

ESTABLISHING SIGNAL LOSS THRESHOLDS IN NON-INVASIVE FETAL ECG ACQUIRED HEART RATE RECORDINGS

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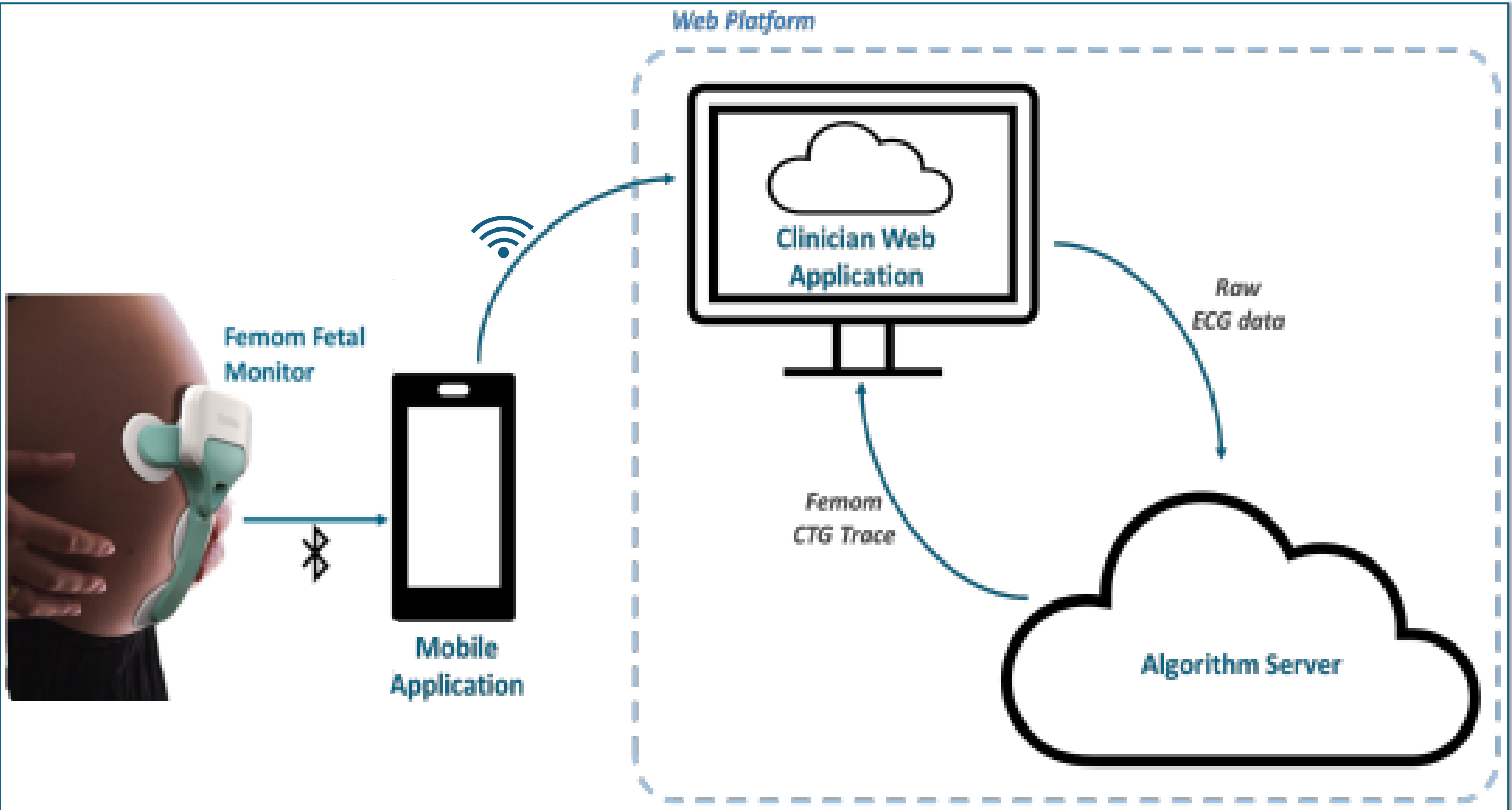
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Background:

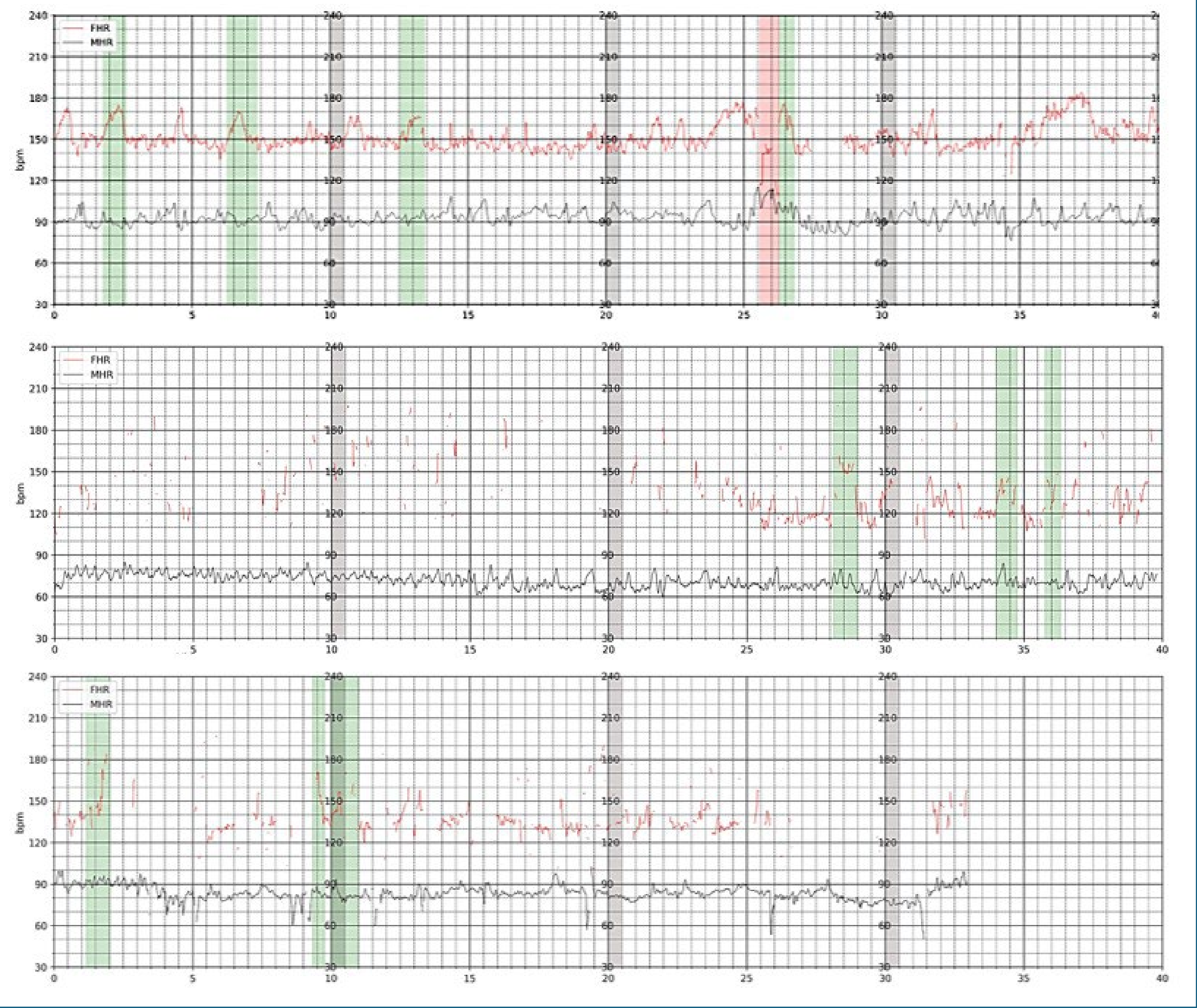
- Fetal Heart rate (FHR) monitoring is the cornerstone of antenatal fetal care. Remote fetal monitoring is possible using non-invasive fetal ECG (NIFEKG) Such devices, like Femom® enable more frequent and comfortable monitoring in high and low risk pregnancies.
- Commonly accepted threshold for signal loss in FHR monitoring is arbitrarily set at 50% of the entire monitoring session. However, NIFEKG recordings are prone to discontinuous signal, and some traces are deemed unacceptable despite long periods of good signal.
- Rigid arbitrary criteria based solely on total signal loss may unnecessarily exclude valuable data.

The aim of this study was to explore how modifying signal loss thresholds affects the proportion of traces which are acceptable. We assessed the impact of total as well as consecutive interpretable minutes on the proportion of NIFEKG traces deemed acceptable.



The Femom® device consists of a pod and a spreader which stick to the mother's abdomen with electrodes. It has been developed for self application by mothers without healthcare worker intervention. It connects to the mobile phone via Bluetooth. Monitoring sessions are started using the mobile application. The app transfers the data to the Clinician's web portal via wifi. The algorithm server translates the raw ECG data into a Femom CTG trace.

Examples of Femom® CTG traces: The first trace demonstrates minimal signal loss and would be deemed acceptable under conventional criteria. The lower two exceed 50% overall signal loss. The second contains at least 10 consecutive interpretable minutes. The third trace illustrates 10 total interpretable minutes distributed non-consecutively across the recording.



Methods

Low-risk women more than 26 weeks' gestation were approached in the antenatal clinic setting in a tertiary hospital. Self-applied home FHR monitoring was performed using the Femom® device (Biorithm Pte, Singapore). Participants were instructed to monitor FHR at home daily for minimum 45 minutes for 7 days.

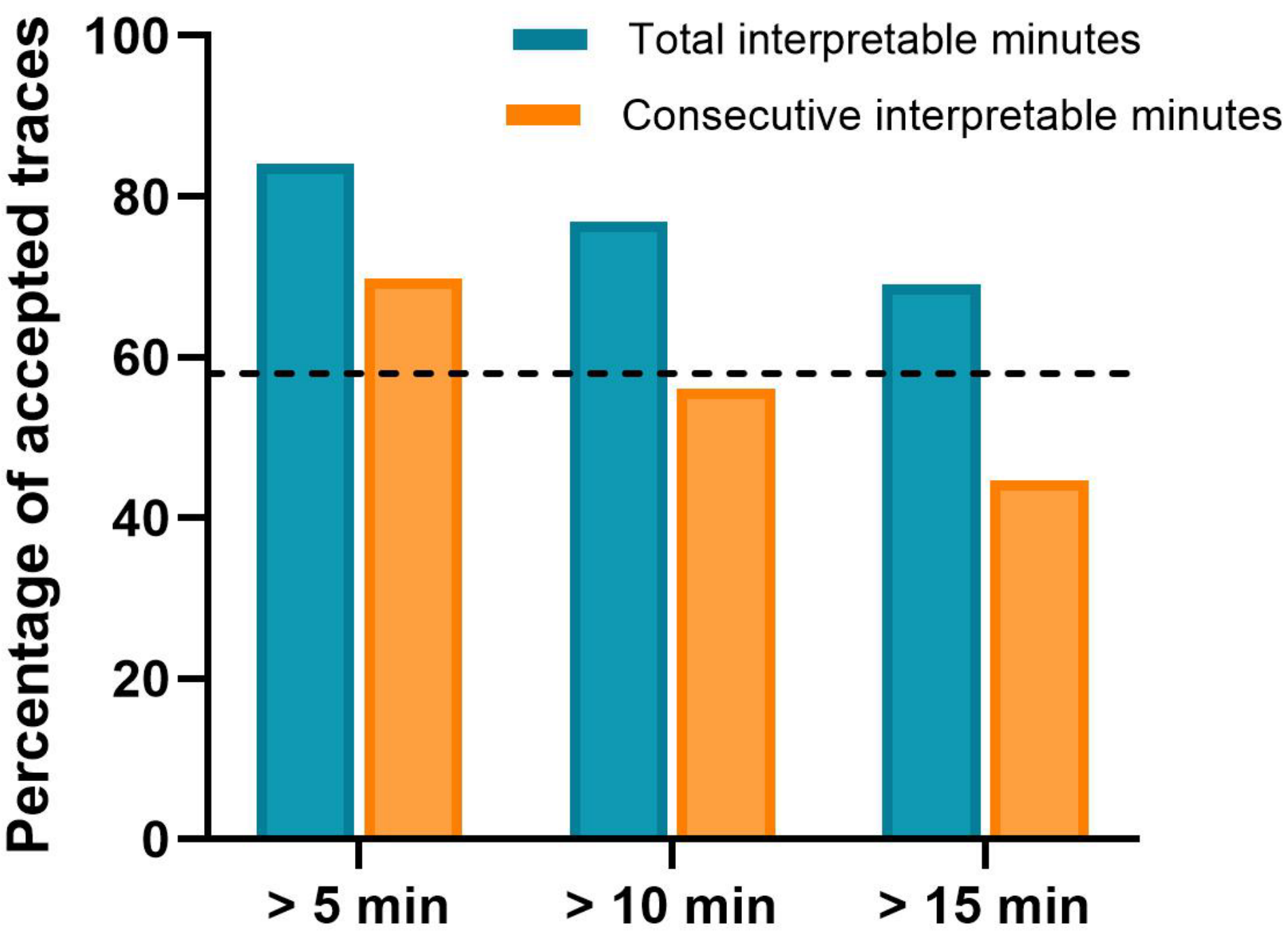
The raw ECG signal underwent de-noising and amplification to obtain the fetal ECG. Each trace was processed to calculate the number of interpretable minutes using time window shifting in 15 second increments. These were defined as minutes with <50% signal loss at 4Hz. Consecutive interpretable minutes were also recorded.

Results

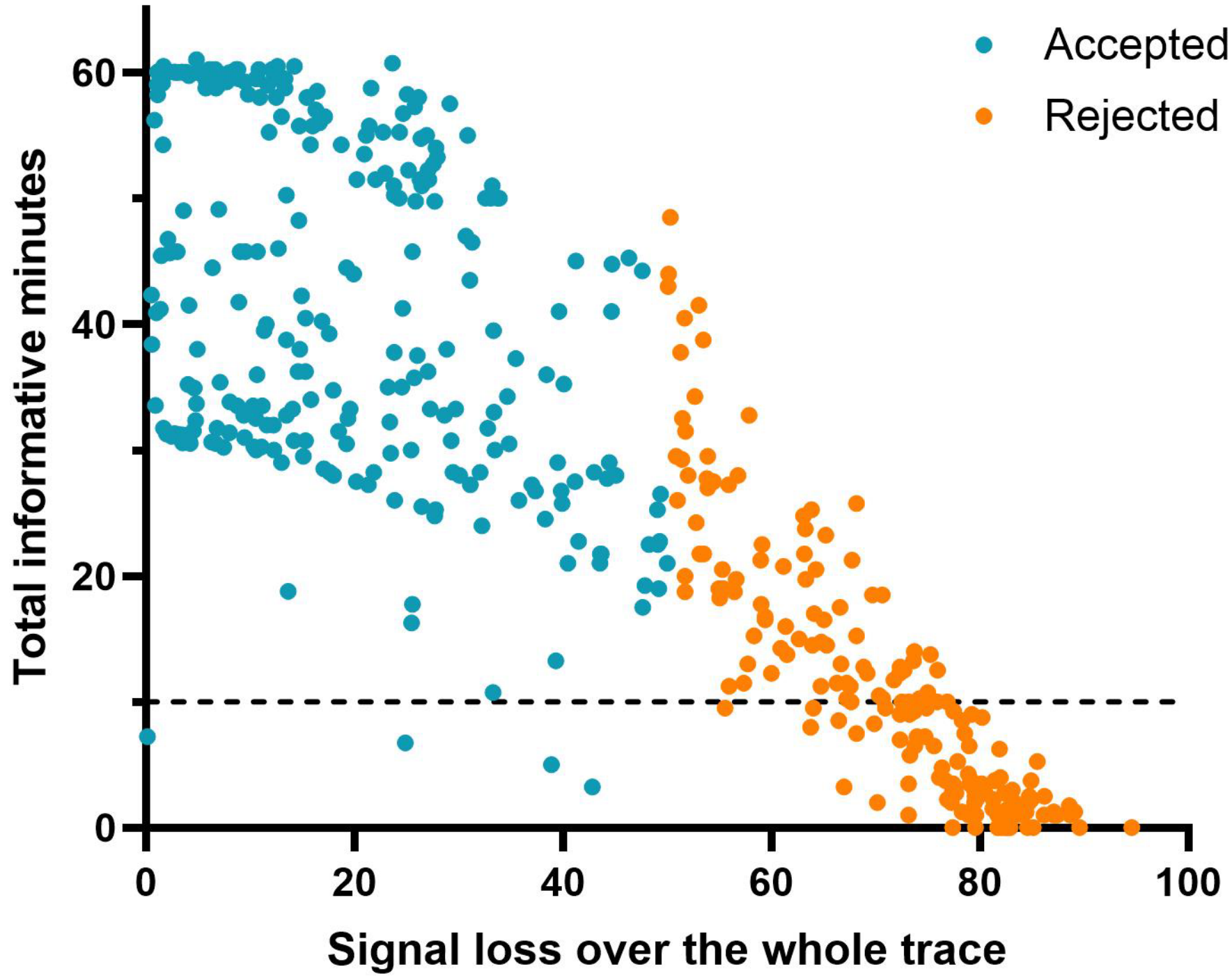
- 99 low risk patients
464 traces
- Gestation age 35+4 (IQR: 31+2-38+1)
Length of recording: 42min (IQR: 32-60min)



Signal loss over the whole trace 35.12% (IQR:13.1-70.0%)
Total interpretable minutes 29.4min (IQR: 10.3-45.8)
Consecutive Interpretable minutes 12.3min (IQR 3.8-30.5)



Histogram showing the proportion of acceptable traces under different signal loss thresholds. Blue bars represent total interpretable minutes; orange bars represent consecutive minutes. The dotted line marks the current <50% signal loss threshold, which accepts 58% of traces.



Scatterplot showing overall signal loss (%) vs. total interpretable minutes per trace. Colours indicate classification based on the current 50% signal loss threshold. The dotted line marks a proposed 10-minute threshold, which would increase the number of acceptable traces.

Conclusion

- The criteria currently used to decide if a trace acceptable, are based on arbitrary signal loss thresholds. This study shows that using different thresholds with alternative time epochs can improve the yield of acceptable NIFEKG traces.
- Further studies and larger numbers are needed to validate alternative signal loss thresholds and the influence this change may have on assessing fetal status.

References:

1. Liu, B., Ridder, A., Smith, V., Thilaganathan, B. & Bhide, A. Basky Thilaganathan & Amar Bhide (2023) Feasibility of antenatal ambulatory fetal electrocardiography: a systematic review. *The Journal of Maternal-Fetal & Neonatal Medicine* **36**, (2204).
2. Liu, B., Thilaganathan, B. & Bhide, A. Correlation of short-term variation derived from novel ambulatory fetal electrocardiography monitor with computerized cardiotocography. *Ultrasound in Obstetrics & Gynecology* (2023) doi:10.1002/uog.26191.