-income countries, despite recommendations from evidence-based guidelines.

Aim: To understand why midwives use cardiotocography for low-risk women despite evidence-based recommendations and to understand the roles of the cardiotocograph machine.

Method: This qualitative study used focus groups for data collection. Thirty-one midwives and three student midwives participated from four different countries: New Zealand, Australia, Denmark, and Norway. Constant comparative analysis, informed by an actor-network theory framework, was the method of data analysis.

Findings: Cardiotocography was multifaceted and influenced all attendants in the birth environment. The cardiotocograph itself is assigned different roles within the complex networks surrounding childbirth. The cardiotocograph's roles were as a babysitter, the midwives' partner, an agent of shared responsibility, a protector that 'covers your back', a disturber of normal birth, and a requested guest.

Discussion: The application of the actor-network theory enabled us to understand how midwives perceive cardiotocography. The assigned roles of the cardiotocograph shape its everyday use more than evidence-based guidelines. Discussion of these inconsistencies must inform the use of cardiotocography in the care of women with low-risk pregnancies.

Conclusion: We found that the cardiotocograph is a multifaceted actant that influences practice by performing different roles. Drawing on this study, we suggest that actor-network theory could be a helpful theoretical perspective to critically reflect upon the increasing use of technologies within maternity care.

Statement of significance

Problem

Non-clinically indicated cardiotocography for intrapartum fetal monitoring and assessment of uterine contractions for women with low-risk pregnancies is overused.

What is already known

Midwives and doctors increasingly use intrapartum cardiotocograph (CTG) monitoring in women with low-risk pregnancies despite robust evidence of its reliability and validity. This overuse leads to increased maternal morbidity associated with

unnecessary medical interventions without improving neonatal outcomes.

What this paper adds

Applying actor-network theory (ANT) as a conceptual framework enabled a new understanding of how midwives perceive the CTG and how the machine influences care provision. Midwives need to regain confidence and competence in Intermittent Auscultation (IA) to withstand the security, the trace/the proof, the defence, and the partnership that the CTG machine offers.

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1. Introduction

Intrapartum fetal monitoring aims to identify fetuses at risk of injury due to asphyxia enabling the health professionals to perform interventions to prevent such injuries. There are two main methods for monitoring fetal well-being during labour and birth: 1) listening to and assessing the fetal heart rate at prescribed intervals is called intermittent auscultation (IA), and 2) continuous electronic fetal monitoring (Table 1). Cardiocography is a technique used to monitor the fetal heart rate and uterine contractions antenatally and during labour and birth producing a continuous visual display and paper tracing of the heart rate and contractions. The machine used to perform the monitoring is called a cardiotocograph (CTG) [1].

The CTG entered clinical practice during the late 1960s and early 1970s and soon became widespread. Continuous electronic fetal monitoring was considered a better method for detecting signs of fetal compromise earlier, enabling health professionals to expedite birth and reducing perinatal and neonatal morbidity and mortality rates [2]. However, subsequent research has found that the introduction of CTG monitoring did not affect stillbirth rates [3] and that, compared to IA, the use of CTG monitoring has contributed to a reduction in neonatal seizures after prolonged labour, but without improving long term outcomes, e.g. cerebral palsy [2,4]. In addition, the use of CTG monitoring is associated with increased rates of interventions such as caesarean sections and assisted vaginal deliveries [1,4,5].

International and national guidelines for Fetal Heart Rate Monitoring from WHO [7], FIGO [8], ICM 2017 [9], and NICE [10] recommend IA for healthy, low-risk women. These guidelines recommend continuous CTG monitoring for pregnant women with risk factors, although there is no evidence of any actual benefit [6]. Additionally, the guidelines from Australia, Denmark, New Zealand, and Norway, the four countries included in the present study, recommend IA for low-risk pregnancies [11–13].

Despite evidence that the use of CTG monitoring is associated with unnecessary interventions without improved neonatal outcomes [4], as well as guidelines recommending IA for fetal heart monitoring in pregnant women with low-risk pregnancies [14], the overuse of CTG monitoring for low-risk women continues. Miller et al. claim in their article “Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide” that overuse of CTG monitoring is an unnecessary use of a non-evidence-based intervention [15]. For example, in Norway, 82% of low-risk women had admission CTGs, while only 53% of women with low-risk pregnancies received intermittent auscultation during labour [16]. In addition, increasingly low-risk women in New Zealand receive continuous CTG monitoring [17]; a study from Ireland also supports these findings [18].

Some studies have investigated how midwives and other healthcare providers experience the use of CTG for intrapartum fetal monitoring. A systematic review of professionals’ views on the use of intrapartum CTG monitoring for low-risk women included 11 studies and 1194 participants. The authors found that some clinicians felt reassured by CTG monitoring and that it provided proof that protected them against medico-legal action. Furthermore, they found that the CTG machine became a substitute for staffing in busy periods and could hinder

Table 1

The two main methods for fetal heart monitoring during labour.

Intermittent auscultation (IA)	Continuous or intermittent cardiotocography (CTG)
Recommended for women with low-risk pregnancies. IA can be performed via Pinard stethoscope or handheld Doppler device. The midwife palpates uterine contractions manually.	Recommended for women with high-risk pregnancies. A CTG machine records the fetal heart rate and uterine contractions simultaneously and continuously.

communication [19].

A recent study from the United States of America with 41 informants explored midwives’, nurses’, and physicians’ perspectives regarding facilitators and barriers to evidence-based use of CTG monitoring and IA. They concluded that there should be appropriate national guidelines for implementing IA and that this implementation requires training, education, and evidence-based policies [20].

An Australian study included 22 midwives and explored how different fetal monitoring technologies influenced the work of midwives. They showed that current CTG technology in the birth room can be a barrier for midwives in the provision of woman-centred care and that the CTG machine draws the attention of the midwives away from the woman [21].

An Irish study of eight midwives explored their experiences of using IA during labour. The findings indicated that the main barriers for using IA were a lack of professional guidelines, inconsistency in the documentation and the fact that they were working within a biomedical model of care [18].

The above studies show that the CTG machine has significance beyond being a fetal monitor and contraction assessment tool. However, none of these studies used an explicit theoretical approach to explore beyond what the midwives said to gain a deeper understanding of the underlying conditions for implementing or using this technology.

Why has the use of cardiotocography become so widespread for the care of healthy women, during low-risk pregnancies, despite evidence of no benefit and guidelines not recommending it? To further explore this conundrum, we argue that a new perspective might be needed - a perspective that takes a curious look at current practice while seeing technology in a new light. The present study uses the actor-network theory (ANT) as a conceptual framework to challenge our beliefs and everyday perception of CTG monitoring.

The perception of technology within ANT reshapes ‘who’ or ‘what’ influences decisions. The assignment of influence (agency) occurs for both human and inanimate objects [22,23]. From this perspective, the CTG machine might not be a passive tool but a technology that influences midwives and others. ANT is a way of thinking that aims to understand the influence of technology. It is a method that can help us question our everyday perceptions and distance ourselves from fixed categories and concepts. ANT offers a new way of looking at technological practices and may provide clues about the ongoing unnecessary use of CTG to monitor women with low-risk pregnancies.

The purpose of this paper is to apply ANT as a conceptual framework to explore why midwives use the

CTG machine instead of intermittent auscultation for fetal heart rate monitoring for low-risk women during labour. Furthermore, we aim to understand how technology influences the birth room, the maternity ward, and other surroundings.

2. Methods

2.1. Study design

Qualitative descriptive methodology informed the study design and consisted of focus group interviews conducted with midwives in four different countries: New Zealand (NZ), Australia (AU), Denmark (DK), and Norway (NO). The study design aimed to improve understanding of CTG technology in clinical practice, and the conceptual framework used for this study was the actor-network theory (ANT).

2.2. Ethical approval

The study received ethical approval from the Victoria University of Wellington Human Ethics Committee, New Zealand, the Norwegian Centre for Research Data, and the HREC Western Sydney Local Health District, Australia. In Denmark, anonymised qualitative studies do not need ethical approval from the regional ethical committee [24]. We

obtained informed consent to participate in all countries’ focus groups before the start of each focus group.

2.3. Study setting, participants, and preunderstanding

Most participating midwives worked in public maternity units in New Zealand, Australia, Denmark, and Norway. In Norway and New Zealand, some midwives from midwifery-led birth units and community-based practices also participated. The aim was to explore midwives’ perceptions of intermittent auscultation of the fetal heart during labour or women with low-risk pregnancies.

Recruitment in Australia included employed and privately practicing midwives from a prominent New South Wales tertiary maternity unit. Midwives from the central region of New Zealand took part in the study, and both hospital-employed and midwife-led unit midwives from central Norway participated. In Denmark, Case-loading midwives and standard-care midwives from the North Denmark Region participated.

The key researcher from each country distributed an invitation to participate in the focus group in each participating maternity ward. Invitations were also circulated to the self-employed midwives through their mail folders within the maternity units. To be eligible for recruitment, midwives must be providing intrapartum care to low-risk women giving birth in Australia, New Zealand, Norway, and Denmark.

Public places such as the university, a hospital, or the midwifery-led unit were the venues for the focus group interviews. We had prior permission to do the focus group interviews in these spaces.

Thirty-one midwives and three student midwives participated. Each focus group consisted of five to eight participants. The participating midwives’ amount of experience in the labour ward varied from a few months to thirty years. For more information about participants, see Table 2.

In ANT, the approach to the field of study is open-minded and bears no preconceived understanding. However, as described in the introduction, we, as midwifery researchers, found ourselves critical of the non-judicial use of CTG monitoring for low-risk women. We recognise our preunderstanding, but we have become increasingly curious and want to challenge our understanding of how technology influences day-to-day practice and overrules the evidence. Therefore, to enhance our

Table 2 Participant information.

Participants	New Zealand	Australia	Denmark	Norway
31 midwives (RM), 3 student midwives	10 midwives (5 LMC ^a and 5 core midwives)	7 midwives and 3 student midwives	7 midwives	7 midwives
Average years of experience	Range 2–25 years (av. 13.25 yrs)	Range 1–33 years (2 new grads) (av. 16.5 yrs)	Range 1–32 years (2 new grads) (av. 11.8 yrs)	Range 1–27 years (1 new grad) (av. 16.4 yrs)
RN	1	7	1	7
Current work type	1 × Midwife-led unit	2 × Privately practicing midwives	1 × supervising midwife	4 × Employed at hospital
Current work type	4 × LMCs ^a	1 × consultant midwife	4 × employed case loading midwife	3 × Midwife-led unit
Current work type	5 × maternity unit	1 × employed case loading midwife	1 × employed ‘standard’ care midwife	
Current work type		3 × antenatal clinic only, delivery suite only, ward only	1 × Midwife-led unit	
		3 × students		

^a LMCs – Lead Maternity Carer: New Zealand has a midwifery-led, primary maternity service where women choose their own LMC.

knowledge of fetal heart monitoring we invited an expert in ANT to participate in the study.

2.4. Data collection

Five focus groups took place across the four countries. Four of the authors conducted the focus group interviews in their respective countries. In New Zealand, two focus groups were organised to capture both employed and self-employed midwives. One author travelled to all countries and participated in all four interviews in person.

We conducted four focus groups in English and the fifth focus group in Norwegian due to participant preference. A Norwegian doctoral candidate translated this interview into English. The in-country researcher validated the transcript. The focus group questions are presented in Table 3. The audio-recorded focus groups lasted between 60 to 90 min.

2.5. ANT - Short introduction of the conceptual framework for the analysis

inside and outside the birthing room. It connects to many chains in society at many different levels. For Actor-network theory (ANT) was developed in the 1980s by Michel Callon, Bruno Latour, Steve Woolgar, and John Law. ANT is a social theory that thinks the social is always a part of the material, and hence ANT challenges the disciplinary distinctions between the social and technical that often shape social theories [26,28]. Moreover, ANT perceives human and non-human actants as parts of more extensive social networks. Humans and non-humans form associations, linking with other actors to form networks. Humans and non-humans have interests that cause them to act in specific ways that must be accommodated, managed, and used [23]. The method of ANT is to understand science or technology in use [25]. In this study, we wanted to understand the CTG machine in use.

As described above, Latour claims that the world consists of actants; actants have agency or are assigned actions from others and actants can be both human and things [26]. When we use this concept on the CTG machine (an actant), we find that the machine acts in the birthing room as it registers the heartbeat, and the midwife (another actant) assigns actions to it when commencing monitoring. The CTG machine ‘speaks’ and ‘acts’ on behalf of others: the unborn child or even the midwife.

Latour uses the concept of “networks” to help understand how ANT provides an understanding of the relational world. Technology never stands alone but is interwoven in a chain of other actants, and a network emerges linking one continuous chain with another [27,28]. As the world consists of networks, everything is relationally understood. As Latour describes it, there is no separation between the social world and the technological world because they are constantly interwoven in networks [26]. The CTG machine is a part of a network example, it connects to the fetus, parents, clinicians, birthing room, guidelines, labour ward, or society. This study narrows the focus to the machine in the birthing room to understand how it influences health professionals and

Table 3 Focus group questions.

Participants were asked to think about a time when they provided intrapartum care to a woman with a low risk pregnancy. The following prompt questions were used:
<ul style="list-style-type: none"> • Describe your practice regarding fetal heart rate monitoring for low-risk women. • What information guides your practice in relation to fetal heart rate monitoring? • Where do you access/obtain this information? • What information do you give women antenatally about the choices, risks and benefits of fetal heart rate monitoring? • What are barriers and facilitators that you experience in the practice of IA? • What does your hospital policy recommend? • How do you interpret what you hear when performing IA? • What are midwives actions when they hear changes to fetal heart rate and rhythm during IA? • What about admission CTG’s?

their use of this technology.

When technologies stabilise, they become a part of the usual background or even become invisible [23]. Within ANT, Latour explains that when a network has achieved stability and predictability, it can disappear into a ‘black box’ [25]. The black box contains knowledge that is agreed upon and seems to require no further interpretation or debate. Likewise, Stadler defines a black box as containing something that has been inscribed in a stable association and is no longer questionable [29]. Black boxes are necessary for our daily lives because civilisation is known to advance by extending the number of operations we can perform without thinking about them [23]. However, in some instances, operations have ended up in a black box because of an unthinking routine, and then the black box needs to be re-opened.

ANT is a complex theory with many concepts to understand. We aim to keep to the basic ANT concepts: network, actant, and the black box. To understand the power of CTG monitoring, we will also present the concept of translation. For example, when one media transforms into another media, this process is called translation [25]. In CTG monitoring, the fetal heartbeat provides a sound that transforms into a visible, written curve on the CTG paper. This translation of sound to a strip of paper visualising the heartbeat is essential in the study of CTG monitoring in the labour ward.

3. Data analysis

Data transcription occurred soon after each focus group, and all researchers received the transcriptions. Next, all authors attended a web seminar with the researcher with expert knowledge of the ANT framework to improve our understanding of the ANT analysis. Following this, all authors read, commented, and supported the analysis.

Latour recommends starting data analysis within the ANT framework by following an actant and how it changes over time while observing how it influences others and how others influence it in the network [28]. To analytically unpack CTG monitoring, we have adopted this strategy to understand how the CTG becomes part of the network in the birthing environment. This analysis aims to initially identify parts of the interview where CTG monitoring is used and investigate how the machine is an actant that influences acts and attitudes in the birthing room and the labour ward. As described by Glaser; Glaser and Strauss [30,31], and Leech and Onwuegbuzie [32], we used constant comparative analysis to compare the findings from four different countries and convert data into findings.

The researcher starts by coding each incident into as many categories in constant comparison analysis as possible. Each new category is constantly compared with the previous categories. [30,31]. This process ensures that one starts thinking with the full categories, dimensions, and conditions of the situation along the way. Initially, reading all transcribed data occurs several times to get a sense of the data. Then findings within the data focusing on IA and CTG monitoring were extracted, coded, and constantly compared.

Data integration begins in the second stage of constant comparison analysis, where the grouping of categories and data delimited occurs [30,31]. In this stage, our many categories were gathered into fewer groups, first in each interview, and then the codes from all focus groups were compared, integrated, and grouped by similarity.

In the final stage, themes solidify [30,31]. As a result, the creation of significant themes regarding the use of IA and CTG monitoring within the conceptual framework of ANT across all four countries occurred. Table 4 provides an example of the data analysis steps.

We were not looking to generate theory, so data collection finished once we saw commonalities amongst data from each country, and data saturation occurred.

4. Findings

The findings focus on understanding the network within the birthing

Table 4

Example of analysis: how the analysis brought forward the theme “the CTG as a babysitter”.

Initial dialogue coding	ANT focus	Comparison coding	Code grouping	Emergent theme
“The CTG becomes sort of a babysitter, so that you can at least look at that once in a while, which is very wrong...” (No)				
“it’s used as a babysitter...” (Au)				
“I use the CTG ... when I want to go and talk to someone.” (NZ)				The CTG looks after the baby
“Put it on to be sure, or to hold extra care for the baby” (DK)				
I’m sure that they would all say, “Put it on. Better to put it on than not.” (DK)				
“You should have a midwife attached to it” (Au)				The role of the CTG as a babysitter
“You should at least look at the CTG” (No)				
“So, you’re supposed to sight and sign a CTG every 15 minutes anyway so you should be in that room” (Au).				
“...and you could be out the room and a massive deceleration there that turns into bloody cardio and you go back in and it’s been going on for 15 minutes.” (Au)				
“You find a bloody awful CTG and no one has looked at it” (NZ)				
	The CTG is assigned a role in the birthing room	CTG is used because of business in the labour ward		
	CTG as a safety measure - just in case	CTG means extra care for the baby		
	The CTG needs a network	The CTG should not be used alone		
				The CTG cannot look after the baby - it needs a midwife
	The CTG needs a network	Consequence of CTG left alone		

room, with the CTG machine as an actant. We aimed to explore the networks, with the birthing room as the starting point. The birthing room networks consist of many actants, for example, the fetus and its heartbeats, the CTG machine, which displays and traces the heart rate, the parents, the midwife who interprets and acts, the doctor who decides ongoing management, the labour ward outside the birthing room, other colleagues, and the central monitor system in the staff room. Studying the use of CTG monitoring during labour for low-risk women created several key themes: the CTG as a babysitter, as the midwife’s partner, as an agent of shared responsibility, as a protector that ‘covers your back,’ as a disturber of normal birth, and finally, as a requested guest. In the

text, supportive quotes in italics indicate the origin ((Norway = NO; Australia = AU; Denmark = DK; New Zealand = NZ).

4.1. The CTG machine as a babysitter

Using the CTG machine as a babysitter means that the only functioning network is between fetus and machine; parents cannot interpret or act. The rest of the actants in this scenario should include a midwife and a doctor if there is a fetal heart abnormality, but they are missing. In some larger maternity units, central monitoring displays the heartbeat on a screen in the office/staff room, but it interacts with no one if it is unchecked.

The most striking comment from midwives across all countries was that the CTG machine was used as a 'babysitter' for labouring women in a busy labour ward, even though everyone stated that this was inappropriate and meaningless. Babysitting here means that the midwife commences CTG monitoring but does not constantly observe the trace because the midwife is not in the room. For example, a midwife from Norway stated: *"In a busy ward... You are not with the women; ... And then you put on (the CTG) ... The CTG becomes a sort of a babysitter, you can only look at it occasionally, which is very wrong"* (NO). In an example from New Zealand, the bustling birthing suite contributed to an inability to provide one-to-one care leading to the initiation of CTG monitoring. Later, the midwife finds a *"bloody awful CTG"* that no one had noticed. In all four countries, the midwives recognise that a CTG trace means nothing if no one interprets the output. In another example, an Australian midwife says: *"Everyone knows that the CTG can only register the state of the fetus but not act. If used alone as a babysitter, we can have a perfect registration of a dying fetus..."*. Another midwife emphasised: *"... it [the CTG] has got no alarm, and therefore it should not be used by itself"* (AU). In New Zealand, a midwife raised the question, *"Who monitors the monitor?"* All midwives recognised that when the required surveillance by a midwife is not possible, the CTG monitoring is not a solution - even though they had experienced this use.

4.2. The CTG machine as the midwives' partner

Some midwives working in tertiary-level maternity units caring for uncomplicated and complex pregnancies find the CTG a necessary tool/actant in their network. The machine is a wanted partner in the network, and it is often regarded as a routine that the midwife performs a CTG trace for uncomplicated pregnancies. The CTG machine might, through its presence and as a partner in the network, embody a 'routine' pattern of use. That indicates that CTG monitoring might be black-boxed and used without further consideration in high-tech units. Midwives working in midwifery-led units saw the CTG machine as a "stranger" in the birthing room and did not want it to be present. Here, the use of CTG monitoring was not black-boxed.

Midwives working with women with various risk factors in obstetric-led maternity wards regarded the CTG as a partner and wanted it in the room. They believed it was 'missing' if it was not there. Midwives in Denmark claimed that the use of CTG has escalated over the last five years: *"It takes more effort for me to use a Pinard or a Doppler, and not put a CTG on...It has become increasingly difficult not to put on the CTG"* (DK). The midwives regarded the CTG as a standard tool in intrapartum care in high-tech units and claimed its use had become a routine practice (habit or custom), even in low-risk pregnancies: *"it is just like a habit... every-body does CTG"* (NZ).

In contrast, midwives working in a midwifery-led unit in Norway or as lead maternity carers (LMCs) in New Zealand did not want the machine to be in the room. A midwife from Norway said: *"... that is exactly the big difference between a unit like ours and the more high-tech wards, where all the machines are inside the labour rooms - [it is] extremely easy to use when it is already standing there"*. Midwives from NZ explained they could not remove the machine from the room because they could not leave it in the corridor. A midwife from Australia explained: *"When I first*

got here, I moved all the CTGs out of the room every night before I went home, and when I came back in the morning [laughter], they were all back" (AU); *"The midwives want them there"* (AU).

A very different reason for wanting the CTG in the birthing room was that the Pinard and handheld Doppler devices were often missing in the Australian setting (believed to be stolen). Hence, the midwives often used the CTG as an alternative and said they were losing their IA skills.

4.3. The CTG machine as an agent of shared responsibility

When the midwife performs CTG monitoring, they broaden the network by transmitting data outside the room. Colleagues and doctors outside the room can join the network by watching the central monitor or the CTG trace, and thus they all share responsibility. The midwife and the parents can hear the sound in the room and watch the trace of the heartbeat as proof that the baby is alive. When the midwife uses the Pinard, she cannot audibly share the heartbeat sound in the network. Therefore, the parents who consider themselves part of the network may feel excluded.

In a scenario where fetal heart monitoring occurred using a Pinard, the parents blamed a Danish midwife because their child had asphyxia at birth: *"They got a child (their first child) with low Apgar scores, and they want it (the CTG) on for the next delivery"* (DK); *"They complained that they did not hear the baby's heartbeat during labour"* (DK). Because of such experiences, the midwives admit that they often use the CTG trace as proof of the care provided: *"We need documentation and a way to share responsibility with other professionals outside the room"* (DK); *"the CTG is kind of reassuring - I can show it to the doctor..."* (DK).

Midwives from Australia might also need the trace as a backup and, in that way, share the responsibility: *"Sometimes if I am not sure, but I will put the on monitor ... because I back myself up sometimes"* (AU).

To share responsibility through the central monitoring screen is also mentioned by a midwife, but she is not happy about this sharing opportunity: *"I think the saddest thing that has happened at the ward ... is the screen at the staff room (the central monitoring system)"* (NO). The midwife worried about the interruptions outside the birth room, but other midwives said central monitoring enabled: *"discussion outside and not in front of the woman"* (NO).

4.4. The CTG machine is a protector that 'covers your back'

The CTG trace can prove what happened in the birthing room. The CTG reaches its network to society outside the birthing room in this situation. It can activate the chain to criminal court and become part of a trial. Some midwives perceive this network as a threat, and they express feeling uncertain. Uncertainty surrounding the CTG becomes an integral part of the network. Traces produced by CTG monitoring provide proof of a living fetus and calm the nervous midwife, the doctor, or the parents. Conversely, midwives working in maternity-led models of care seem to be more at ease with intermittent auscultation.

There was a discussion about legally protecting self during all focus groups. Having a CTG trace was seen to "keep you safe," and that visual evidence was lacking when using the Pinard or handheld Doppler: *"And then you have got proof. If you have got a CTG, you have actually got proof that you have done something"* (NZ). In Australia, usage of the CTG equates with the desire *"to cover yourself"* (NZ), and it is the same in Denmark: *"we need to, what we call in Danish, keep our backs clear. We do not need anybody coming after you"*. All focus groups discussed that we live in a society concerned with risk and how to avoid *r manage risk*: *"We are always uncertain"* (NO). The CTG is, from that perspective, an almost inevitable intervention: *"Because the public is scared because they know so much more now through social media... and they just expect to be monitored"* (AU).

Newly educated midwives can be particularly uncertain: *"and especially me, when I am so new and all, that it is a security in having the CTG"* (NO). Some use it to be sure: *"Personally, if I have a concern for the child or*

- *I will put it on to see if there is anything to my concern*" (DK). In Australia, a midwife asked, "*What if I miss something - then they will come back, and they will say, 'why did you not put the CTG on?'*" (AU). Another midwife said: "*So after certain years, we practice it this way. I am not so confident to not do a CTG*" (NZ). However, others did not accept this: "*If there is no reason to use it, we do not use it*" (DK).

Interestingly, midwives working in midwifery-led models of care stated they felt uncertain when using the CTG machine. For example, a midwife said: "*I prefer to use intermittent auscultation because it makes me less nervous. Using a CTG makes me very nervous*" (NO). The lead maternity care (LMC) midwives in NZ explain that their pregnant women do not want to use the CTG and that the midwife would observe the situation for some time before the midwife decides to put it on: "*I would probably listen longer and more frequently at first with IA [crosstalk], until I thought, 'Okay, maybe this is—' And I would be looking at what is going on with the labour as well.*"

4.5. The CTG as a disturber of normal birth

Most midwives found and recognised that the CTG acted as a disturber of normal birth in different ways. It appears that it is not a neutral technology, and it has become an essential and disturbing actant in the network around childbirth. The use of CTG for low-risk births influences other actants, including the midwife, the woman, and the woman's partner, in different ways.

Midwives observed a shift in focus from woman to the machine in the birthing room: "*You really have to be conscious that all of their (the partner's) attention does not end up on the machine instead of on the woman... I turn it (the CTG) away or turn off the sound, but it seems easier to relate to a machine than a woman*" (DK). The midwife explained that the husband asked to turn the CTG around to see the trace's visual display. Midwives were aware that the focus on the CTG machine was problematic when the woman was in labour and needed focused attention from her partner and focused midwifery care.

Moreover, the use of the CTG can potentially restrict freedom of movement during labour: "*Then they are also locked to a smaller radius as well. It is fantastic to be able to see them move and be able to do as they feel like, not they have to be here, close to the system (the CTG machine)*" (NZ). A Danish midwife said that the CTG might interfere with the woman's movement. She said: "*I primarily use the Doppler because I do not want to interfere with the woman's position if she is in water or on all fours or standing up and over never use the CTG unless I have to*" (DK).

In all interviews, the midwives discussed their knowledge of the fact that routine use of CTG monitoring during normal labour often led to continuous monitoring: "*Just a little deceleration – and then, oh my God now, we have to keep it on forever and ever, because there has been this one*" (DK). Likewise: "*I feel really sad for the woman. Once she is on the CTG, she does not get off, generally. She does not*" (NZ). In Australia, one midwife discussed a situation where the CTG trace showed a slight deceleration before discharge and then an overall normal pattern and no other risks: "*Now she is not going home, and she is staying here, and 'she' is getting assessed, and on it goes...*" (AU).

Many women had non-clinically indicated continuous fetal heart monitoring after the initial CTG on admission, meaning normal birth can be disturbed. In Norway, a midwife said: "*... you... have to continue when you have first started*" (NO), which underlines the need for critical reflection before the CTG monitoring is initiated.

4.6. The CTG machine as a requested guest

It is unclear who is the most important actant in promoting the overuse of CTG monitoring. The midwife, the parents, the doctor, the managing midwives, or the CTG itself have important network positions as actants. The CTG machine is an actant that can transform a heartbeat into an inscription on a piece of paper. It is already in the room and available, leading to its use. The midwife also has a central place in the

network in the birthing room and the parents and the machine; the parents might ask for CTG monitoring, and the midwife is the one who most often initiates monitoring. The midwife and the CTG network have strong chains to medical and midwifery staff outside the birthing room. The doctors, some midwives, and some midwifery team leaders want documentation — a recorded trace on paper — and to get this, they join and influence the networks in the birthing room.

All focus groups discussed whether the midwife or the doctor requested CTG monitoring. The midwives stated they usually initiate monitoring (admission assessment) when they expect the doctor is going to order it regardless of any risk assessment and that arguing against it might be pointless (NO)(DK)(NZ)(AU). A midwife from New Zealand said: "*It is an assumption from them (the doctors) that there will be an admission CTG*", and a midwife from Australia said: "*Therefore, some midwives do an admission CTG to have a piece of paper when the doctors ask for it*" (AU). However, there was a midwife from Denmark who said: "*We do not do an admission CTG*". In Norway a midwife stated: "*The CTG leaves a trace*" (NO). The CTG trace becomes a requested piece of documentation that the midwife and doctor can discuss, and some midwives stated that they put the monitor on to please the doctors. If there is no trace: "*we have got nothing to show them (the doctors) physically and ...they have to take your word for it*" (NZ). In Norway, a midwife directly claimed, "*Legally they (the doctors) trust the midwife's word. But (in real life) they still do not*" (NO). Thus, it might be the input from the medical staff that results in more CTG monitoring.

Another finding was that some team leaders (leading midwives) requested or questioned the use of CTG monitoring: "*the team leader, that was the one who came in, and I got completely dressed down in front of the woman.*" She said, "*This (monitoring) is not going to stand up in the court of law.*" (NZ). An Australian midwife, chastised by her midwifery manager, was told that she would get into trouble because she did not perform monitoring. The midwife said: "*That was the focus - it was not the well-being of the baby; it was not the well-being of the mum. It was: 'This is not proper (documentation)! You will go and legally get in trouble for this'*" (AU). In contrast, in Denmark, the midwives reported that their team leaders might question why the midwife put on a monitor.

But what about the evidence? Midwives from Australia said: "*So they are trying to teach us at uni (university) to hold back off the CTG unless it is absolutely needed. But as midwives, we are still doing it because we are fearful of getting in trouble*" (AU). The midwives know the recommendations; a midwife said, "*For women who do not have a risk factor... admission CTGs are not recommended*" (NZ). Another added: "*We know about evidence-based practice, why have we become so fearful of doing evidence-based practice? I think it is the environment that we work in. You know the culture of the unit...*" (NZ). These quotes illustrate that the midwives know and understand the recommendations, but they are afraid of getting in trouble.

5. Discussion

This study proposed to explore the paradox of cardiotocography in uncomplicated pregnancies even though guidelines do not recommend this.

The ANT conceptual framework for the analysis has brought forward a much deeper understanding of the CTG and its role in the birthing environment. We found the CTG to be a multifaceted actant that influences the birthing room and other actants in many ways. The constant comparison method identified that the midwives in four countries described similar experiences with the CTG. We translated and interpreted these experiences from the ANT perspective and found that the CTG machine is assigned different roles in the complex networks around childbirth. These roles became themes during the analysis. We have discussed the themes of CTG machine as a babysitter, midwives' partner, agent of shared responsibility, a protector that 'covers your back,' disturber of normal birth, and as a requested guest.

ANT allowed us to rethink how technologies influence our daily

work. Using the ANT perspective, the CTG in the maternity ward acts as part of a complex network, and the presence of the machine influences midwives, parents, and doctors. However, the CTG is not just a neutral monitoring tool. Evidence-based use of CTG monitoring exists in textbooks and clinical recommendations [13,33], but midwives from this study said that these guidelines are not followed, as they commonly perform continuous CTG monitoring for uncomplicated labours. The previously mentioned researchers reinforce this by claiming that evidence based CTG monitoring recommendations have not been translated into practice [8,34,35].

By exploring the meaning of the CTG for the midwives using the ANT framework, we tried to understand its usage for low-risk women. For example, in the case of the CTG being a babysitter, midwives claim this is due to busy maternity wards where they do not have time to stay in the room with the woman. Other researchers have confirmed this finding [20,36]. Furthermore, understaffing of our maternity units is acknowledged by others [37,38], and therefore the solution to this problem might be improved staffing in maternity wards. However, seen from an ANT concept, it is interesting that a CTG machine can act as a babysitter when a babysitter would usually be a person.

We also found that the CTG acted as the midwives' partner, and if the machine was removed from the birthing room, the midwives brought it back. It has grown to be part of the birthing room network, and we need to consider why and what it adds. We found that CTG took some of the responsibility away from the midwives by enabling the sharing of the CTG traces; moreover, the midwives felt that the CTG trace could 'cover their back' in a medico-legal sense when they felt uncertain or felt that the team leaders or doctors did not trust them. Chuey also found that the CTG machine offered reassurance and protection against legal action [20]. Moreover, Patey found that legal concerns hindered the use of IA [5]. None of these studies mentioned the CTG machine as the midwife's partner.

The midwives felt they needed the CTG trace to prove that everything had gone well. This notion points to a work environment and culture that stresses the midwives. Hill also found that vulnerability and the biomedical culture of the organisation inhibited the midwives from using intermittent auscultation [18]. The midwives need to protect themselves and have a trace available or risk medico-legal consequences in a poor outcome. This culture needs to change for midwives to feel trusted and safe enough to use the handheld Doppler or the Pinard.

The findings in this study claim that CTG monitoring for low-risk women can be initiated by the midwife, the machine itself, midwifery team leaders, doctors, the need for a trace, the screen in the staff room, lack a Pinard fetoscope or handheld Doppler, lack of midwives, the parents, or even the general culture of risk. These findings demonstrate that the CTG is important in many networks, not just a technology separate from the social realm. As Latour describes it, the social and technological worlds are not separated [26]. Therefore, it might not be essential to determine who initiates CTG monitoring for low-risk women but rather to reflect upon why non-evidence-based monitoring continues to dominate practice.

Especially midwives working in high-tech wards found CTG monitoring hard to avoid, and some of them felt uncertain when doing IA for low-risk women. In contrast, more midwives working in midwifery-led models felt uncertain if they used the CTG machine. There appear to be different cultures in high- and low-tech wards that influence technology's role. The midwives in midwife-led units reported supporting uncomplicated births without CTG monitoring. The CTG machine was often not a part of the network, which the midwives appreciated. It seems that in midwife-led units, there is a culture of self-confidence that is strong enough to resist unrecommended technology. If more women got access to midwife-led units, more women would give birth in a setting where IA is practiced. These findings about the cultural influence underline that changing the use is complex.

From an ANT perspective the routine use of CTG monitoring in low-risk pregnancies seems black-boxed. Latour says, that if we want to

change midwives'/doctors' attitudes or the culture around the CTG, we must re-open the black box. Within ANT, changing a stable network is met with inherent difficulties [39]. The degree of irreversibility of a routine depends on 1) the extent to which it is impossible to go back to a point where that translation/understanding was only one amongst others, and 2) the extent to which it shapes and determines subsequent translations [40]. Thus, changing the overuse/routine use of CTG monitoring for low-risk women depends on whether we can go back to when only the Pinard or handheld Dopplers were the monitoring choice for low-risk women. There were only two CTG machines for 3000 annual births in the birth unit in Northern Denmark in the eighties. Today, the CTG is an integral part of every birthing room and has, by its sheer presence, become difficult not to use. We cannot go back in time, but we can critically reflect on the extent to which the CTG shapes current practice and determine future work. As we reveal why CTG monitoring is overused and what might fill the CTG role, we will be able to change the culture around CTG monitoring.

The overuse of the CTG machine was a concern for all the interviewed midwives. They participated in our study because they wanted to discuss auscultation. They found that CTG monitoring disturbed normal birth in many ways, as it took the focus off the woman, hindered the use of different birth positions, and was not easy to discontinue. This study shows that we should not blame the midwives for using CTG monitoring during low-risk labours. The context, the time, the culture, and the lack of staff influence the use of the CTG machine. We also consider that professionally, we need to stop the routine use of CTG monitoring for low-risk women and start a debate on the use of technology.

In the present study in New Zealand, midwives said that they needed strong leadership to become strong supporters of the normal, non-interventionist philosophy. Midwifery leaders cooperate with doctors, who have a more risk-thinking attitude to childbirth, and it is essential to be strong to retain a non-interventionist focus. We need to recognise that changing how technology is being used in large birth units will be challenging and that extra effort is required if low-risk births are monitored appropriately. One solution could be that each maternity unit should have a technology group that discusses and evaluates choices and implementation of new technologies.

5.1. Strengths and limitations

The inclusion of midwives from four countries could have reduced the study's depth and the possibility of finding common themes. However, we balanced this potential limitation against two higher-ranking concerns. Firstly, we prioritised an international perspective to investigate whether midwives in other high-income countries experienced similar challenges and dilemmas with CTG monitoring. Secondly, "the role of the CTG" did emerge as a theme during the continuous reading of all focus group interviews. Thus, midwives from all four participating countries were engaged in the CTG monitoring. We tried to focus on low-risk women, but in the discussion, midwives might sometimes forget this focus and discuss monitoring in general, which might be a limitation of this study.

The participation of an ANT expert strengthened the study as she educated the four authors, participated in the analysis, and reviewed and edited the manuscript.

The management of pregnancy and childbirth within these countries is somewhat similar, but there are many countries where the approach to childbirth is quite different, which might lower the transferability. For example, the Netherlands has the highest homebirth rate [41], limiting potential transferability. Likewise, countries like Brazil do not have midwives and have a high caesarean section rate. However, technology use within midwifery needs consideration, no matter the organisation of maternity care.

All four researchers did focus group interviews, which validated the use and interpretation of the gathered data. In addition, one of the

researchers participated in all five interviews, which also strengthened the validity of the coding.

One limitation of doing focus groups is that group discussions can be challenging to steer and control. Another limitation is that respondents can feel peer pressure to similarly answer the moderator's questions. Therefore, the moderator's skill in steering, phrasing questions, and creating the setting can affect responses. We discussed these issues before the focus groups, and the two moderators helped each other keep track. CTG monitoring did not seem sensitive, and all participants contributed eagerly. The midwives self-selected into the focus groups, which may have ensured they wanted to participate in the discussion. This could have led to the midwives in the discussions being firmly for or against a specific kind of monitoring, but there turned out to be a very nuanced view of auscultation.

6. Conclusion

Thinking with ANT enabled us to understand how midwives perceive CTG monitoring and shed light on the use of the CTG in low-risk pregnancies despite evidence and clinical guidelines. We found that the CTG is a multifaceted actant that influences practice by performing different roles. Careful consideration should be given to this influence when discussing monitoring in low-risk pregnancies. We now understand that if we want less monitoring for low-risk births, we must ensure that midwives regain confidence and competence in using, interpreting, and communicating their intermittent auscultation practices and do not need the security, the proof the defence that the CTG trace offers. We must look at staffing levels in our maternity units, how midwives are supported and cared for, and the birthing unit's culture more broadly. We also recognise that we need to focus on intermittent auscultation if all midwives can provide this practice.

It is essential to understand that the assigned roles of the CTG shape everyday use more than the question of evidence-based practice does. Therefore, we would suggest paying close attention to how technologies are used and practiced. We also need to rethink how we perceive and work with technologies in the future.

Drawing on this study, we suggest that ANT could be a helpful theoretical perspective for critically reflecting upon the increasing use of technologies within midwifery and obstetrics. In addition, this study demonstrates how theory from other disciplines might enlighten midwifery. Further research in this area and a nuanced discussion of technology within midwifery are needed to focus on spontaneous and undisturbed childbirth.

Authors' contributions

(RM) designed and got approval for the overall study and data-collection. The authors (EB, RM, HC and IJ) recruited participants and collected data. (IJ) introduced, planned, and designed the ANT analysis. Data analysis was performed in collaboration with (IJ, EB, RM, HC) but with great help from (SWA) an expert into ANT. (IJ) drafted the manuscript, which all authors (IJ, EB, RM, HC, SWA) commented and critically revised. All authors read, contributed to, and approved the final manuscript.

Author agreement

The manuscript describes original work and is not under consideration for publication by any other journal. The authors have seen and approved the manuscript and this submission. Upon request all data is available.

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Ethical statement

We obtained informed consent for participation in the focus groups in all countries before each focus group.

They were informed that data would be treated anonymously and confidentially.

Ethical approval to conduct the study was granted by Victoria University of Wellington Human Ethics Committee (Ref: 23348), 22/8/16; NSD – Norwegian Centre for Research Data (Ref: 49419), 2/9/16, and HREC Western Sydney Local Health District, Australia (Refs: AU RED HREC/16/WMEAD/-394; SSA AU RED SSA/17/WMEAD), 7/2/17. According to national legislation in Denmark and the Danish Ethics Committee, no ethical approval was necessary for this study (<https://en.nvk.dk/how-to-notify/what-to-notify>).

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Conflicts of interest

None declared.

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