main page

Continuous Monitoring of Placental Blood Flow

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Clinical Population: Pregnant women with known or suspected placental blood flow complications.

Unmet Needs

Pregnant women with placental blood flow complications are at risk of reduced oxygen and nutrient delivery to the fetus, which can affect growth and development.

While routine ultrasounds are usually performed during pregnancy, they only provide snapshots in time. Changes in blood flow can occur between visits, leaving potential issues undetected. Continuous monitoring of maternal blood flow makes sure that the placenta is delivering enough oxygen and nutrients and allows clinicians to respond quickly if perfusion (the flow of blood through the placenta) is reduced.

Although ultrasound is safe,it usually needs to be performed in a hospital or clinic, and factors like scheduling, cost, and accessibility make it difficult to use for real-time monitoring.

Why Continuous Blood Flow Monitoring Matters

Even short-term reductions in perfusion can have clinical consequences. Continuous monitoring helps clinicians to observe trends over time, making it possible to detect gradual declines before they reach critical levels and intervene earlier.

Proposed Device

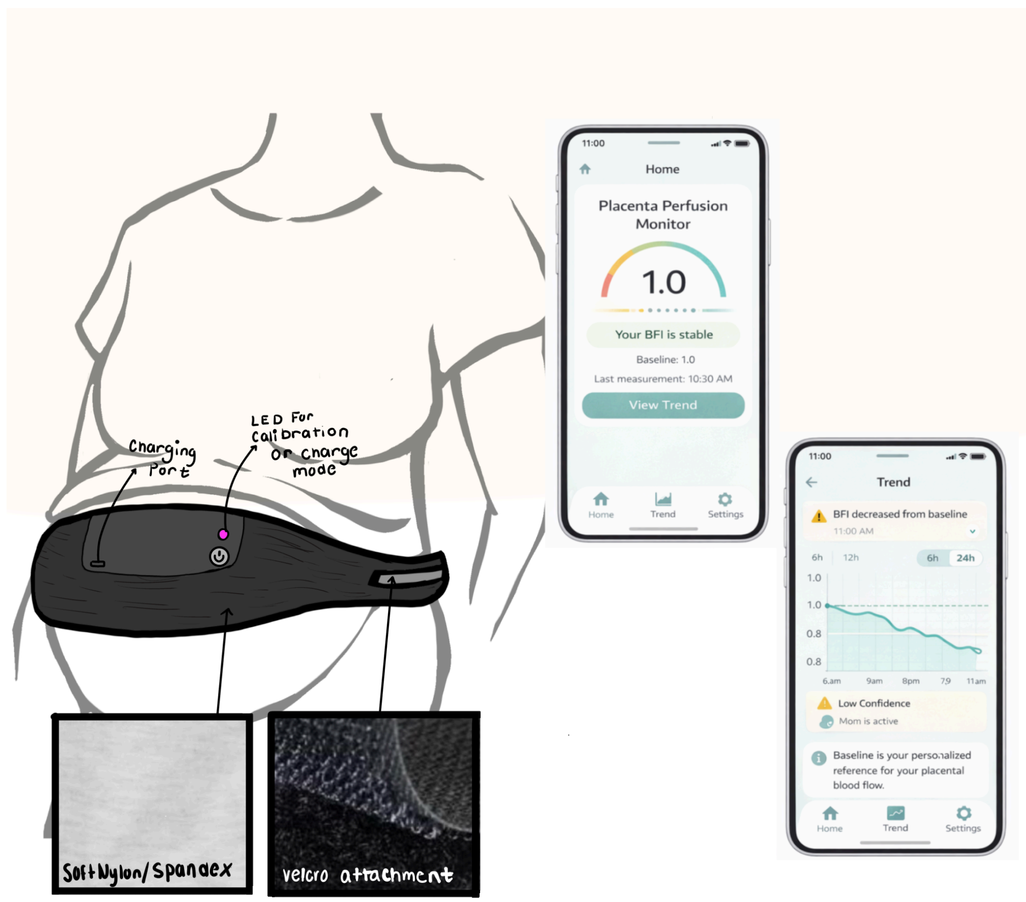
We propose a soft, adjustable belt worn around the abdomen that uses **Diffuse Correlation Spectroscopy (DCS)** to continuously track placental blood flow. The belt sends data to a smartphone app, showing real-time trends, history, and alerts if blood flow drops, helping clinicians intervene early. It's comfortable, non-invasive, and personalized.

The device continuously measures Blood Flow Index (BFI), a relative measure of how fast red blood cells are moving in the placenta. Instead of providing a single value, the system tracks changes in BFI over time, which is more clinically meaningful for monitoring placental perfusion.

Each patient establishes a personal baseline by wearing the device at rest for 5–10 minutes. Future measurements are compared to this baseline:

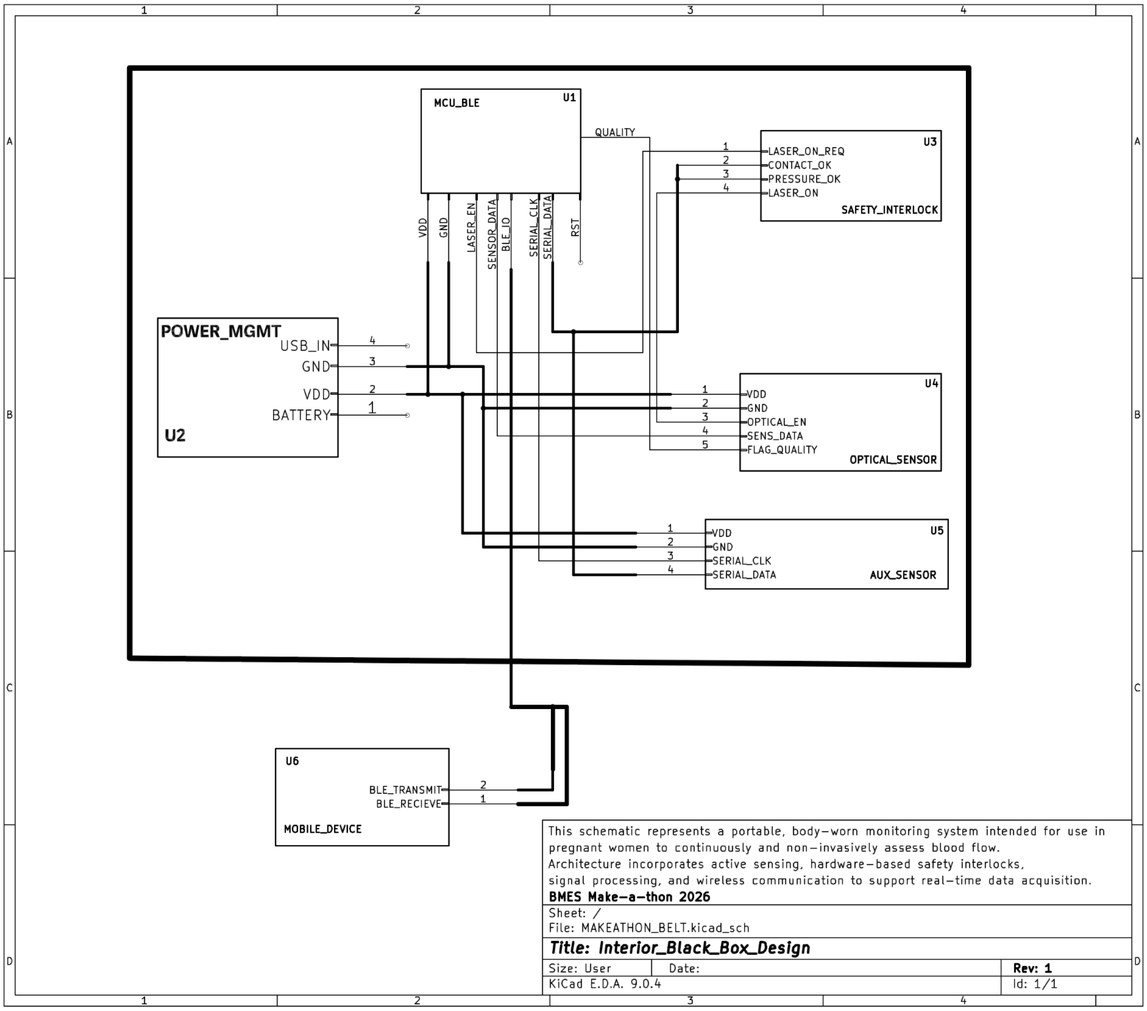
Belt Features:

- Adjustable Strap:
  - Made of soft, elastic nylon and bamboo-spandex material (similar to postpartum support belts). Non-invasive, only gentle contact.
  - Lightweight and ergonomic for comfort during daily activities and sleep.
  - Velcro straps allow adjustment to fit changes in belly size throughout pregnancy.
  - LED above the power button indicates calibration or battery charging status.



- Electronics "Black Box":
  - Compact hub attached to the strap that houses all functional components:
    - NIR(Near-Infrared) laser diodes for light emission
    - Photodiodes for detecting scattered photons
    - Optical fibers to allow flexible sensor placement

- ■ Central electronics hub containing control PCB (Printed Circuit Board), battery, and wireless module

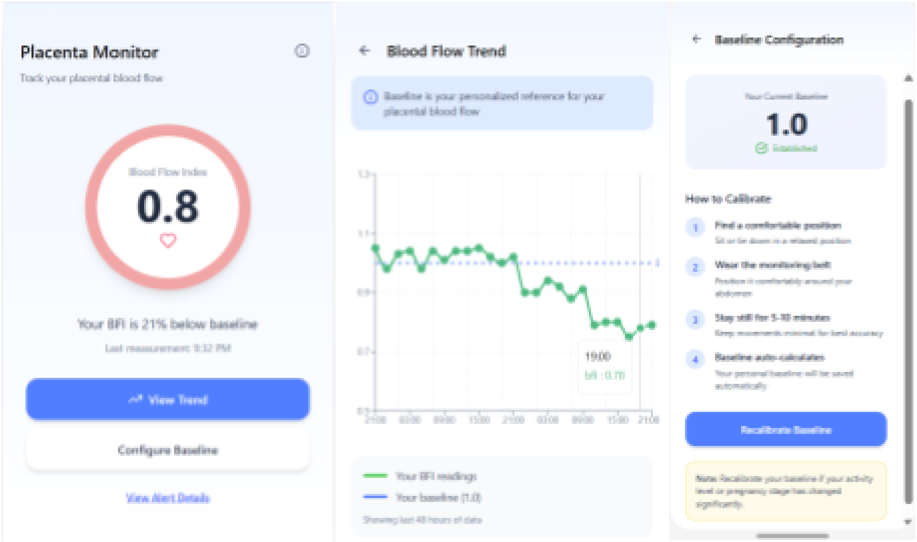


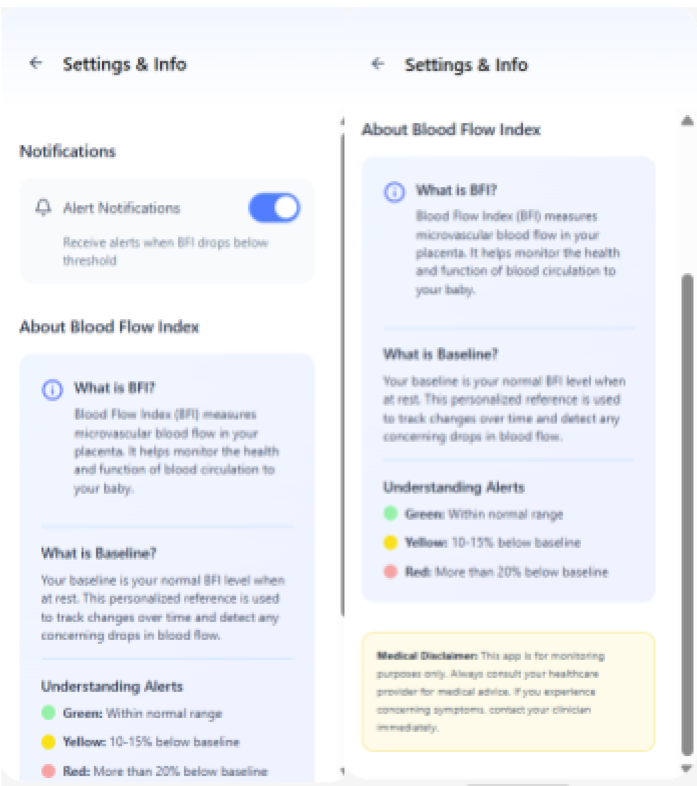
App Features:

- Home Screen: Displays real-time Blood Flow Index (BFI). Higher BFI indicates more blood flow; lower BFI indicates reduced perfusion.

- History Tab: Shows blood flow data over days and weeks, allowing users and clinicians to track trends.

- Alerts Tab: Provides active alerts, clinical guidance, and contact information for the care team.





Data Interpretation Pathway:

1. Continuous BFI measurements are collected by the belt

2. Data is compared to the patient-specific baseline:
    - Measured over 5–10 minutes at rest to set a patient-specific baseline
    - Can be updated periodically as pregnancy progresses.

3. Percent changes in BFI are calculated

4. Alerts are generated when thresholds are crossed

5. Data is visualized in the app for clinicians to review trends

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Safety, Usability, and Accessibility

- Fully non-invasive with no skin penetration
- NIR laser power kept within established safety limits for pregnancy
- Black sensor housing blocks ambient light and prevents overheating (in Schematic)
- Encrypted data storage in app protects patient privacy
- Designed for home use, reducing the need for frequent hospital visits

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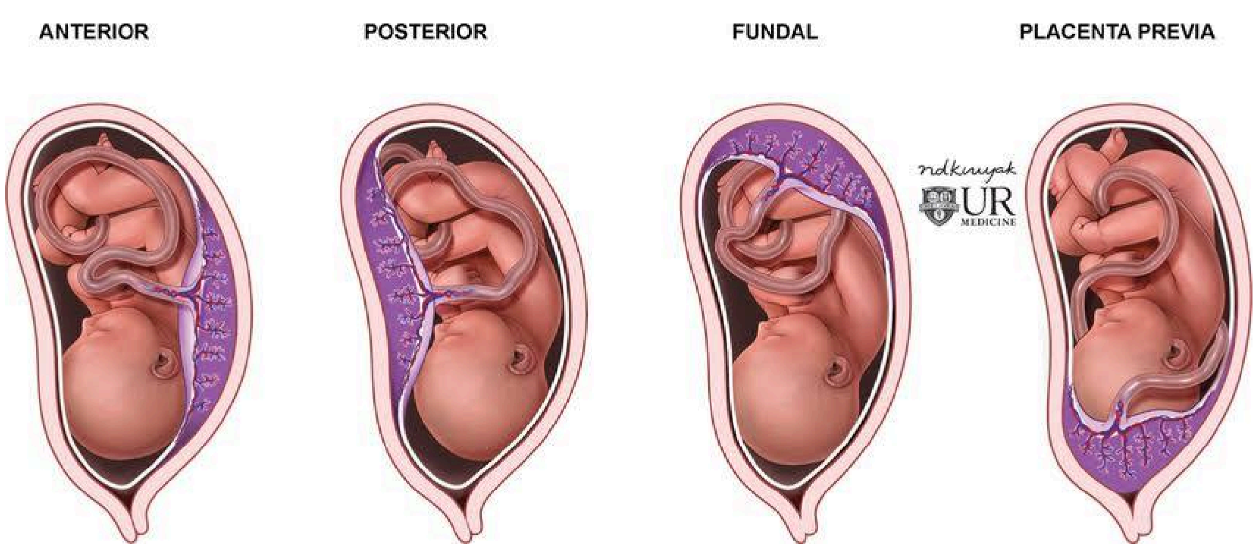
Power, Sustainability & Long-Term Use

The belt is designed to be reusable throughout the entire pregnancy, reducing waste and cost compared to single-use adhesive patches. After proper cleaning and sensor replacement if needed, the device can be safely reassigned to other patients, making it more sustainable. This reusable design improves accessibility while lowering long-term material use and overall healthcare costs. The belt also uses a rechargeable battery, reducing disposable battery waste.

Anatomical Placement

Placental position directly impacts signal quality. Anterior placentas (placenta is attached to the front wall of the uterus, closest to the maternal abdomen) provide the strongest measurements because the near-infrared light travels a shorter distance through tissue. In contrast, posterior (back wall of the uterus) and fundal placentas (top of the uterus) require the light to pass through more maternal tissue, which can weaken the detected signal and increase noise. For low-lying (near the cervix) or lateral placentas(attached to the side walls), reliable



measurements may not always be feasible, representing a key limitation of the device.

Sensor Selection

We chose Diffuse Correlation Spectroscopy (DCS) sensors because they measure blood flow directly, instead of relying on indirect signals like pulse or oxygen levels. The system uses near-infrared (NIR) laser diodes (750–850 nm), which safely pass through tissue to reach the placenta without any radiation risk. Single-photon detectors were selected for their ability to pick up tiny fluctuations in light caused by moving red blood cells, making it possible to detect even small changes in placental blood flow. Together, these sensors allow continuous, non-invasive monitoring.

references

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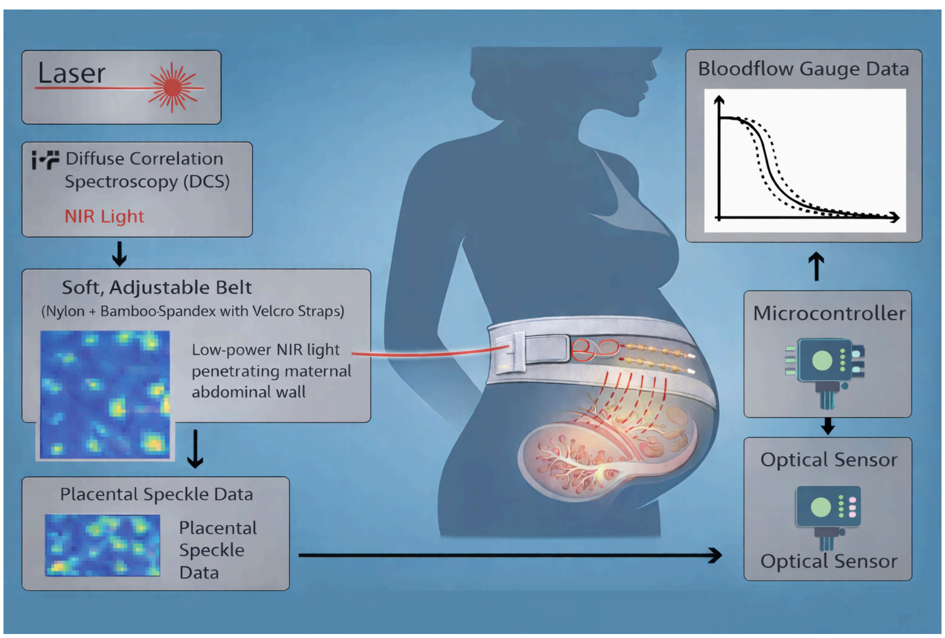
Images Used:

amazon.com/Fixic-Freestyle-Adhesive-Patch-PCS/dp/B07QB7V6MF
https://media.kohlsimg.com/is/image/kohls/7067353?wid=805&hei=805&op_sharpen=1
https://www.geeksforgeeks.org/electrical-engineering/duty-cycle/
https://pmc.ncbi.nlm.nih.gov/articles/PMC9982436/?utm_source=chatgpt.com
https://www.thebump.com/a/anterior-placenta

AI Usage:

1. Using CHATGPT to generate graphical representation of study
https://chatgpt.com/share/6988cc8d-0080-8007-bde5-3a60d96cb64e
2. Used Figma with Claude AI (Anthropic) for code generation and UI implementation of app prototype. Main prompt: “Create a simple mobile app prototype for pregnant users to monitor placental blood flow trends, track a personal baseline, and receive alerts if flow decreases. This is a mock-up, no real-time sensor needed”
https://www.figma.com/make/cu9tr2TKVijTwCVBbUYsMi/Placenta-Perfusion-Monitor-Prototype?p=f&t=Y8VYdmRH3nLUVUY0-0
3. Using Chatgpt to generate workflow
Graphical Inspiration:
https://www.photon-force.com/applications/diffuse-correlation-spectroscopy/
https://chatgpt.com/share/6988d0a0-d320-8007-a14a-415dad7da127



SCRIPT

Script:

INTRO:

During pregnancy, one organ quietly supports every aspect of fetal development: It delivers oxygen and nutrients, removes waste, and adapts as the fetus grows. Do you know what it is?*S1* The PLACENTA!!

S2

The Placenta depends on adequate blood flow. If blood flow is reduced (AKA placental perfusion) the fetus may not receive enough oxygen. This can lead to fetal growth restriction, preterm birth, and stillbirth. It is hazardous *S3*for pregnant women with known Placental Blood Flow Complications.

Today, placental blood flow is assessed periodically during hospital visits.*S4* During these visits, ultrasounds provide information, but it is limited to brief snapshots taken weeks apart in controlled environments where the mother is at rest. Additionally, factors like scheduling, cost, and accessibility make it difficult to use for real-time monitoring.

blood flow is also always changing due to stress, activity, and environment. Due to time gaps between visits, blood flow can decline gradually and silently without detection. Currently, there is no clinically available, noninvasive system to continuously monitor placental blood flow at home.

S5

Therefore, we introduce Placentra. It is a noninvasive device that enables continuous, real-world monitoring of blood flow in the placenta.

GOAL: <ash>

Our goal is not to replace ultrasound or make diagnoses.

Instead, our goal is to provide early warning signs for pregnant women with known Placental Blood Flow Complications by tracking changes in blood flow over time. This helps doctors detect gradual declines sooner and intervene early, before the fetus is affected.

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Script:

The device is worn around the abdomen as a , adjustable belt made of materials such as nylon and bamboo-spandex. It consists of Velcro straps to accommodate changes in belly size during pregnancy

Inside the belt, light sources and sensors collect blood flow infor+mation using Diffuse Correlation Spectroscopy (DCS). It is a non-invasive method that uses low-power near-infrared light, or NIR. As reported by Dr. Junko Kakogawa, an uhb-stet-rics researcher, NIR can safely monitor placental oxygenation through the abdomen without harming the fetus or mother and other studies confirm it can safely measure placental blood flow in real time.

In the device, NIR laser diodes shine light into the tissue. As the light scatters based on how blood cells are moving, photodiodes detect these changes. The processing unit then analyzes this information and sends the data wirelessly

SCHENEMATICS: (feasilbilty) <becca

“To make this more concrete, this abstract schematic shows how the hardware pieces fit together inside the wearable system.” **

- Microcontroller bluetooth unit -> data read from the COMMUNICATE
- optical sensor (LED) photo diode to send out and read NIR light (purely blood flow)
- Aux sensor is general sensor to track skin contact, movement, skin temperature (any other detection needed other than blood flow)
- Safrey interlock lets device know when to turn laser on after aux sensor detects if contact and pressure to skin.

During the detection period, the processed data is sent to a smartphone app using Bluetooth.”

APP FEATURE: (feasibility)

We utilized Figma AI to prototype the interface of the app which manages data from the belt.

1On the home screen, users see their Blood Flow Index, or BFI, which is a single number that reflects how much blood is flowing through the placenta. This value comes from the DCS signals collected by the belt.

Script:

There is no single BFI value that defines healthy or unhealthy blood flow. ***2***Instead, the app allows users to set or calibrate their personal baseline by measuring blood flow for 5 to 10 minutes while the user is at rest. All future readings are compared to this individual baseline. This flexibility accounts for natural differences between people.

Higher BFI values indicate increased blood flow, while lower values indicate reduced flow. ***3***The app also tracks BFI trends over time. ***4***If BFI drops significantly from a user's personal baseline, the Alerts tab notifies the user and provides an option to contact their doctor.

POWER, COST, SUSTAINABILITY: <becca>

How does our system uphold power cost and Sustainability?

S2 ******

Our system relies on low-power near-infrared light within established safety limits, with no needles or invasive components, ensuring safety and comfort for everyday use. The soft, adjustable belt is designed for extended wear, encouraging continued use as the body changes throughout pregnancy.

**power*

Power consumption is reduced by collecting data in short, scheduled measurement windows rather than continuous illumination. This duty-cycled approach significantly reduces energy use while still capturing meaningful blood-flow trends. As a result, the device only requires once-daily recharging, similar to a smartwatch.

** switch in between

From a cost and sustainability perspective, the design relies on commercially available near-infrared components, a low-power microcontroller, and a reusable fabric belt. **s4**Originally we thought about disposable patches but in order to encourage sustainability, we pivoted to a fully reusable BELT system reduces medical waste, lowers costs, and decreases long-term environmental and healthcare burden.

FUTURE WORK: <ash>

Script:

While our technology is a leap forward, it faces a natural hurdle: individual body differences . Because this device relies on near-infrared light, the physical distance between the sensor and the placenta is everything.

We have 4 main places that the placenta can be located during pregnancy

Anterior placenta refers to when the placenta is attached to the front wall of the uterus, offering the 'gold standard' for signal quality. In this position, the light travels through minimal tissue, resulting in a high Signal-to-Noise Ratio leading to more accurate blood flow measurements.

However, in non anterior positions, light must go through significantly more maternal tissue. This increases 'noise' and weakens the signal captured ,leading to less accurate results.

As a result, the current design is optimized for individuals with anterior placenta placement. While that might sound like a niche group, the data suggests otherwise

pii. According to dr Heather Bartos,of Women's Health & Wellness, nearly one-third of pregnancies involve an anterior placenta, making this a common anatomical presentation. By focusing our initial baseline on this 33%, we are ensuring the highest level of accuracy for a very large, common demographic before expanding further.

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Some improvements we can predict is building on this current device to allow for reliable signals for other placenta positions by improving depth sensitivity. This introduces more anatomical personalization. Another improvement is to Incorporate adaptive signal processing to clear out background noise

Conclusion: <becca>

In conclusion, we believe early detection and timely care should be available to every patient, especially during pregnancy. By allowing placental blood flow to be monitored continuously and non-invasively outside the clinic, this system promotes early detection and gives health care provider better information to support healthy outcomes for both mother and child.