








## CLINICAL ARTICLE

## Obstetrics

# Inter- and intraobserver agreement of antenatal cardiotocography assessments by maternity care professionals: A prospective study

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## Abstract

**Objective:** In the Netherlands, antenatal cardiotocography (aCTG) to assess fetal well-being is performed in obstetrician-led care. An innovative initiative was started to evaluate whether aCTG for specific indications—reduced fetal movements, external cephalic version, or postdate pregnancy—is feasible in non-obstetrician-led care settings by independent primary care midwives. Quality assessment is essential when reorganizing and shifting tasks and responsibilities. Therefore, we aimed to assess the inter- and intraobserver agreement for aCTG assessments between and within four professional groups involved in Dutch maternity care regarding the overall classification and assessment of the various components of aCTG.

**Method:** This was a prospective study among 47 Dutch primary care midwives, hospital-based midwives, residents, and obstetricians. Ten aCTG traces were assessed twice at a 1 month interval. To ensure a representative sample, we used two different sets of 10 aCTG traces each. We calculated the degree of agreement using the proportions of agreement.

**Results:** The proportions of agreement for interobserver agreement on the classification of aCTG between and within the four professional groups varied from 0.82 to 0.94. The proportions of agreement for each professional group were slightly higher for intraobserver (0.86–0.94) than for interobserver agreement. For the various aCTG components, the proportions of agreement for interobserver agreement varied from 0.64 (presence of contractions) to 0.98 (baseline heart frequency).

**Conclusion:** The proportion of agreement levels between and within the maternity care professionals in the classification of aCTG traces among healthy women were comparable. This means that these professional groups are equally well able to classify aCTGs in healthy pregnant women.

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**Funding information**

Nationaal Regieorgaan Praktijkgericht Onderzoek SIA, Grant/Award Number: RAAK.MKB09.009

**KEYWORDS**

antenatal cardiotocography, interobserver agreement, intraobserver agreement, low-risk pregnancy, midwife-led care

## 1 | INTRODUCTION

Value-based healthcare has gained considerable momentum at international and national level. It aims to organize care based on the principle of the best possible quality of care for patients, with optimal use of resources.<sup>1,2</sup> This also holds for maternity care. Recently, three regions in the Netherlands (Nijmegen, Zwolle, and Amsterdam) started an innovative initiative according to this principle. Healthy women whose pregnancies were monitored in midwife-led practices were offered antenatal cardiotocography (aCTG) in midwife-led care, autonomously performed and assessed by a primary care midwife, for specific indications (i.e., reduced fetal movements, external cephalic version, or postdate pregnancy [41 + 0 to 41 + 6 weeks gestation]) to assess fetal well-being.<sup>3,4</sup> Usually, aCTGs are performed in obstetrician-led care only. Within this value-based healthcare initiative, pregnant women fulfilling the above criteria were offered aCTG by their midwife either at home, in the midwifery practice, or in a community healthcare center nearby. This task shift increases value for pregnant women, as it led to a reduction of referrals and an increase in the continuity of maternity care.<sup>1,4-6</sup>

There is growing evidence that task shifting to midwife-led care can be safe and effective.<sup>7</sup> Unlike in Canada, New Zealand, and Scandinavian countries, the aCTG is not yet part of the diagnostic tools available to Dutch midwives. Now that access to obstetrician-led care in the Netherlands is under pressure due to capacity issues, it is important to study the quality and usability of alternative forms of care provision, such as aCTG, in midwife-led care.<sup>8</sup> Assessment of aCTGs between groups of healthcare professionals in obstetrician-led care varies.<sup>9-14</sup> Although the interobserver agreement in the assessment of reassuring aCTGs is fair to good, low interobserver agreement was found for non-reassuring aCTGs.<sup>11,12</sup> There is also variation in the assessment of the various aCTG components: baseline heart frequency, accelerations, and contractions showed good to excellent interobserver agreement in aCTG assessment while other aCTG components such as variability and the number of decelerations did not.<sup>9,11,14</sup>

To date, little is known about the inter- and intraobserver agreement in aCTG assessment by different groups of maternity care professionals (primary care midwives, hospital-based midwives, residents, and obstetricians). Regarding the overall classification and the various components of aCTG, the aim of this study was therefore to assess: (1) the level of interobserver agreement between the four professional groups, (2) the level of interobserver agreement within

these professional groups, and (3) the level of intraobserver agreement per professional group.

## 2 | MATERIALS AND METHODS

### 2.1 | Study design

We conducted a prospective study among four professional groups involved in Dutch maternity care. All were purposively selected from different parts of the country.

The participants were provided with written information about the aim and procedure of the study and gave their written informed consent. Data about the aCTG assessments by all participants were collected between January 25, 2021 and August 29, 2021. The identity of the participants was anonymized and processed confidentially in an SPSS file. The aCTG traces used in the study were not traceable to patients. Ethical approval was requested from the Medical Ethics Committee of VU University Medical Center. They deemed the Medical Research Involving Human Subjects Act not to be applicable to our study (VUmc MEC, no. 2016.484).

### 2.2 | Setting

In the Netherlands, pregnant women at low risk receive midwife-led care from primary care midwives, while women at high risk receive obstetrician-led care from obstetricians, residents, and hospital-based midwives.<sup>15</sup> When a risk factor or a complication arises during pregnancy or childbirth, the midwife refers the woman to obstetrician-led care for consultation or transfer of care.

### 2.3 | Participants

All care professionals acquired CTG assessment skills during their initial training and are legally authorized to perform CTGs. To acquire competence in performing an aCTG, the primary care midwives providing aCTGs followed a 2-day course concluded with an examination. The course consisted of the theoretical background of the CTG, the assessment of a CTG according to the International Federation of Gynecology and Obstetrics (FIGO) guidelines,<sup>16</sup> skills needed to carry out aCTG, and training in clinical decision-making taking into

account the woman's overall well-being. To maintain competence, primary care midwives attended at least four multidisciplinary quality meetings annually with an obstetrician, organized in each region, about interpreting and evaluating aCTGs.

The participating hospital-based midwives, residents, and obstetricians were already performing aCTG monitoring daily in clinical settings and were therefore, not obligated to follow a course and attend quality meetings.

## 2.4 | Measurement

The participants were recruited by email. Each participant received personal login details for the Castor Electronic Data Capture system. In this secure environment, they received an online set of 10 aCTGs with additional information about the indication for the aCTG, the woman's pregnancy details, relevant medical history, and a scoring form to assess the aCTGs. The participants could assess the aCTGs after informed consent at a time and place convenient to them. The aCTG traces of healthy women with specific indications for aCTG (reduced fetal movements, external cephalic version, or postdate pregnancy) were obtained from the wireless portable CTG-system Sense4Baby.<sup>17</sup> The aCTG traces were at least 30 min and the paper speed was 2 cm/min. We used two sets of 10 aCTG traces each to ensure a representative sample. Each set was assessed by at least five assessors per professional group. The participants were asked to assess the same 10 aCTGs twice, in a different order, at a 1-month interval (see Appendix A1 for sample size considerations). All aCTG assessments were conducted independently, that is, assessors were blinded to the results of other assessors.

In the study, for the aCTG assessment, we used a classification system based on the FIGO classification (Figure 1). Although this classification is developed for intrapartum CTG, the Dutch Federation of Obstetrics and Gynecology also recommends using it for aCTG.<sup>18</sup> The adapted classification system for various components and overall classification was provided to the assessors.

## 2.5 | Statistical analysis

The analyses were performed using SPSS statistics 28.0 and Rstudio 2021.09.1. The baseline characteristics of the study population were analyzed using descriptive statistics. Frequencies and percentages are presented for categorical variables and means with standard deviations (SD) or medians with ranges for continuous variables.

We expressed the inter- and intraobserver agreement among professional groups as a proportion of agreement with a 95% confidence interval (CI) because agreement is a better concept than Cohen's kappa for answering our research questions. Cohen's kappa is a widely-used measure of reliability, providing information on how well subjects/objects can be distinguished from each other, while agreement measures assess to which extent classifications or scores are identical.<sup>19</sup> To calculate the degree of agreement between and within the professional groups, we used the agreement formula and calculations (R package from <https://github.com/iriseekhout/Agree>), including a 95% CI. We analyzed the interobserver agreement for the aCTG classifications (reassuring, non-reassuring) and various aCTG components (baseline heart frequency, variability, presence of accelerations, decelerations, and contractions) for each possible pairing of two participants. At least five assessors in each professional group led to a minimum of 10 different pairs of assessors in each professional group, calculated by  $(m * (m - 1) / 2)$ , where  $m$  is the number of assessors. This means the proportion of agreement for each set of 10 aCTGs was calculated on at least 100 pairwise comparisons.

For the interobserver agreement between the professional groups, the classification of 10 aCTGs of each primary care midwife's first assessment were compared with those of each hospital-based midwife, resident and obstetrician. Similarly, hospital-based midwives were compared with residents and obstetricians, and residents with obstetricians. Two professional groups always concerned five versus five assessors, so there were 25 comparisons per aCTG and 250 pairwise comparisons per set of 10 aCTGs. The proportion of agreement of the first and second set of 10 aCTGs was statistically pooled.

Antenatal CTG classification				
CTG classification	Baseline Heart Frequency (bpm)	Accelerations and variability	Decelerations	Contractions
<b>Reassuring:</b> The CTG complies with <i>all</i> criteria	110-150	Minimal two accelerations in a 45-minute CTG tracing  Variability 5-25 bpm	Absence of decelerations	Maximum of two contractions per 10 minutes  Absence of hypertonia
<b>Non-reassuring:</b> The CTG deviates from <i>one or more</i> criteria	<110 or >150	< two accelerations in a 45-minute CTG tracing  Variability <5 or > 25 bpm	Presence of 1 or more decelerations	>two contractions per ten minutes.  Presence of hypertonia

FIGURE 1 Antenatal cardiotocography (CTG) classification system used in the study. CTG, cardiotocography; bpm, beats per minute.

For the interobserver agreement within the professional groups, the proportion of agreement was calculated within five assessors. Therefore, the formula  $m(m-1)/2$  applies. The results were statistically pooled over the first and second set of 10 aCTGs.<sup>20</sup>

For the intraobserver agreement, the results of the first and second assessments of each individual assessor for each aCTG were compared. The results were statistically pooled over the members of each professional group.<sup>20</sup>

Whether the four professional groups differed in proportions of intra- and interobserver agreement was tested with the independent sample *t*-test for differences in proportions. A *P* value below 0.05 was considered statistically significant. Appendix A1 justifies the statistical methods used.

### 3 | RESULTS

Figure 2 shows the inclusion of the participants. A total of 66 health-care professionals were asked to participate, of whom 47 (71.2%) took part in the study. In the first round, 23 participants (at least 5 per professional group) assessed the first set of 10 aCTGs, and 24 other participants (at least 5 per professional group) assessed the second set of aCTGs. In the second round, the 47 participants were asked to assess—after a 1-month interval—the same aCTGs they assessed before, in a different order. Five participants did not complete the second round and were excluded from the intraobserver analyses.

Table 1 shows the baseline characteristics of the participants. The mean work experience with aCTG assessment was 7.6 years (SD 6.3), varying from 3.7 (SD 1.4) (primary care midwives) to 16.7 years (SD 4.0) (obstetricians). The median training in aCTG assessment yearly varied from 8.0h (primary care midwives) (range 6.0–16.0) and residents (range 1.0–30.0) to 11.5h (range 3.0–70.0) (obstetricians). In the first set of 10 aCTG traces, one out of ten aCTGs appeared to be non-reassuring according to most assessors, and in the second set, five out of 10 aCTGs appeared to be non-reassuring according to most assessors.

Table 2 presents the results of the interobserver agreement on the classification of aCTG patterns (reassuring, non-reassuring) between the four professional groups (in the off-diagonal cells) and within the professional groups (in the diagonal cells). The proportions of agreement between and within the four professional groups varied from 0.82 (95% CI: 0.67–0.91) to 0.94 (95% CI: 0.87–0.98). We found no differences in proportions of agreement within the professional groups among obstetricians and either primary care or hospital-based midwives. We did find a statistically significant difference in the proportion of agreement within the obstetricians versus residents (−0.12 [−0.03;−0.21], *P* value 0.006).

Table 3 describes the intraobserver agreement for the classification of aCTG patterns for the professional groups. The proportions of agreement were slightly higher for intraobserver than for interobserver agreement and varied from 0.86 (95% CI: 0.55–0.97)

to 0.94 (95% CI: 0.66–0.99) for aCTG classification for the various professional groups. We found no differences in proportions of intraobserver agreement between obstetricians and the other professional groups.

We also investigated the inter- and intraobserver agreement on the different components (baseline heart frequency, variability, accelerations, decelerations, and contractions) of aCTG patterns between and within the four professional groups. These results are presented in Tables S1 and S2. For interobserver agreement, the proportions of agreement on the aCTG components varied from 0.64 (presence of contractions) to 0.98 (baseline heart frequency). Overall, the proportions of agreement for the various aCTG components between and within the professional groups were comparable. The proportions of agreement for each professional group were slightly higher for intraobserver than for interobserver agreement.

### 4 | DISCUSSION

We aimed to study the inter- and intraobserver agreement between and within maternity care professionals (primary care midwives, hospital-based midwives, residents, and obstetricians) in the assessment of aCTG traces among healthy women with an indication for an aCTG (reduced fetal movements, external cephalic version, or post-date pregnancy). The proportions of agreement for interobserver

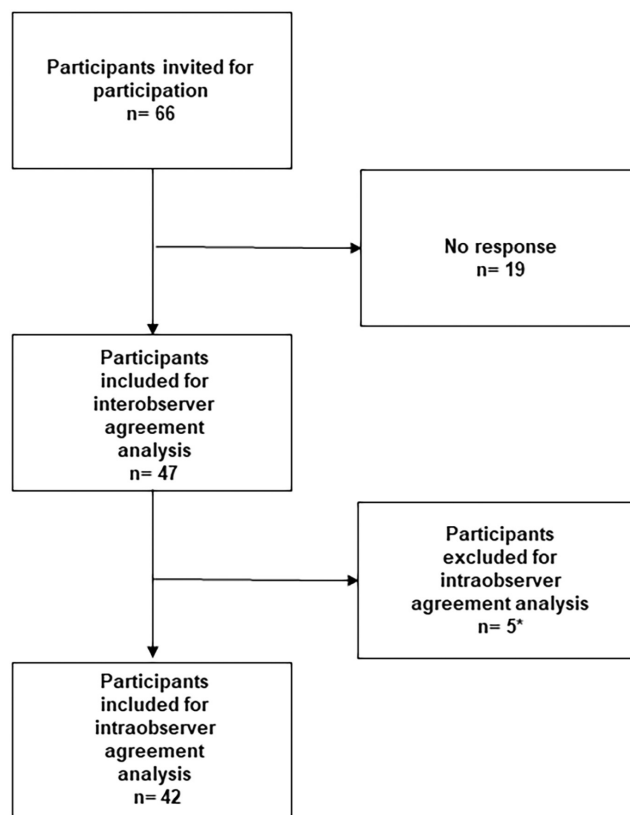


FIGURE 2 Flow chart of the participants. \*Exclusion of participants, because of incomplete surveys (primary care midwives  $n=2$ , hospital-based midwives  $n=1$ , residents  $n=2$ ).

TABLE 1 Baseline characteristics of the participating maternity care professionals.

	All professionals <i>n</i> = 47 (100%)	Primary care midwives <i>n</i> = 12 (25.5%)	Hospital-based midwives <i>n</i> = 12 (25.5%)	Residents <i>n</i> = 13 (27.7%)	Obstetricians <i>n</i> = 10 (21.3%)
Age (years), mean (SD)	36.5 (9.4)	35.0 (6.7)	39.2 (13.8)	30.1 (2.6)	43.2 (6.0)
Work experience in maternity care (years), mean (SD)	11.2 (8.8)	11.2 (7.3)	14.1 (12.5)	4.1 (2.2)	16.7 (4.0)
Work experience in current profession (years), mean (SD)	8.4 (7.8)	11.2 (7.3)	9.9 (11.2)	3.7 (2.2)	9.2 (6.0)
Work experience in CTG assessment (years), mean (SD)	7.6 (6.3)	3.7 (1.4)	8.0 (6.5)	4.0 (1.8)	16.7 (4.0)
Hours of training in CTG assessment (yearly), median (range)	8.0 (0–70.0)	8.0 (6.0–16.0)	9.0 (0–50.0)	8.0 (1.0–30.0)	11.5 (3.0–70.0)

Abbreviations: CTG, cardiotocography; SD, standard deviation.

TABLE 2 Interobserver agreement in classification (reassuring and non-reassuring) of antenatal CTGs between (values off the diagonal) and within (values on the diagonal) professional groups using proportions of agreement.

	Proportions of agreement (95% CI)			
	Primary care midwives	Hospital-based midwives	Residents	Obstetricians
Primary care midwives	0.84 (0.72–0.91)	0.84 (0.73–0.90)	0.83 (0.73–0.90)	0.82 (0.71–0.90)
Hospital-based midwives	x	0.86 (0.75–0.92)	0.90 (0.81–0.95)	0.86 (0.75–0.93)
Residents	x	x	0.94 (0.87–0.98)	0.87 (0.77–0.93)
Obstetricians	x	x	x	0.82 (0.67–0.91)

Abbreviations: CI, confidence interval; CTG, cardiotocography.

TABLE 3 Intraobserver agreement in classification (reassuring and non-reassuring) of antenatal CTGs for professional groups in maternity care using proportions of agreement.

Proportions of agreement (95% CI)			
Primary care midwives	Hospital-based midwives	Residents	Obstetricians
0.92 (0.62–0.99)	0.94 (0.66–0.99)	0.91 (0.63–0.98)	0.86 (0.55–0.97)

Abbreviations: CI, confidence interval; CTG, cardiotocography.

agreement on the classification of aCTG between and within the four professional groups varied from 0.82 to 0.94. The proportions of agreement for each professional group were slightly higher for intraobserver (0.86–0.94) than for interobserver agreement. For the various aCTG components, the proportions of agreement for interobserver agreement varied from 0.64 (presence of contractions) to 0.98 (baseline heart frequency).

To the best of our knowledge, the strength of this study is that it is the first to include both primary care midwives and obstetrician-led care professionals (hospital-based midwives, residents, and obstetricians). For data collection, we used an efficient approach to maximize the number of aCTGs without extra work for the professionals. With at least five assessors per professional group for each set of 10 aCTGs, we guaranteed a reasonable sample of the four professional groups (*n* = 47). The sample size was large enough to gain sufficient power (20 aCTGs) (see Appendix A1 for sample size considerations).<sup>21,22</sup> However, some limitations need to be addressed. Standard criteria for agreement measures are not available. There

are various suggestions in literature on how agreement levels can be labeled, although these guidelines are arbitrary.<sup>23,24</sup>

Another limitation is that the participants in our sample, who worked in obstetrician-led care, more frequently worked in the same center and region than the participating primary care midwives. The literature shows that professionals working in the same center share similar clinical cultures, which could have influenced the results (observer bias).<sup>25</sup> We tried to minimize observer bias (1) by using multiple assessors per professional group, (2) all assessors were trained, and (3) by standardizing our procedure. Furthermore, the risk of observer bias was the same for each group of professionals; therefore, we do not expect this has impacted our results.

Despite the fact that aCTGs were sent to the participants via a personal link, there is no absolute guarantee that all aCTG assessments were completed individually.

Other studies on the reliability of the overall classification of CTG patterns among healthcare professionals in obstetrician-led care showed a lower rate of observer agreement.<sup>12,13</sup> Ayres-de-Campos

et al. found a proportion of agreement of 0.62 for normal traces, 0.42 for suspicious traces, and 0.25 for pathological traces.<sup>12</sup> This difference in agreement levels compared to our findings may partly be related to the fact that they expressed the proportion of agreement for ante- and intrapartum CTGs together and not specifically for antepartum CTG traces as in our study. In our study, the participants assessed a sample of aCTGs selected from a population of healthy women with a specific aCTG indication, which includes a larger number of reassuring traces and thus yields a higher level of agreement.<sup>25</sup>

Previous studies showed variable results for the assessment of the various components of the aCTG: good to excellent interobserver agreement in aCTG assessment was found for baseline heart frequency, accelerations, and contractions, in contrast to other aCTG components such as the variability and decelerations.<sup>9,11</sup> In our study, for the various aCTG components, the proportions of agreement for interobserver agreement varied from 0.64 (presence of contractions) to 0.98 (baseline heart frequency). We suggest two main reasons for these differences. First, in our study the aCTG component deceleration was dichotomized into present or absent, instead of classifying deceleration as early, variable, or late, as defined in FIGO guideline. Second, exposure to aCTGs in clinical practice has increased in the past decade, potentially improving professionals' assessment of aCTGs.

Other studies showed that both clinical midwives and residents had better agreement than obstetricians.<sup>25,26</sup> We also found that the level of interobserver agreement in the classification of aCTGs within the professional group of residents was higher than within the group of obstetricians. Di Lieto et al. assessed the agreement in aCTG interpretation between experienced and inexperienced assessors. They found no differences between experienced and inexperienced professionals.<sup>14</sup> This is in line with our results, showing comparable interobserver agreement levels between different professionals (e.g., primary care midwives and obstetricians) for the classification of aCTGs, despite differences in years of experience.

In line with the literature,<sup>13</sup> we detected a slightly higher level of intraobserver agreement than interobserver agreement for the classification of aCTGs. This observation shows consistency in the assessment of aCTGs by all maternity care professionals.

It should be noted that high levels of agreement do not necessarily mean that the aCTGs have been assessed correctly. It indicates whether different professional groups provided the same assessment with a comparable level of error when classifying aCTGs.

This study showed that the quality of aCTG assessment is equally good for primary care midwives, hospital-based midwives, residents, and obstetricians. In addition, our previous work showed high satisfaction among women and reassuring maternal and perinatal outcomes after aCTG.<sup>27,28</sup> We therefore recommend reconsidering the current strict task division between primary care midwives and obstetrician-led care and optimizing the roles of these professionals, hereby contributing to accessible care.

However, continued governance of quality of care in midwife-led and obstetrician-led care remains an important issue.

For the assessment of aCTG, a classification system based on the FIGO classification was used, although FIGO originally was developed for intrapartum use. The Dutch Federation of Obstetrics and Gynecology, however, also recommends using it for aCTG.<sup>18</sup> The authors recommend implementing an internationally accepted classification system for assessing aCTGs.

Another implementation strategy could be using computerized CTG, which has been suggested to increase the level of agreement on CTG classification since this assessment is more objective, although it did not lead to better perinatal outcomes.<sup>29</sup>

Future studies are needed to establish the added value of these strategies to the level of agreement in the assessment between and within the professional groups in maternity care.

## AUTHOR CONTRIBUTIONS

Elise M. Neppelenbroek, Henrica C. W. de Vet, Amanda J. J. de Groot and Corine J. M. Verhoeven contributed to the conceptualization of the study, design, data analysis, interpretation of the data and drafting of the manuscript. Olivier W. H. van der Heijden, Darie O. A. Daemers and Ank de Jonge contributed to the conceptualization of the study, interpretation of the data and reviewing and editing of the manuscript. All authors agreed with the final version and have agreed to be accountable for the integrity of the data published.

## ACKNOWLEDGMENTS

We would like to thank Iris Eekhout for her consultation role during the analysis. We would also like to thank the participants for their contributions to this study.

## FUNDING INFORMATION

National Agency for Practice-Oriented Research (SIA), part of NWO.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are available from the corresponding author upon request.

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## REFERENCES

1. de Jonge A, Downe S, Page L, et al. Value based maternal and newborn care requires alignment of adequate resources with high value activities. *BMC Pregnancy Childbirth*. 2019;19(1):1-6.
2. Porter ME, Teisberg EO. *Redefining Health Care: Creating Value-Based Competition on Results*. Harvard Business Press; 2006.

3. Grivell RM, Alfirevic Z, Gyte GM, Devane D. Antenatal cardiotocography for fetal assessment. *Cochrane Database Syst Rev*. 2015;9:CD007863.
4. Neppelenbroek E, Verhoeven C. *Handboek implementatie antenataal CTG in verloskundigenpraktijken*. Amsterdam UMC, location Vrije Universiteit Amsterdam, Midwifery Science; 2022:1-102.
5. Sandall J, Soltani H, Gates S, Shennan A, Devane D. Midwife-led continuity models versus other models of care for childbearing women. *Cochrane Database Syst Rev*. 2016;4:CD004667.
6. Martínez-González NA, Djalali S, Tandjung R, et al. Substitution of physicians by nurses in primary care: a systematic review and meta-analysis. *BMC Health Serv Res*. 2014;14(1):1-17.
7. Colvin CJ, de Heer J, Winterton L, et al. A systematic review of qualitative evidence on barriers and facilitators to the implementation of task-shifting in midwifery services. *Midwifery*. 2013;29(10):1211-1221.
8. van den Berg LM, Gordon BBM, Kleefstra SM, et al. Centralisation of acute obstetric care in the Netherlands: a qualitative study to explore the experiences of stakeholders with adaptations in organisation of care. *BMC Health Serv Res*. 2021;21(1):1-9.
9. Bernardes J, Costa-Pereira A, Ayres-de-Campos D, van Geijn H, Pereira-Leite L. Evaluation of interobserver agreement of cardiotocograms. *Int J Gynecol Obstet*. 1997;57(1):33-37.
10. Donker DK, van Geijn HP, Hasman A. Interobserver variation in the assessment of fetal heart rate recordings. *Eur J Obstet Gynecol Reprod Biol*. 1993;52(1):21-28.
11. Figueras F, Albela S, Bonino S, et al. Visual analysis of antepartum fetal heart rate tracings: inter-and intra-observer agreement and impact of knowledge of neonatal outcome. 2005.
12. Ayres-de-Campos D, Bernardes J, Costa-Pereira A, Pereira-Leite L. Inconsistencies in classification by experts of cardiotocograms and subsequent clinical decision. *Br J Obstet Gynaecol*. 1999;106(12):1307-1310.
13. Lotgering FK, Wallenburg HC, Schouten HJ. Interobserver and intraobserver variation in the assessment of antepartum cardiotocograms. *Am J Obstet Gynecol*. 1982;144(6):701-705.
14. Di Lieto A, Giani U, Campanile M, de Falco M, Scaramellino M, Papa R. Conventional and computerized antepartum telecardiotocography. *Gynecol Obstet Investig*. 2003;55(1):37-40.
15. Obstetric Vademecum. *Eindrapport van de Commissie Verloskunde van het College voor zorgverzekeringen [Final Report of the Advisory board on Obstetrics of the Health Care Insurance Board]*. College voor Zorgverzekeringen; 2003.
16. Ayres-de-Campos D, Spong CY, Chandrachan E, Panel FIFMEC. FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. *Int J Gynecol Obstet*. 2015;131(1):13-24.
17. Sense4Baby. Accessed September 17, 2022. <https://www.ict-healthcare.eu/nl/oplossingen/ctg-thuismonitoring/sense4baby>
18. Kolkman D, Offerhaus P, Middeldorp JM, Erwich JJHM. *NVOG KNOV Guideline*. Verminderde kindsbewegingen tijdens de zwangerschap; 2013.
19. Kottner J, Audigé L, Brorson S, et al. Guidelines for reporting reliability and agreement studies (GRRAS) were proposed. *Int J Nurs Stud*. 2011;48(6):661-671.
20. Mokkink LB, de Vet H, Diemeer S, Eekhout I. Sample size recommendations for studies on reliability and measurement error: an online application based on simulation studies. *Health Serv Outcome Res Methodol*. 2023;23(3):241-265.
21. Nezek JB. A practical guide to understanding reliability in studies of within-person variability. *J Res Pers*. 2017;69:149-155.
22. Altaye M, Dormer A, Klar N. Inference procedures for assessing interobserver agreement among multiple raters. *Biometrics*. 2001;57(2):584-588.
23. Cicchetti D, Bronen R, Spencer S, et al. Rating scales, scales of measurement, issues of reliability: resolving some critical issues for clinicians and researchers. *J Nerv Ment Dis*. 2006;194(8):557-564.
24. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159-174.
25. Rei M, Tavares S, Pinto P, et al. Interobserver agreement in CTG interpretation using the 2015 FIGO guidelines for intrapartum fetal monitoring. *Eur J Obstet Gynecol Reprod Biol*. 2016;205:27-31.
26. Rhöse S, Heinis AM, Vandenbussche F, van Drongelen J, van Dillen J. Inter- and intra-observer agreement of non-reassuring cardiotocography analysis and subsequent clinical management. *Acta Obstet Gynecol Scand*. 2014;93(6):596-602.
27. Neppelenbroek EM, Ammerlaan AJ, van der Heijden OW, et al. Antenatal cardiotocography in primary midwife-led care: Women's satisfaction. *Birth (Berkeley, Calif)*. 2023;50:798-807.
28. Neppelenbroek EM, Verhoeven CJ, van der Heijden OW, et al. Antenatal cardiotocography in dutch primary midwife-led care: maternal and perinatal outcomes and serious adverse events. A prospective observational cohort study. *Women Birth*. 2024;37(1):177-187.
29. Baker H, Pilarski N, Hodgetts-Morton V, Morris R. Comparison of visual and computerised antenatal cardiotocography in the prevention of perinatal morbidity and mortality. A systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. 2021;263:33-43.

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Neppelenbroek EM, van der Heijden OWH, de Vet HCW, et al. Inter- and intraobserver agreement of antenatal cardiotocography assessments by maternity care professionals: A prospective study. *Int J Gynecol Obstet*. 2024;00:1-7. doi:[10.1002/ijgo.15497](https://doi.org/10.1002/ijgo.15497)