Creation of a Novel Real-time Communication Solution for Timely Sepsis Management

Computer Integrated Surgery II

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Introduction

- We have developed a two-pronged approach to improve the sepsis management process by tracking antibiotic delivery within the pneumatic tube system using Bluetooth and the PICU using barcode scanning.
- Our solution will also allow for the collection of more data regarding how much time each step of the delivery process takes, providing justification for procedural changes in how medications are delivered and received.
- The significance of our work lies in its potential to visualize the antibiotic delivery process and alert relevant sepsis team members in order to improve communication and coordination and ultimately enhance the efficiency and effectiveness of sepsis treatment.

The Problem

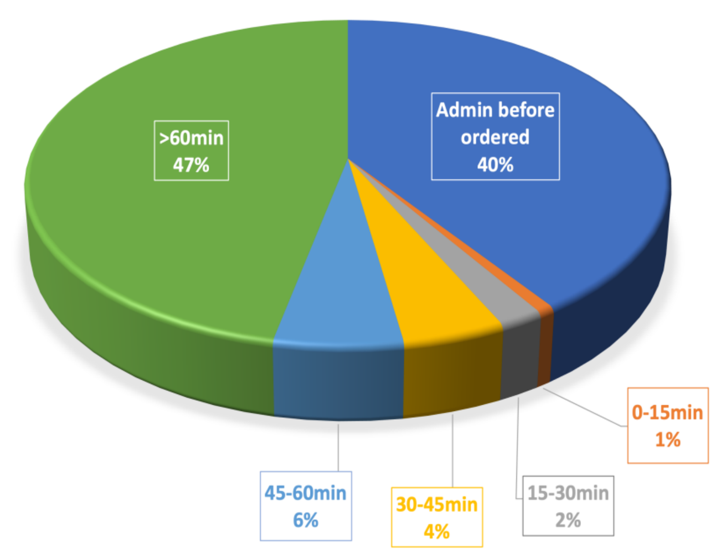
- Sepsis is the body's extreme reaction to an infection, and it is a main cause of global morbidity and mortality, with peak mortality occurring in pediatric and elderly patients. Since sepsis attacks the body so quickly, immediate antibiotic administration is of the utmost importance. Children who receive antibiotics within one hour have, on average, a shorter hospital length of stay and shorter in-hospital mortality rate.
- Though it is known that identifying sepsis early and treating patients within one hour is critical, the Hopkins Hospital does not currently meet this standard. After speaking with Dr. Fackler and other attending physicians at the Johns Hopkins PICU, it is evident there is a communication issue when it comes to treating children with sepsis, with different team members being unaware of when the antibiotics have been delivered to their location.

The Solution

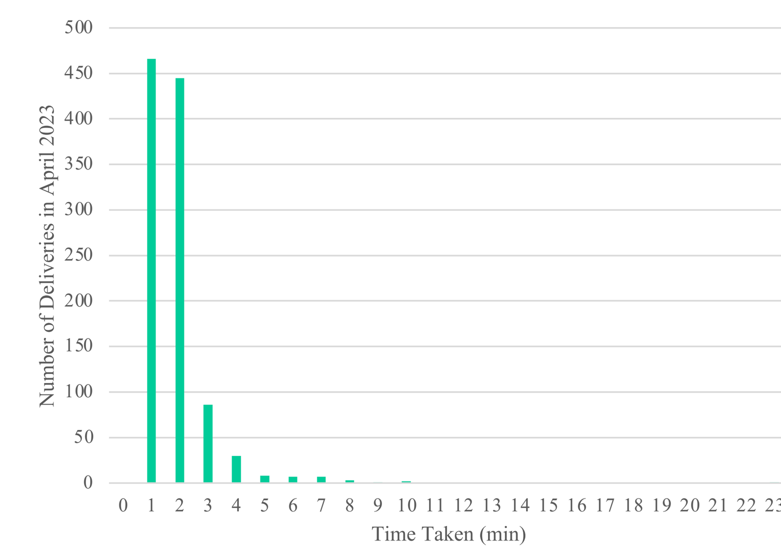
- To address the gaps in the current antibiotic delivery process, we decided to first target the pneumatic tube system connecting the pharmacy and PICU by implementing a Bluetooth proximity sensor to detect the arrival of important capsules carrying antibiotics. We aimed to place a BLE tag inside the pneumatic tube capsule containing the antibiotics and have an ESP32 microprocessor act as a receiver by the tube station in the PICU. In this way, when the capsule reaches the PICU, the microprocessor can use the strength of the Bluetooth signal to estimate proximity and alert nurses when the antibiotics have arrived.
- We also developed design specifications for a barcode scanning system to track the antibiotics within the PICU. We envision that a pharmacist would print a barcode sticker onto the antibiotic before sending it out through the pneumatic tube. After being alerted that the antibiotic has arrived at the PICU using the Bluetooth proximity sensor, the next relevant sepsis team member would use a barcode scanner located at different locations within the PICU to scan the antibiotic's barcode. Every time the barcode is scanned, the antibiotic's location would be tracked and updated.

ESP32 Microprocessor (Top) and Nutale BLE Tag (Bottom) Used for Bluetooth Proximity Sensing

PICU Pneumatic Tube Station No. 845 with Two Capsules Visible



Antibiotic Administration Times for PICU Patients at JHMI



Time Taken for Pneumatic Tube Deliveries Between Children's Pharmacy and PICU in April 2023

Outcomes and Results

- Through our gap analysis, we found that 47% of PICU patients from our provided dataset were administered antibiotics more than one hour after the initial diagnosis.
- We also found that the biggest unknown in the delivery process is the transition from the pharmacy to the PICU through the pneumatic tube system, as there is both no alert system and no recorded timestamps for when antibiotics are received. Although these deliveries through the pneumatic tube take 2.4 minutes on average, there are about 140 cases per month that take longer than 3 minutes, with the longest delivery taking more than 23 minutes.
- Using the ESP32 microprocessor and BLE tags mentioned earlier, we tested the accuracy of proximity sensing by placing the tag inside a capsule and placing the microprocessor on the table next to the PICU pneumatic tube station. Although we were a little worried that the plastic and foam insulation would drastically weaken the Bluetooth signal strength, we were happy to find that the signal strength consistently stayed between -63 and -70 while the capsule was in the tube station holding area. Moving the capsule away from the tube station caused the signal strength to weaken to between -85 and -95 before the signal was eventually lost.

Future Work

- Test the Bluetooth proximity sensor by placing receivers in the pharmacy and PICU and seeing how well it can track a BLE tag as it moves with the antibiotic
- Integrate our tracking solution with the JHH EHR system to enable automatic alerts
- Set up monitors in the hospital to visualize the tracking progress of antibiotics in real-time

Lessons Learned

- We gained a deeper understanding of sepsis and the importance of timely administration of antibiotics.
- We also learned a great deal about hardware and tracking solutions, including the limitations and benefits of different tracking methods.

Credits

- Rahul brainstormed, designed, and tested the Bluetooth proximity sensor as well as conducted a gap analysis using the pneumatic tube delivery data
- Sofia researched and created design specifications for the barcode tracking system and conducted a gap analysis using patient data as well as created a mockup of a monitor display.

Support by and Acknowledgements

- Thank you to our mentors Dr. Fackler and Dr. Ghobadi for guiding us throughout this project
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