

# The knowledge level of health professionals in cardiotocography and the resulting adverse perinatal outcomes

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**S u m m a r y.** *The purpose of fetal cardiotocography (CTG) is to monitor fetal status during the intrapartum period. Even though CTG is a safe evaluation method, errors in the interpretation of CTG contribute significantly to infant mortality and morbidity. The findings of this systematic review have shown that there are several knowledge gaps of health professionals regarding the cardiotocography and the adverse perinatal outcomes that may result from misuse or misinterpretation of CTG. Constant education and training programs for healthcare professionals, coupled with regular evaluations of CTG practices, can help to enhance the knowledge and proficiency of healthcare professionals in using CTG. In conclusion, the appropriate level of knowledge and proficiency of healthcare professionals in utilizing induction CTG is crucial in minimizing the risk of adverse obstetric outcomes such as intrapartum hypoxia and perinatal brain damage.*

## INTRODUCTION

Hypoxia and its consequences during pregnancy and childbirth are among the leading causes of perinatal morbidity and mortality [1]. In the context of perinatal morbidity and increased incidence of perinatal brain damage as a consequence of fetal hypoxia often leads to severe neurological infant disability. During delivery the fetus uses various adaptive mechanisms to hypoxia, which generally follows a similar course to the physiological response [1]. The fetus has a limited range of possible responses to hypoxia, with the response depending largely on the nature of the

hypoxia. Assessment of physiological responses is important for the management of labor and pregnancy in general. The first thing to determine is whether the hypoxic pacing is acute or chronic [2]. When a condition is acute, a fetus effort to increase heartbeat to increase oxygen uptake from the placenta. It may preferentially redirect blood and oxygen from its periphery (legs, arms etc.) to other vital organs such as the brain and heart. It will reflexively try to reduce its unnecessary movements to reduce its overall oxygen requirements and thus increase the amount of oxygen available to the brain [2]. When the fetus is chronically hypoxic it can increase its haemoglobin levels. Thus, at the beginning of an acute hypoxic attack the fetus initially increases its heart rate, but this fact means increased oxygen consumption.[3]. If the hypoxic state continues, then the heart rate will decrease. The duration of the hypoxic attack and the interval between attacks is also important [1]. The early detection of the above pathological conditions is of vital importance for the well-being of the fetus.

Cardiotocography can assess the status of the fetus in terms of fetal heart rate. Metabolic changes affect all the organs of the fetal body and especially the brain [4,5]. The heart is regulated by a combination of neurological, endocrine and local mechanisms [5].The neurological regulation is by chemoreceptors as well as the tendon receptors, the higher centres of the brain, while other centres are regulated by the sympathetic and parasympathetic systems. For the proper functioning of these systems, cardiotocography is currently the only method with continuous recording of the fetal heart function and at the same time the contractility of the uterus, and it is applied both during pregnancy and especially during childbirth [6].The cardiotocography examination contributes to early diagnosis and consequently to the safest mode of delivery[4].

Initial non-randomized human studies concluded that CTG has a positive impact based on early reduction of intra-abdominal mortality and neonatal deaths. The studies were characterized by heterogeneity in terms of design, patient populations and CTG equipment. The following clinical randomized controlled trials questioned the positive effect of CTG on fetal well-being when comparing CTG with intermittent listening. Subsequent meta-analyses found no reduction in perinatal mortality, low Apgar score, low umbilical cord pH or cerebral palsy and concluded that CTG monitoring reduces

the incidence of neonatal seizures as the only neonatal outcome affected and increases the incidence of caesarean sections and assisted vaginal deliveries [4].There are no studies comparing CTG with no fetal monitoring. The diagnostic characteristics of CTG were also criticized early on. Too many surgical deliveries were performed in non-hypoxic infants and the use of CTG was suggested as a warning or diagnostic test rather than as an accurate diagnostic tool for fetal hypoxia. A key aspect of evaluating a diagnostic or screening test is determining how sensitive (ability to detect sick individuals) and specific (ability to detect healthy individuals) the test is, as well as knowing how well the test results predict disease (positive predictive value) or absence of disease (negative predictive value) (Fig. 1) [7].

		Birth hypoxia		
		Present	Absent	
Cardiotocography	Positive	True positive A	False Positive B	Positive predictive value: $A / (A+B)$
	Negative	False negative C	True Negative D	Negative predictive value: $D / (C+D)$
		Sensitivity: $A / (A+C)$	Specificity: $D / (B+D)$	

Figure 1. Sensitivity, specificity and the positive and negative predictive value.

The purpose of CTG recordings is to identify when there is concern about the well-being of the fetus so that interventions can be made. The focus is to identify fetal heart rate (FHR) patterns associated with inadequate oxygen delivery to the fetus. In general, FHR patterns characterized as normal are a reliable indicator of fetal well-being. Up to 50 % of FHR patterns classified as abnormal reflect physiological changes and can therefore be classified as false positive (false abnormal). This can lead to an increased number of induced deliveries and a higher number of elective caesarean section [8]. The most common causes of false positive results are when certain disturbances and influencing variables are not taken into account (e.g., fetal behaviour states, gestational age), the non-use of additional complementary assessment methods, uncertainty of interpretation and inconsistent threshold values and assessment modalities.

For the correct interpretation of the cardiotocogram, sufficient knowledge is needed for perinatal health professionals [9]. For registered midwife the scope of practice includes monitoring the progression of pregnancy, labour and delivery and postnatal care. The European Community Midwives Directive and Midwives' Code of Practice

states that fetal monitoring is fundamental to midwifery practice and that: “the midwife must care for and assist the mother during labor and monitor the condition of the fetus in the womb by appropriate clinical and technical means”[10]. Continuous learning is an inevitable part of any health worker to ensure professional and personal enrichment and development.

There are several methodologies that can be implemented to enhance the level of knowledge of health professionals in the induction cardiocography and avert the possibility of adverse obstetric outcomes such as intrapartum hypoxia and perinatal brain damage. To enhance the level of knowledge of health professionals in the induction cardiocography and avert the possibility of adverse obstetric outcomes such as intrapartum hypoxia and perinatal brain damage, several methodologies can be implemented, including: continuous education and training programs, regular audits of CTG practices, simulation-based training, collaboration and teamwork, professional development, and evidence-based practice. These methodologies can help to ensure that health professionals have the necessary knowledge and skills to properly interpret CTG traces and respond appropriately to signs of fetal distress [4].

The aim of the present study is to determine the level of knowledge of health professionals regarding cardiocography in relation to adverse obstetric outcomes that may result from inadequate knowledge of health professionals using the methodological approach of a systematic review.

## MATERIAL AND METHOD

In the present paper a mixed methodological approach was utilized aiming to investigate the level of knowledge of health professionals about the induction cardiocography and their ability to interpret outcomes associated with adverse obstetric outcomes (fetal hypoxia and perinatal brain injury). The literature review, which developed in the introduction, examines the related to cardiocography aspects, and then the methodological approach of a systematic review is used to examine studies related to the topic under analysis aiming for a more precise and broader analysis. A systematic review search of electronic databases concerning medical care (PubMed, Medline, Cochrane, CINAHL, Scopus, WHO) was held on April 2023 in English and Greek language from inception to 2023. The sample for the systematic review consists of 8 sur-

veys of which the predominant sample has quantitative prospective research as the methodological approach. To be included in the systematic review, studies had to meet the following criteria: original research studies that provided sufficient detail on methods and results, allowing for the identification and collection of data and results. The factors responsible for the lower level of evidence were: methodological limitations, inconsistency, inaccuracy and publication bias. The study selection flow diagram is shown in Figure 2.

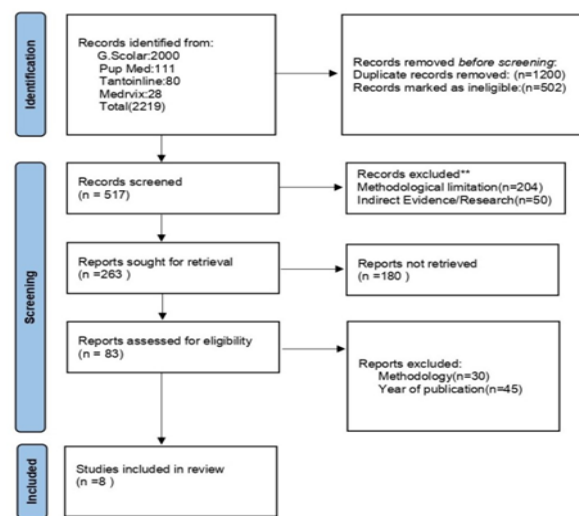


Figure 2. PRISMA flowchart

## RESULTS

The majority of the studies included in this systematic review have consistently found that there are several knowledge gaps of health professionals regarding the cardiocography and the adverse perinatal outcomes that may result from misuse or misinterpretation of CTG. Gourounti et al.(2020) conducted a study on the development and psychometric evaluation of the Electronic Fetal Monitoring (EFM) knowledge scale. The majority of midwives and obstetricians showed good levels of knowledge about EFM, while about a third had low levels of knowledge [11]. Based on research by Sindiwe, Maduna and Morton (2007) midwives in public hospitals in KwaZulu-Natal were found to have a lack of knowledge about cardiocography which may have been due to lack in-service training as more than half of the participants (70%) reported the need for this [12]. Zhu et al. (2020) evaluated a CTG training program based on fetal physiology and its impact on CTG interpretation by

healthcare professionals. The study demonstrated significant short-term improvements in CTG interpretation and consistent long-term outcomes [13]. Reif (2016) conducted a multicenter European study to investigate whether knowledge of fetal outcome influences the interpretation of intrauterine cardiotocography and subsequent clinical management. Findings indicated that when health professionals had information about adverse fetal outcomes, they tended to provide a more pessimistic assessment of detection characteristics, overall classification, and clinical management recommendations [14]. Carbonne and Sabri-Kaci (2015) evaluated an e-learning training program for the analysis of cardiotocography through a multicenter randomized trial. The findings highlighted the positive outcomes of the training program, including improvements in knowledge, interpretive skills, interobserver agreement, management of intraventricular cardiotocography, and quality of care. The study also noted that clinical skills declined faster than theoretical knowledge [15].

## CONCLUSION

The majority of the studies included in this systematic review have consistently found that there are several knowledge gaps of health professionals regarding the cardiotocography and the adverse perinatal outcomes that may result from misuse or misinterpretation of CTG. It is undeniable that errors in the interpretation of FHRM contribute significantly to infant mortality and morbidity globally. Misinterpretations of the FHRM in relation to infant mortality and morbidity were highlighted in the United Kingdom (UK) confidential enquiry into stillbirths and deaths in infancy 2001 [19]. CTG is a valuable method for reducing neonatal mortality and morbidity, but only if CTG is interpreted correctly and appropriate measures taken to ensure neonatal and maternal wellbeing, but at the same time if the user is unable to interpret the findings there is an increased chance of misdiagnosis [20]. Neonatal-related causes of death are reported as the highest contributing factor in the causes of death of children under 5 years of age worldwide. Asphyxia at birth is the third most common cause of neonatal mortality [21].

Similarly, a survey of mature stillbirths and neonatal deaths in the West Midlands region of the UK revealed that 78% of deaths were due to factors related to caregivers' clinical practice. Medical staff contributed to 39.3% of suboptimal care,

Thellesen (2017) examined the association between CTG interpretation skills and maternity unit size, years of obstetric work experience and healthcare professional background. Findings showed that working in larger maternity units and less than 15 years of obstetric experience were positively associated with better CTG knowledge, interpretation, and decision-making skills [16]. Lafontan (2018) investigated knowledge acquisition of a newly developed electronic fetal heart rate monitor among birth attendants in Tanzania. The findings highlighted the need for frequent training sessions over time to increase overall knowledge and ensure proper use of the equipment [17]. Tedesco et al. aimed to re-investigate and evaluate intrapartum fetal monitoring training in Victorian public maternity services. Findings showed that while 15 years ago most services didn't provide training to health professionals, today public and private hospitals require their obstetric and medical staff to carry out regular knowledge assessments [18].

while 12.8% was due to failure to interpret and manage CT scans [22].

Accurately interpreting CTG patterns is critical in identifying fetuses that are at risk of distress during the induction process. However, if healthcare professionals do not possess the required knowledge or make errors in interpretation, it can lead to delayed interventions or failure to intervene, resulting in intrapartum hypoxia and perinatal brain damage.

Healthcare professionals involved in labor induction must possess the appropriate knowledge and training in CTG, and the ability to recognize and respond to signs of fetal distress. This includes understanding the normal and abnormal patterns of the fetal heart rate, and the appropriate usage of interventions such as amnioinfusion, vacuum or forceps delivery, and cesarean delivery.

Constant education and training programs for healthcare professionals, coupled with regular evaluations of CTG practices, can help to enhance the knowledge and proficiency of healthcare professionals in using CTG during induction, and reduce the potential for adverse obstetric outcomes. In conclusion, the appropriate level of knowledge and proficiency of healthcare professionals in utilizing induction CTG is crucial in minimizing the risk of adverse obstetric outcomes such as intrapartum hypoxia and perinatal brain damage. Regular training and education programs ensure that healthcare professionals possess the necessary

skills and knowledge to correctly interpret CTG traces and respond appropriately to signs of fetal distress.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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