PROJECT PROPOSAL
EN 601.656 COMPUTER INTEGRATED SURGERY II
SPRING 2023

CREATION OF A NOVEL REAL-TIME COMMUNICATION SOLUTION FOR TIMELY SEPSIS MANAGEMENT

Team Member

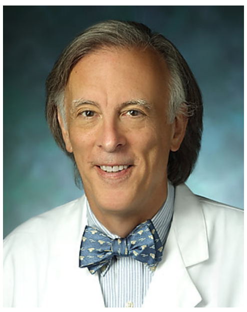
Sofia Posada, Junior

Department of Computer Science

Team Member

Rahul Swaminathan, M.S.E Student

Department of Biomedical Engineering



Mentor

Dr. Jim Fackler, M.D.

Anesthesiology and Critical Care Medicine

Mentor

Dr. Kimia Ghobadi, Ph.D.

Department of Civil and Systems Engineering

Table of Contents

1 Goal

Create a novel communication platform that allows a sepsis team in the PICU to see each step of the sepsis management process and alerts each person on the team when it is their turn to act.

2 Clinical Relevance and Motivation

Sepsis is the body's extreme reaction to an infection. However, diagnosing a child with sepsis has different criteria than diagnosing an adult with sepsis, which is evident from the bolded text in Figure 1 (1). Regardless of age, sepsis is a life-threatening condition that attacks the body quickly. It is a main cause of global morbidity and mortality, with peak mortality occurring in pediatric and elderly patients (2). Based on a systematic review with 15 studies included in the meta-analysis, they found that there are, on average, 48 sepsis cases in children per 100000 person-years. Within these cases, mortality ranged from 13 to 54% (3). The majority of deaths from children with severe sepsis occur during the first 24 hours after the children are referred to the pediatric intensive care unit (4).

Table 2. Definitions of systemic inflammatory response syndrome (SIRS), infection, sepsis, severe sepsis, and septic shock

SIRS[a]

The presence of at least two of the following four criteria, **one of which must be abnormal temperature or leukocyte count:**

- Core[b] temperature of >38.5°C or <36°C.
- Tachycardia, defined as a mean heart rate >2 SD above normal for age in the absence of external stimulus, chronic drugs, or painful stimuli; or otherwise unexplained persistent elevation over a 0.5- to 4-hr time period **OR for children <1 yr old: bradycardia, defined as a mean heart rate <10th percentile for age in the absence of external vagal stimulus, β-blocker drugs, or congenital heart disease; or otherwise unexplained persistent depression over a 0.5-hr time period.**
- Mean respiratory rate >2 SD above normal for age or mechanical ventilation for an acute process not related to underlying neuromuscular disease or the receipt of general anesthesia.
- Leukocyte count elevated or depressed for age (not secondary to chemotherapy-induced leukopenia) or >10% immature neutrophils.

Infection

A suspected or proven (by positive culture, tissue stain, or polymerase chain reaction test) infection caused by any pathogen OR a clinical syndrome associated with a high probability of infection. Evidence of infection includes positive findings on clinical exam, imaging, or laboratory tests (e.g., white blood cells in a normally sterile body fluid, perforated viscus, chest radiograph consistent with pneumonia, petechial or purpuric rash, or purpura fulminans)

Sepsis

SIRS in the presence of or as a result of suspected or proven infection.

Severe sepsis

Sepsis plus one of the following: cardiovascular organ dysfunction OR acute respiratory distress syndrome OR two or more other organ dysfunctions. Organ dysfunctions are defined in Table 4.

Septic shock

Sepsis **and cardiovascular organ dysfunction as defined in Table 4.**

Modifications from the adult definitions are highlighted in boldface.

[a]See Table 3 for age-specific ranges for physiologic and laboratory variables; [b]core temperature must be measured by rectal, bladder, oral, or central catheter probe.

Figure 1: Differences in Sepsis Symptoms Between Adults and Children

Since sepsis attacks the body so quickly, timing is of utmost importance when treating children with sepsis. A child can appear healthy one moment and quickly develop sepsis and need to be put on life support, so detecting sepsis as soon as possible is critical. Once detected, delivering antibiotics to a septic child within one hour is critical, with a noted decrease in mortality by 40% (5). The data showed that the children who received antibiotics within one hour had, on average, a shorter hospital length of stay and shorter in-hospital mortality rate (6). Evidently, timing is critical when treating sepsis.

Though it is known that identifying sepsis early and treating patients within one hour is critical, there is no implementation in place to accomplish this. 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. Although a process map exists regarding the team members involved when it comes to treating sepsis, the map is not finalized as it is still missing several members and workflows. We will finalize this map by interviewing providers as well as collect timestamps regarding the people on this map. With this data, we will perform a gap analysis and see where there is the biggest lack of communication. Our goal is to find a viable solution to this problem and be able to successfully provide IV antibiotics within an hour to children diagnosed with a serious bacterial infection. We will then test our solution in the PICU and collect new timestamps. We hope our solution will allow antibiotics to be delivered within one hour and, therefore, indirectly improve treatment outcomes for children diagnosed with sepsis.

3 Technical Approach

The project workflow is split into the following main components:

1. Augment the Process Map
2. Collect Data and Perform Gap Analysis
3. Develop a Physical Prototype of the Communication Solution
4. Test Efficiency of Solution (if time permits)

Augmenting the process map will involve conducting clinician and provider interviews with the help of Chen Wang, a Master's student currently working with Dr. Fackler. We will start in the hospital pharmacy, where the antibiotics first originate, and interview the pharmacists there to learn more about the beginning of the workflow and any problems they face with initial delivery. We will then interview nurses and attending physicians to learn about problems they are facing and what their ideal communication solution would entail.

We anticipate that different groups within the hospital may use different communication platforms, so we will also identify common means of communication and what works best for each group.

The bulk of our time will be focused on the second and third components, namely performing the gap analysis on the dataset of timestamps to determine and create a solution to the lack of communication that occurs when treating pediatric sepsis patients. To do this, we plan to re-purpose the existing Versus Information System (VIS) tracking technology in the hospital. VIS is a real-time locating system that was initially introduced to hospitals as a way of tracking the locations of nurses and patients within a hospital. VIS uses infrared and radio-frequency based tracking to identify room-level locations rather than approximate locations. Rather than using it to track nurses, we plan to collaborate with the hospital pharmacy to place VIS tags in the bags containing the antibiotics in order to track their location throughout the delivery process. This will not only give us an idea of how the antibiotics go from the pharmacy to the patient, but also where and when delays happen, and whether there are any specific problem areas within the hospital. Upon successful collection of this data, we intend to export the tracked locations and correlate them to specific roles or team members that are in charge of transporting or administering the antibiotics at those locations. We plan to use this information in combination with either VIS's internal alert system or Epic's secure chat to contact the relevant personnel when it is their turn to take over antibiotic delivery.

The following process map in Figure 2, developed by Chen Wang, will be used to assist in developing a physical prototype of a communication solution. Our eventual goal is to attempt to implement a program in which we can display the augmented process map on a monitor in the hospital with certain areas highlighted to show where the antibiotic is currently located. This will allow all team members to see where they currently are in the sepsis management process as well allow the relevant team members at each location to receive timely alerts. In order to program this live process map and integrate the location data, we will also be requesting assistance from our mentor Dr. Ghobadi who has prior experience with similar computational work involving healthcare systems capacity management and resource allocation. Finally, we will re-do the VIS tracking experiment from step 2 in order to compare the antibiotic delivery time before and after implementation of our solution, ideally reducing delivery time to be consistently below one hour.

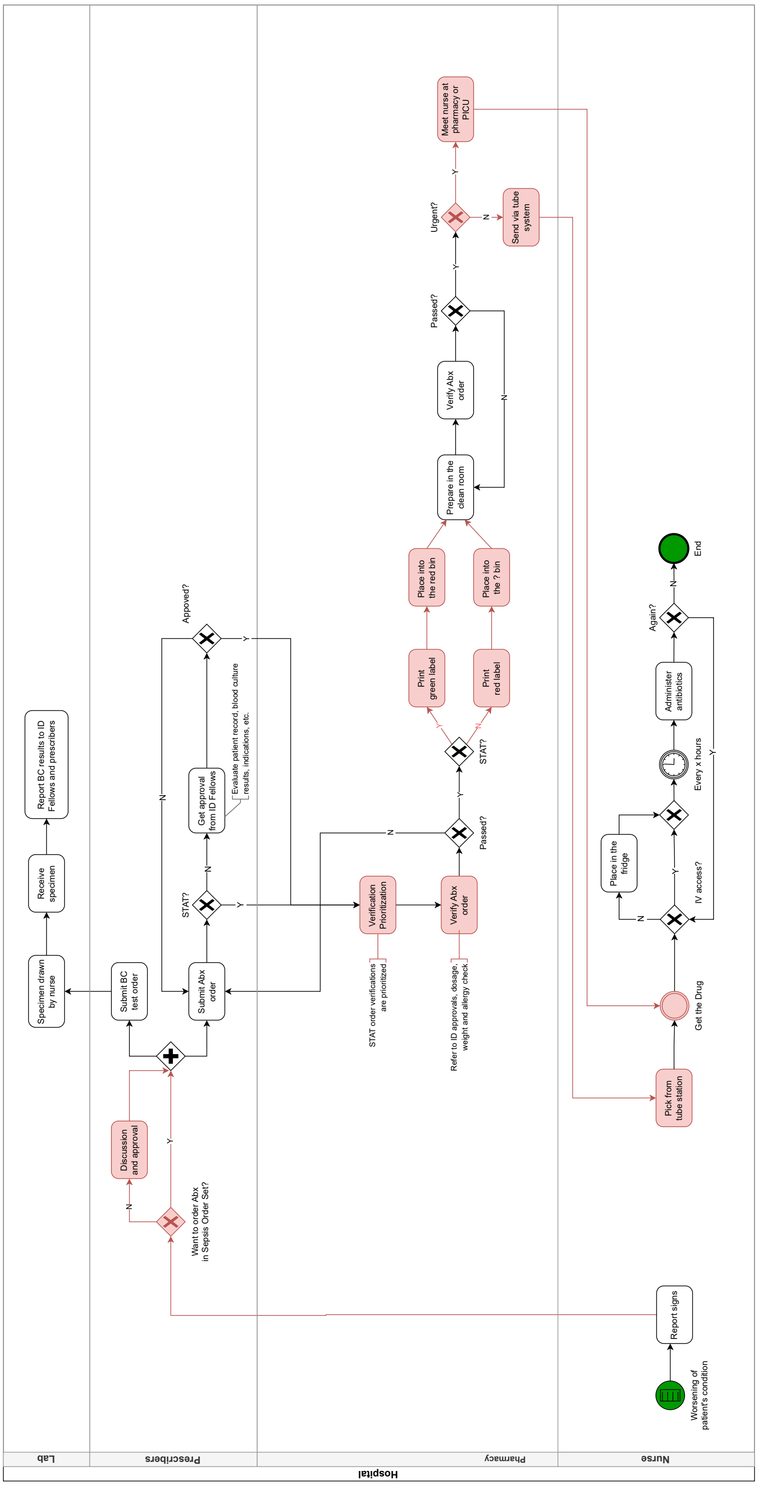


Figure 2: Process Map of Sepsis Management (flipped vertically)

4 Key Deliverables

Minimum (by 3/17/2023):

- Finalized process map of sepsis management workflow
- Complete dataset of timestamps and locations for antibiotic delivery
- Short report of gap analysis showing where a communication solution is most needed

Expected (by 4/28/2023):

- Physical prototype of communication solution that allows providers to visualize where the antibiotics are within the hospital

Maximum (by 5/18/2023):

- Implemented prototype of communication solution that uses a monitor to display the location of the antibiotics and whose turn it is within the process map
- Dataset of timestamps and locations for antibiotic delivery after the solution is implemented

5 Key Tasks and Deadlines

Minimum Deliverable	Associated Tasks/Milestones	Expected Date
Finalized process map of sepsis management workflow	Shadow Dr. Fackler in the PICU to observe the steps of antibiotic delivery during sepsis management	2/21
	Identify all team members involved in sepsis management at a role-level	3/2
	Conduct clinician/provider interviews to augment the existing process map and identify commonly used communication platforms	3/7
Complete dataset of timestamps and locations for antibiotic delivery	Place a locator tag inside the bag containing the antibiotics to track its location and time throughout the delivery process and fill in the gaps in the existing timestamp data	3/9
Short report of gap analysis showing where a communication solution is most needed	Analyze the complete timestamp data and see where the antibiotics are held up for the longest periods of time in order to cross-reference that with the process map to see where a solution would be most useful	3/16

Figure 3: Minimum Deliverables and Associated Tasks

Expected Deliverable	Associated Tasks/Milestones	Expected Date
Physical prototype of communication solution that allows providers to visualize where the antibiotics are within the hospital	Test out the Versus Information System (VIS) to see if antibiotic location can be accurately and reliably tracked and exported outside of their software. Find an alternate tracking solution if VIS is not viable	4/6
	Correlate antibiotic location with the roles of team members as described in the process map	4/20
	Set up alerts to automatically inform the relevant personnel when it is their turn	4/27

Figure 4: Expected Deliverables and Associated Tasks

Maximum Deliverable	Associated Tasks/Milestones	Expected Date
Implemented prototype of communication solution that uses a monitor to display the location of the antibiotics and whose turn it is within the process map	Set up an additional monitor in the PICU's huddle room that displays the location of the antibiotics as well as the process map	5/4
	Program the process map to light up in the relevant sections when the antibiotics have reached that part of the workflow	5/11
Dataset of timestamps and locations for antibiotic delivery after the solution is implemented	As done earlier, place a locator tag inside the bag containing the antibiotics to track its location and time throughout the delivery process in order to see how the efficiency of antibiotic delivery has changed as a result of the implemented solution	5/18

Figure 5: Maximum Deliverables and Associated Tasks

Documentation of all work and deliverables described in Figures 3, 4, and 5 will be done continuously and simultaneously throughout all these tasks. The schedule above is summarized in the Gantt chart below in Figure 6, where green signifies that a task is complete, yellow signifies that a task is in progress, and red signifies that a task is yet to be started. The black bar in the middle of March represents Spring Break, where we will not have access to the technology we need at the Johns Hopkins Hospital.

Figure 6: Gantt Chart of Key Tasks

6 Dependencies

Dependency	Need	Status	Planned Deadline	Hard Deadline	Contingency Plan
IRB Approval	Tracking location of antibiotics from the pharmacy	No approval needed for sticking a gps tag in the antibiotics bag because someone from the pharmacy is on the existing IRB	2/16	2/28	N/A
Access to Versus Information System technology	Tracking location of antibiotics from the pharmacy	Dr. Fackler is still looking for the trackers because the hospital stopped using this system some time ago	2/28	3/7	Use our own tracking device like an Apple AirTag and find out how to export that location data
Access to existing timestamp data	Gap analysis for identifying solution space	The person in charge of this data had a family emergency and had to leave, so it is unclear when this will be resolved	2/20	3/7	Conduct gap analysis using our own limited data from antibiotic tracking
HIPAA Training	Access to certain datasets and Epic Secure Chat	Most trainings should be completed – currently checking with Dr. Fackler	2/28	4/13	May be able to use anonymized data for all analysis purposes

Figure 7: Dependencies and Plans for Resolving

As shown in the table of dependencies in Figure 7, green signifies that the dependency has been successfully resolved, yellow signifies that the dependency is in the process of being resolved, and red signifies that the dependency is yet to be addressed.

7 Management Plan

Meetings:

- Weekly full team check-in with mentors: Thursdays 4 pm - 5 pm
- Weekly check-in with Dr. Fackler
- Weekly group work sessions: Mondays, Wednesdays, Fridays 11 am - 12 pm

Other platforms:

- Communication: Formal communication and document sharing will occur over email, whereas informal or time-sensitive communication will occur over text.
- Code: All code will be stored in a private GitHub repository that will be made public at the discretion of Dr. Fackler and Dr. Ghobadi.
- Documentation Storage: All working documents will be written and stored on Google Drive for ease of collaboration, with final reports being compiled using OverLeaf. All final documents, presentations, and deliverables will be uploaded to the CIIS Wiki page for this project.

Individual Responsibilities: Both group members will contribute to all parts of the project, but roles for individual tasks may be divided based on time, interest, and background skillsets. Rahul may lead the initial steps of tracking the antibiotic delivery, while Sofia may lead the later steps of displaying the tracking within the process map.

8 References

1. Goldstein, B. , Giroir, B. Randolph, A. (2005). International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics*. Pediatric Critical Care Medicine, 6 (1), 2-8. doi: 10.1097/01.PCC.0000149131.72248.E6.

2. Fleischmann-Struzek, C., Goldfarb, D. M., Schlattmann, P., Schlapbach, L. J., Reinhart, K., Kissoon, N. (2018). The global burden of paediatric and neonatal sepsis: a systematic review. The Lancet. Respiratory medicine, 6(3), 223–230. https://doi.org/10.1016/S2-213-2600(18)30063-8

3. Fleischmann-Struzek, C., Goldfarb, D. M., Schlattmann, P., Schlapbach, L. J., Reinhart, K., Kissoon, N. (2018). The global burden of paediatric and neonatal sepsis: a systematic review. The Lancet. Respiratory medicine, 6(3), 223–230. https://doi.org/10.1016/S2-213-2600(18)30063-8

4. Cvetkovic, M., Lutman, D., Ramnarayan, P., Pathan, N., Inwald, D. P., Peters, M. J. (2015). Timing of death in children referred for intensive care with severe sepsis: implications for interventional studies. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies, 16(5), 410–417. https://doi.org/10.1097/PCC.0000000000000385

5. Qian, J.1; Wang, Y.I.N.G.1; Zhang, Y.2; Rong, Q.2; Zhu, X.3. ABSTRACT 696: AN EVALUATION OF SIMULATION ON THE FIRST HOUR BASIC CARE TASKS OF THE SEPTIC SHOCK IN PEDIATRIC PATIENTS. Pediatric Critical Care Medicine 15(4_suppl):p 157, May 2014. | DOI: 10.1097/01.pcc.0000449422.48869.74

6. Cowart, M. C., Heath, T. S., Shipman, A. (2022). The Effect of Rapid Initiation Versus Delayed Initiation of Antibiotics in Pediatric Patients With Sepsis. The journal of pediatric pharmacology and therapeutics : JPPT : the official journal of PPAG, 27(1), 45–50. https://doi.org/10.5863/1551-6776-27.1.45

9 Reading List

- Mari, D. , Rush, T. Biswas, A. (2023). 730: Antibiotic Timing in Neonates and Children with Sepsis or Septic Shock Does Not Affect PICU Stay. Critical Care Medicine, 51 (1), 355-355. doi: 10.1097/01.ccm.0000908652.60631.11.
- Im, Y., Kang, D., Ko, RE. et al. Time-to-antibiotics and clinical outcomes in patients with sepsis and septic shock: a prospective nationwide multicenter cohort study. Crit Care 26, 19 (2022). https://doi-org.proxy1.library.jhu.edu/10.1186/s13054-021-03883-0
- Chua W, Ooi S, Chan G, Lau T, Liaw S The Effect of a Sepsis Interprofessional Education Using Virtual Patient Telesimulation on Sepsis Team Care in Clinical Practice: Mixed Methods Study J Med Internet Res 2022;24(4):e-35058 URL: https://www.jmir.org/2022/-4/e35058 DOI: 10.2196/35058
- Nomura O, Ihara T, Morikawa Y, Sakakibara H, Horikoshi Y, Inoue N. Predictor of Early Administration of Antibiotics and a Volume Resuscitation for Young Infants with Septic Shock. Antibiotics. 2021; 10(11):1414. https://doi.org/10.3390/antibiotics10111414