

To: Dr. Alpa Gautam

From: Timothy Hillyer, Colten Palkon, Shaquille Ancrum, Cole Malenich, Paige Smith, Aida Lopez Rietti, Benjamin Budenstein

CC: Vipisha Pazhanivel

Subject: BMED 2250 A04 Team 3 Progress Report 3

Title: Maternal Mortality in Black Mothers Caused by Excessive Bleeding

Date: 10/22/23 - 12/12/23

Problem Statement:

Our goal is to design a way to monitor blood loss in postpartum women that is affordable, comfortable, and accurate in its measurement in order to curb maternal mortality due to Postpartum Hemorrhaging.

We changed the wording of the beginning of our problem statement to align with a design rather than a "product". Along with this, we removed the word "abnormal" as this design will track all blood loss, not just those who are considered irregular.

User Story:

Jessica Barnes was a mother born and raised inside the perimeter of Atlanta, Georgia. She often imagined playing with her son Anthony on the playground in the years to come after his birth; for her and her husband Mark to enjoy the roller coaster of raising a child.

The process of labor was daunting to Jessica as many of her family and friends had experienced complications during pregnancy. Many would say that it is scary to have a child as a black woman due to the much higher rates of issues, but fortunately for Jessica, this would not be the case as the delivery was "easy". Soon a perfectly healthy baby Anthony was born to be taken home in the arms of his loving parents.

Five days later Jessica started to notice that she was feeling off. Her appetite faded and an unshakable feeling of anxiety swept over her constantly so Mark rushed her to the ER. There she was told that the anxiety was likely due to the stress of being a new mother and that it would fade over time. This response and neglect would wind up putting Jessica in a situation that she would never have the chance to understand.

In the days to follow Jessica would visit her OB/GYN and her normal physician. They said things to her such as "This happened to my wife. She was okay, and you will be, too." This would continue until a hysterectomy was attempted and failed. 15 days after pregnancy Jessica passed away from hypovolemic shock due to excessive blood loss. She was never informed about any aspect of the bleeding. She was never aware of how much she should be losing during this post-partum period. The lack of this crucial information as well as no way to measure said blood loss took her life.

We made minor changes to the user story from Phase II. The changes added more empathy by attempting to make the reader better understand how Jessica felt and what she dealt with, as well as her overall life situation.

Progress Summary:

Overall Accomplishments

In Phase 3 we were able to complete our prototype of the volume measuring/tracking postpartum diaper. This involved lots of planning, sourcing materials, and testing. With the time allocated during this phase, we worked to make the best functioning prototype for our problem statement with the aid of our facilitators. One of the main accomplishments we had was getting the Arduino to function and control the RFID reader as well as the moisture sensor. With these, there came the ability to test the devices with the use of our fake blood in the diapers. This data was then compiled in order for us to show the effectiveness of our product. The effectiveness of both of our products was evaluated based on our design inputs, constraints, and criteria we had established in phase 2. Both devices showed different advantages and disadvantages when we conducted our evaluation. When taking into account affordability, accuracy, comfort, feasibility of the testing process, and ease of use, we determined that the RFID sensor would work best if we purchased a stronger reader in the future. Additionally, we were able to come up with a computational model using Python that would translate the results measured by the Arduino and the sensors into statements that the mother could understand with ease so they could determine whether the amount they were hemorrhaging was safe or not.

New Inquiry Findings and Impact

For our second prototype, we were able to find a more effective moisture sensor than we found in phase 2. This sensor allowed us to more accurately measure the amount of blood in the diaper because it used capacitance instead of voltage. This phase also forced us to dive into more of the business side of designing this device. It is important that our device is available to our user group which are individuals in low socioeconomic situations. This means that our addition to the diaper roughly cost the same as normal diapers. During testing, we saw that these sensors cost \$0.50 each, however, buying them in bulk will greatly reduce the cost of each sensor. We believe it would only increase the cost of the diaper packet \$1-\$3 overall which we think is reasonable given the importance of our product.

Goals Met

Because we planned ahead in phase 2, we were able to order the materials needed (diaper, sensors, fake blood supplies) early in phase 3 which allowed us to test our prototypes effectively. There were some issues with testing that are highlighted later but we were able to determine the best sensor for our device. However, the testing process helped us draw different conclusions based on our prototype. When we tested the RFID sensor, we based our results off of failure; the more volume the diaper held, it would mean the signal between the RFID and the reader would be interfered. For our moisture sensor, we based our results on arbitrary values given by the Arduino. As the volume in the diaper increased, the arbitrary values would decrease. Given these results, we met the goal of deciding which prototype to go with if we were to move forward with the process. Combining our results and an evaluation conducted with a Pugh matrix, we concluded that even though the moisture sensor showed more “accurate” results, it would be best to move forward with an RFID sensor with a higher-strength reader. Lastly, another goal met was that we were able to create a computational model that would present the data collected by the sensors to mothers, making our device something that would, ultimately, alert mothers if the amount they are bleeding is considered abnormal.

Ongoing Difficulties:

The group was presented with the most bumps in the road during this phase. That was because it felt like a race against the clock for us as there was only so much we could do about the delivery of our materials in a timely manner. This meant that everything had to move faster in order to account for the time waiting for the materials to arrive. It was particularly difficult for the designing and application of the computational model of the device. This was due to the lack of knowledge of integrating the data gathered from the Arduino into other scripts for analysis, forcing a large tie-up of group resources and time to be contributed as it was a necessary component of our design.

Besides that, there was difficulty with the actual testing process. This was because the RFID reader that we were working with was relatively weak and could only read the tag signals from a short distance away. There was nothing to be done to combat this for the time being so we just had to continue testing as effectively as possible. Going along with this, the moisture sensor was problematic in that it only produced arbitrary numerical data. There was no indication about what the units of the outputs were anywhere that the group was able to find. This just meant that the initial interpretation of the data, as well as its presentation, was more difficult than expected.

Team and Individual Goals:

Team Goals: We would like to spend more time testing the device in the future so that we can obtain more data and perfect our computational model around this data. We would also like to obtain more knowledge related to our problem statement by interviewing mothers who have experienced abnormal bleeding after pregnancy. Finally, we would like to continue exercising our engineering mindset through the numerous courses offered to us in the Georgia Tech curriculum, namely BMED 2310 and capstone.

Cole: I would like to enhance my scheduling and planning skills in future courses - I feel as if I had more of a roadmap laid out in front of me as to what I needed to accomplish by when, I wouldn't run into a situation like this one where we only had a couple meetings to do testing.

Paige: I would like to continue improving on speaking and providing input during studio sessions. This will facilitate better conversations between the team while giving different insights to the problem the team is trying to solve.

Tim: I would like to keep working on sharing more of the leadership role so as to not feel as stressed during the project. I took on responsibility that was not always necessary and I feel as though I can add more to the group by being in different roles.

Aida: If I were to continue working on this project, I would like to ask for more feedback from my teammates in order to keep improving my skills based on what I can learn from them.

Ben: I would enjoy continuing to work on the project. It would be really nice to keep testing the RFID sensor and find a more powerful one that can be sensed from farther away from the reader. I'm excited to take what I've learned from this class on to future design courses. Going through this class definitely had its learning curve but it will only serve to benefit my career in the long run.

Colten: For next projects, I will work on improving the quality of my personal research by using credible sources, such as journals and studies.

Shaquille: In the future, I will use my research and problem-solving abilities I learned during this class and apply them to other problem statements.

Project Timeline:

Phase 1:

Aug 22: First brainstorming studio session sharing information researched

Aug 24: Want to focus on postpartum mortality

Aug 29: First idea of a heart monitor

Aug 31: Discussed user stories

Sep 5: Focus on blood loss aspect of maternal mortality after birth

Sep 7: Diaper idea generated

Phase 2:

Sept 29: Brainstorm device specifics

Oct 3: Finalize device specifics

Oct 5: Work on creating prototype (putting together arduino hardware)

Oct 10: Work on creating prototype (coding arduino software + computer simulation)

Oct 12: Work on creating prototype (add final touches to software, ensure prototype is functional)

Oct 17: Finish/practice presentation

Oct 21: Practice presentation in front of TA's

Phase 3:

Oct 31: Work on finalizing parts of the second progress report

Nov 2: Go over pros and cons of prototypes and choose the best prototype and begin thinking of ways it can be improved

Nov 7: Start coming up with ways to test the prototype

Nov 9: Begin gathering people who are willing to test the prototype

Nov 14: Put together data from testing

Nov 16: Finish presentation

Nov 27: Showcase presentation to TA's

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Relevant Diagrams

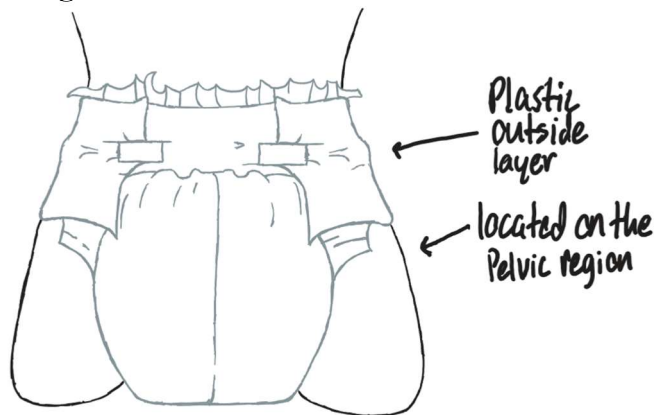


Figure 1: Drawing of a diaper on a woman's pelvic area

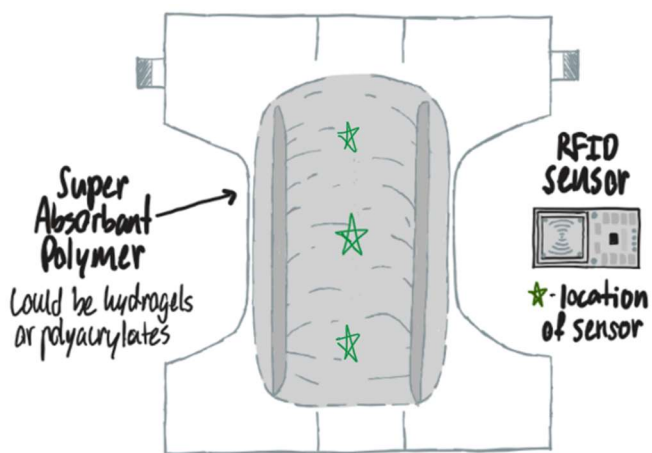


Figure 2: Sketch of the inside of a diaper with the locations of the RFID tags

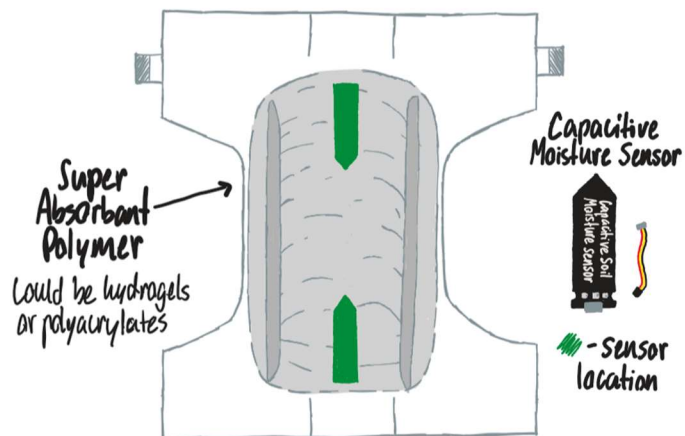


Figure 3: Sketch of the inside of a diaper with the location of the Capacitance Moisture Sensors