CSIS 4495 Project Proposal

Title: Optimizing Emergency Department Throughput via Remote Digital Triage and Synchronous Telemedicine Interventions

Team Members

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CSIS 4495-003

INTRODUCTION

Domain Overview and Background

Emergency departments (EDs) play a critical role in healthcare systems by providing immediate care for patients with urgent and life-threatening conditions. However, Emergency Rooms (ERs) worldwide continue to face persistent challenges, including overcrowding, limited clinical resources, and increasing patient demand. Population growth, aging demographics, and the rising prevalence of chronic illnesses have significantly increased the volume and complexity of emergency presentations.

ER overcrowding has been widely associated with prolonged waiting times, increased staff workload, and reduced quality of patient care. In many healthcare systems, patients must physically arrive at the emergency department before any formal triage assessment is conducted. This model creates congestion in waiting areas and delays the prioritization of patients whose conditions may deteriorate rapidly while waiting for evaluation.

Recent advancements in digital health technologies, particularly web-based systems and telemedicine platforms, have demonstrated the potential to improve access to healthcare services beyond traditional clinical settings. During public health emergencies and routine care alike, remote patient assessment tools have been increasingly adopted to reduce inperson contact and improve care efficiency. Despite these advancements, emergency care workflows remain primarily dependent on in-person triage, limiting the benefits that digital health solutions can deliver in high-pressure emergency environments.

This research is situated at the intersection of emergency medicine, health informatics, and web-based system design. It explores how remote triage and telemedicine technologies can be leveraged to support emergency departments by enabling earlier patient assessment, improving prioritization, and reducing unnecessary physical congestion within hospital facilities.

Problem Definition and Research Question

While emergency department overcrowding is well-documented, the initial triage process remains a critical bottleneck that exacerbates congestion and delays care delivery. In most

emergency departments, triage begins only after a patient has arrived and registered at the hospital. This approach leads to overcrowded waiting areas where patients with varying levels of acuity compete for limited clinical attention.

Physical congestion in ER waiting rooms poses significant risks to patient safety. Delays in triage may result in the under-prioritization of high-acuity patients, increasing the likelihood of clinical deterioration, adverse events, and, in extreme cases, mortality. Overcrowding also contributes to increased rates of patients leaving without being seen (LWBS), which has been associated with poorer health outcomes and reduced trust in healthcare systems.

From an operational perspective, in-person-only triage places excessive strain on nursing staff, who must manage large patient volumes under time pressure while maintaining clinical accuracy. The lack of early visibility into incoming patient severity limits emergency departments' ability to allocate resources proactively. Consequently, emergency care delivery becomes reactive rather than anticipatory.

Although digital triage tools and symptom checkers have been introduced in recent years, many of these systems operate independently of emergency department workflows or rely solely on automated decision-making. The absence of structured clinical oversight and real-time escalation mechanisms raises concerns regarding patient safety, accountability, and reliability in emergency contexts.

Based on these challenges, this research seeks to address the following questions:

1. How can remote, web-based triage be integrated into emergency department workflows to reduce physical congestion without compromising patient safety?
2. To what extent can early remote triage improve patient prioritization and reduce waiting times and LWBS rates?
3. How does the inclusion of human-in-the-loop nurse oversight impact the reliability and clinical acceptability of automated triage decisions?

Addressing these questions is essential for developing scalable, safe, and clinically responsible digital solutions that enhance emergency department efficiency while preserving the central role of healthcare professionals in critical decision-making.

Literature Review and Knowledge Gaps

Existing research on emergency department efficiency has extensively examined the impact of overcrowding, delayed triage, and prolonged waiting times on patient outcomes and hospital performance. Studies in emergency medicine and health systems research consistently report that early patient assessment and prioritization are critical determinants of care quality, particularly for high-acuity cases.

Digital health literature highlights the growing use of telemedicine and remote patient monitoring to improve access to care and reduce unnecessary hospital visits. Web-based symptom assessment tools and AI-driven triage systems have been developed to guide patients to the appropriate level of care. These systems offer potential benefits, such as faster preliminary assessments and reduced clinical workload for non-urgent cases.

However, existing digital triage solutions exhibit several limitations when applied to emergency care contexts. Many systems function as standalone applications that are not designed to integrate directly with emergency department workflows. As a result, their outputs are often advisory rather than actionable within hospital operations. Furthermore, a significant portion of automated triage tools relies on static decision trees or machine learning models that lack transparency and adaptability to atypical or evolving clinical presentations.

Another critical gap identified in the literature is the limited incorporation of human clinical oversight in digital triage processes. While automation can improve efficiency, the absence of structured mechanisms for clinician review, override, or escalation raises concerns regarding patient safety, ethical accountability, and trust. Emergency medicine research emphasizes the importance of clinical judgment, particularly in cases where symptom presentation is ambiguous or incomplete.

Additionally, few studies examine the role of real-time telemedicine integration within triage workflows. While teleconsultation has been explored in outpatient and follow-up care, its application as a component of emergency triage—particularly before physical arrival at the hospital—remains underexplored.

These gaps suggest a need for research that combines remote digital triage with active clinician involvement and seamless integration into emergency department operations. Addressing these limitations forms the foundation for the proposed research project.

Hypotheses, Assumptions, and Potential Benefits

Based on the identified challenges and gaps in existing emergency triage systems, this research is guided by the following hypotheses:

- Implementing a web-based remote triage system will reduce physical congestion in emergency department waiting areas by enabling earlier patient assessment before arrival.
- Early remote triage will improve patient prioritization accuracy and reduce average waiting times for high-acuity cases compared to traditional in-person-only triage processes.

- The inclusion of human-in-the-loop nurse oversight and override capabilities will increase the clinical reliability and acceptability of automated triage decisions in emergency care settings.

This research operates under several key assumptions. First, it assumes that patients have access to internet-enabled devices capable of supporting web-based forms and video communication. Second, it assumes that emergency departments possess or can integrate the necessary digital infrastructure to support secure remote triage workflows. Finally, it assumes that trained nursing staff are available to review and intervene in automated triage decisions when required.

The potential benefits of this research are both clinical and operational. From a clinical perspective, earlier assessment and prioritization may reduce adverse outcomes associated with delayed care and improve patient safety. From an operational standpoint, remote triage can improve patient flow, reduce Left Without Being Seen (LWBS) rates, and optimize the allocation of nursing resources. More broadly, this research contributes to the development of clinically responsible digital health solutions that balance automation efficiency with human expertise in high-risk healthcare environments.

Proposed Research Project

Research Design and Objectives

This research adopts an academic research design centered on the development and evaluation of a functional software prototype supported by simulation-based analysis. The project is exploratory and evaluative, aiming to investigate how remote digital triage can be integrated into emergency department workflows while maintaining clinical oversight and safety.

The proposed system will be designed as a web-based prototype that enables patients to submit symptom information remotely and receive a preliminary triage assessment before arriving at the emergency department. Automated triage outputs will be subject to review and override by qualified nursing staff, allowing for human-in-the-loop decision-making.

The specific objectives of this research are as follows:

I. To design and implement a web-based remote triage prototype that supports symptom intake, automated prioritization, and nurse override functionality.
II. To simulate emergency department workflows with and without remote triage to evaluate the impact on patient flow and waiting times.

III. To assess the effectiveness of human-in-the-loop oversight in improving the reliability and clinical acceptability of automated triage decisions.
IV. To analyze the potential operational benefits of remote triage, including reductions in waiting room congestion and simulated Left Without Being Seen (LWBS) rates.

These objectives directly support the evaluation of the research hypotheses and provide a structured framework for measuring the system's impact on emergency department efficiency and patient safety.

Research Methodology

This research employs a mixed-methods methodology centered on the development of a functional web-based prototype and a scenario-based simulation of emergency department workflows. The methodology is designed to evaluate the impact of remote triage on patient flow, prioritization accuracy, and operational efficiency in a controlled academic setting.

Prototype Development

A web-based triage prototype will be developed to simulate the pre-hospital patient intake process. Patients will enter structured symptom data, demographic information, and selfreported urgency indicators through an online interface. Based on predefined triage rules derived from standard emergency severity frameworks, the system will generate an initial triage level.

The prototype will include a clinician interface that allows nursing staff to review submitted patient data, conduct optional video consultations, and override or escalate automated triage decisions when necessary. All actions, including timestamps for submission, review, and decision changes, will be logged for analysis.

Scenario-Based Simulation

To evaluate system performance, multiple emergency department scenarios will be simulated using synthetic patient cases representing common ER presentations. Each scenario will include patients arriving at varying times with different levels of acuity.

Simulated queues will be constructed to model patient arrival rates, triage processing times, and clinician availability.

Two workflow models will be compared:

1. A baseline model representing traditional in-person triage only.
2. An experimental model incorporating remote triage before physical arrival.

Key metrics, including triage wait time, queue length, prioritization accuracy, and simulated LWBS rates, will be recorded and compared across scenarios. Timestamp data will be used to analyze delays and bottlenecks within each workflow.

Qualitative Evaluation

In addition to quantitative metrics, qualitative feedback will be collected from participants acting in clinical roles. Structured questionnaires and short interviews will assess usability, perceived decision confidence, and trust in the nurse override mechanism.

This combined approach enables both objective performance evaluation and subjective clinical usability assessment.

Justification of Research Design and Methodology

The selected research design and methodology are intentionally structured to balance clinical safety, technical feasibility, and cybersecurity compliance within an academic research context. Emergency care environments involve high-risk decision-making, making it inappropriate to rely solely on fully automated systems without human oversight. As such, a hybrid approach combining automated triage with clinician review was chosen to reflect best practices in emergency medicine and health informatics.

Ethical and practical considerations justify the use of an academic prototype and scenariobased simulation. Conducting real-world experimentation in live emergency departments would introduce unacceptable risks to patient safety and would require extensive regulatory approval. Simulation-based evaluation allows the research to systematically assess workflow impact, patient flow dynamics, and decision accuracy without exposing real patients to harm.

A web-based system architecture was selected to maximize accessibility and platform independence. Unlike mobile-only solutions, a browser-based approach allows patients to access triage services using a wide range of devices without requiring application installation. This design also facilitates rapid updates, centralized security controls, and easier integration with hospital information systems.

The inclusion of human-in-the-loop nurse oversight is a critical methodological decision. Existing literature highlights the limitations of automated triage systems in handling atypical presentations and incomplete data. Allowing trained nursing staff to review and override automated decisions enhances clinical reliability, supports ethical accountability, and improves trust in the system’s outputs.

Cybersecurity and data privacy considerations further justify the chosen methodology. Emergency triage systems handle sensitive personal and health-related information, making compliance with healthcare data protection principles essential. The proposed design

incorporates role-based access control, encrypted data transmission, and secure authentication mechanisms to protect patient data. Logging and audit trails are included to support accountability, traceability, and incident investigation.

Overall, this balanced methodology ensures that the proposed research solution is clinically responsible, technically robust, and aligned with cybersecurity best practices, while remaining feasible within an academic research environment.

Data Collection and Analysis

Data for this research will be collected through controlled scenario-based simulations using synthetic patient cases. A fixed sample size of approximately **150 simulated patient cases** will be used to ensure consistency and comparability across experimental conditions. The simulated cases will represent a range of emergency presentations, including low-acuity, moderate-acuity, and high-acuity conditions commonly encountered in emergency departments.

Each simulated patient case will include structured attributes such as arrival time, reported symptoms, urgency indicators, and assigned triage level. For the experimental workflow incorporating remote triage, additional data points will include time of remote submission, nurse review timestamps, override decisions, and escalation actions.

Two datasets will be generated for analysis: • A baseline dataset representing

traditional in-person triage workflows.

- An experimental dataset representing workflows incorporating remote triage and human-in-the-loop oversight.

Quantitative analysis will focus on key performance metrics, including time to triage decision, queue length, waiting time for high-acuity patients, and simulated Left Without Being Seen (LWBS) rates. Descriptive statistical techniques such as means, medians, and comparative percentage differences will be used to evaluate performance differences between the two workflows.

Qualitative data will be collected through structured questionnaires completed by participants acting in clinical roles. Responses will be analyzed thematically to identify patterns related to system usability, perceived safety, and nurse confidence override functionality.

This combined data collection and analysis approach enables a comprehensive evaluation of both operational performance and user-centered factors relevant to emergency care environments.

Technologies to be used

The proposed research prototype will be implemented using the following technologies:

Operating System / Platform

- Linux (Ubuntu Server) for backend deployment and server-side services
- Cloud-based hosting environment for scalability and controlled access

Programming Languages and Frameworks

- **Front-End:** ○ JavaScript with React.js for building responsive user interfaces
- **Back-End:**
    - ○ JavaScript using Node.js with Express.js framework for RESTful API

development **Database**

- Supabase **Front-End Tools**
- HTML5 and CSS3 for user interface structure and styling
- WebRTC for secure real-time video communication between patients and nursing staff

Back-End Tools

- RESTful APIs for communication between client and server
- JSON Web Tokens (JWT) for authentication and session management
- Role-Based Access Control (RBAC) to differentiate patient and nurse access
- Secure logging mechanisms for audit trails and system monitoring

These technologies were selected for their reliability, scalability, security support, and alignment with modern web development and healthcare data protection practices.

Expected Result and Practical Contributions

The expected results of this research are focused on measurable improvements in emergency department operational performance and patient flow. Through scenario-based simulation, the proposed remote triage system is expected to reduce the time required to assign initial triage levels by enabling assessment before physical arrival at the emergency department.

Specifically, the experimental workflow incorporating remote triage is anticipated to yield shorter average waiting times for high-acuity patients than the baseline in-person-only triage model. By prioritizing critical cases earlier, the system is expected to reduce queue congestion during peak arrival periods and improve overall patient flow through the emergency department.

Another key expected outcome is a reduction in simulated Left Without Being Seen (LWBS) rates. Early engagement through remote triage may reduce patient uncertainty and perceived waiting time, both of which are known contributors to LWBS behavior. Lower LWBS rates represent both improved patient safety and enhanced operational efficiency.

From a practical perspective, the findings of this research can inform the design of clinically responsible digital triage systems that integrate automation with human oversight. The results may help emergency department administrators make evidencebased decisions about adopting remote triage technologies to improve capacity management and resource allocation.

Although the system is evaluated in an academic research setting, the insights gained from this study have potential applicability to real-world emergency care environments and contribute to ongoing research in digital health, emergency medicine, and healthcare informatics.

Project Planning and Timeline

Project Timeline and Major Milestones

The project will be executed over a twelve-week academic term and structured into four major phases: research, system design, development, and testing and evaluation. Each phase includes defined milestones and deliverables to ensure steady progress and timely completion of the research objectives.

The initial phase focuses on research and planning, during which relevant literature on emergency department triage, telemedicine, and digital health systems will be reviewed. Key milestones for this phase include finalizing the problem definition, refining research questions and hypotheses, and completing the project proposal.

The system design phase involves translating research objectives into technical and functional specifications. Deliverables include system architecture diagrams, data flow models, user interface wireframes, and security design considerations. This phase establishes the foundation for implementation.

The development phase centers on building the web-based prototype. Key milestones include implementing the patient triage interface, the nurse dashboard, video consultation features, authentication mechanisms, and database integration.

The final phase focuses on testing and evaluation. Scenario-based simulations will be conducted using synthetic patient cases, followed by data analysis and documentation of findings. Deliverables include simulation results, usability feedback summaries, and preparation of the final project report.

Phase-Based Deliverables

Phase 1: Research and Planning (Weeks 1–2)

- Literature review summary on emergency department triage and telemedicine
- Finalized problem statement, research questions, and hypotheses
- Completed and submitted project proposal
- Initial risk assessment and ethical considerations

Phase 2: System Design (Weeks 3–4)

- System architecture diagrams
- Data flow and process models
- User interface wireframes for patient and nurse interfaces
- Security and access control design specifications

Phase 3: System Development (Weeks 5–9)

- Implementation of patient remote triage interface
- Development of nurse dashboard with override functionality
- Integration of video consultation features
- Database schema and backend API implementation
- Authentication and role-based access control

Phase 4: Testing and Evaluation (Weeks 10–12)

- Scenario-based simulation execution
- Data collection and performance metric analysis
- Usability evaluation and qualitative feedback summary
- Final project report and presentation materials

Team Member Responsibilities

This project will be completed by a team of two members with complementary academic backgrounds in **Data Analytics** and **Cybersecurity**. Responsibilities will be distributed to leverage each member's area of expertise while maintaining balanced participation across all phases of the research project.

During the research and planning phase, both team members will collaboratively conduct the literature review, define the problem scope, and formulate research questions and hypotheses. The Data Analytics major will emphasize identifying performance metrics, data requirements, and evaluation criteria. In contrast, the Cybersecurity major will focus on reviewing security, privacy, and ethical considerations relevant to handling sensitive health-related data.

In the system design phase, both members will jointly develop the system architecture, data flow diagrams, and user interface wireframes. The Data Analytics major will primarily contribute

to the design of data structures, logging mechanisms, and analytical workflows for simulation and evaluation. The Cybersecurity major will lead the design of authentication mechanisms, access control models, and secure data handling strategies, ensuring alignment with healthcare data protection principles.

During the development phase, implementation responsibilities will be shared. The Data Analytics major will focus on backend data handling, simulation logic, and dataset preparation for performance analysis. The Cybersecurity major will focus on implementing secure authentication, role-based access control, encryption mechanisms, and audit logging. Both members will contribute to front-end development, integration testing, and code review activities.

During the testing and evaluation phase, both team members will collaborate on scenariobased simulation execution and the interpretation of results. The Data Analytics major will lead quantitative analyses of operational metrics, including waiting times, queue lengths, and LWBS rates. The Cybersecurity major will evaluate the system's security posture, review access logs, and assess compliance with security and privacy requirements. Final documentation, reporting, and presentation preparation will be completed jointly.

This role distribution ensures that the project benefits from specialized expertise while maintaining equitable contribution and shared responsibility throughout the research lifecycle.

Project Contract

Project Contract Agreement

This Project Contract Agreement outlines the scope of work, responsibilities, timelines, and collaboration expectations for the research project titled **"Web-Based Remote Emergency Room Triage and Telemedicine System with Human-in-the-Loop Clinical Overrides."**

By signing this agreement, all team members acknowledge and commit to fulfilling the responsibilities and deliverables described in this proposal.

Scope of Work

The project will involve the design, development, and evaluation of an academic research prototype for a web-based remote emergency room triage and telemedicine system. The scope includes literature review, system design, prototype development, scenario-based simulation, data analysis, and preparation of required documentation and presentations. The project will be conducted strictly for academic purposes and will not involve real patient data or real-world deployment.

Timeline and Deliverables

All team members agree to adhere to the project timeline and milestones outlined in the **Project Planning and Timeline** section of this proposal. Deliverables will be completed in accordance with the defined phases, including research, design, development, testing, and evaluation.

Roles and Responsibilities

The project will be completed by a team of two members with academic backgrounds in Data Analytics and Cybersecurity. Responsibilities will be distributed to leverage each member's expertise while ensuring equitable contribution across all phases of the project. Both team members agree to actively participate in research, design, implementation, evaluation, and documentation activities.

Collaboration and Communications

Team members agree to collaborate respectfully and professionally throughout the project. Regular meetings will be held at least once per week, either in person or virtually, to review progress, address challenges, and plan upcoming tasks. Additional meetings may be scheduled as needed to meet deadlines.

Accountability and Conflict Resolution

Each team member is responsible for completing assigned tasks promptly. In the event of disagreements or conflicts, team members agree to resolve issues through discussion and mutual agreement. If unresolved, the matter may be escalated to the course instructor for guidance.

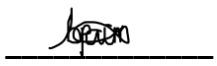
Academic Integrity

All work produced for this project will adhere to the institution's academic integrity policies. Any use of AI tools or external resources will be appropriately documented in the **AI Use Section** and Appendix of the proposal.

Agreement Acknowledgement

By signing below, all team members confirm their understanding of and agreement with the scope, responsibilities, and timelines outlined in this contract.

Team Member Signatures

Bright Ekeator	**300318200**	
AJ Encina	**300381971**	

AI Use Section

AI Tool Name	Version, Account Type	Specific feature for which the AI tool was used	Value Addition
Gemini (LLM)	Pro, Free	Academic writing assistance for proposal drafting and structuring	Refined technical accuracy, aligned content with the course template, integrated domain knowledge from emergency care, cybersecurity, and data analytics, and
			ensured logical flow across sections
ChatGPT	GPT-5.2, Free Account	Brainstorming research structure and methodology	Evaluated AIgenerated suggestions, selected an appropriate research design, and customised the methodology to the academic prototype context.
ChatGPT	GPT-5.2, Free Account	Language refinement and clarity	Reviewed, edited, and rewritten outputs to ensure academic tone, consistency, and originality

Appendix:

- How can I integrate Cybersecurity, Data Analysis, and existing medical knowledge to create a webapp?
- How can I structure the draft of my project proposal on E-Triage?
- Correlate my project idea with existing projects on similar topics.

Work Date/Hours logs for student (or each team member):

Date	Student Name	Number of Hours	Description of Work
06/01/2026	Bright Ekeator, AJ Encina	15 mins	Met with each other to agree on joining together as a group for the project, and exchanged contacts, as well as creating a communication channel
12/01/2026	Bright Ekeator	15 mins	Met with the instructor to discuss
			the project scope and a possible idea.
17/01/2026	Bright Ekeator, AJ Encina	30 mins	Discussed outcome of meeting with instructor and other project ideas pending approval from instructor.
21/01/2026	Bright Ekeator, AJ Encina	20 mins	Met with the instructor for final confirmation on which project idea has a better scope for the two students and decided on the one to choose.
22/01/2026	Bright Ekeator, AJ Encina	1 hour	Team meeting to discuss project objectives, divide tasks, agree on the contract, and plan analysis workflow in preparation for the proposal

24/01/2026	Bright Ekeator, AJ Encina	2 hours	Team meeting to set up the project proposal structure
25/01/2026	Bright Ekeator, AJ Encina	2 hours	Completed the project proposal and agreed to meet the next day after individual proofreading.
26/01/2026	Bright Ekeator, AJ Encina	1 hour	Final proofreading and creating a GitHub repository for collaborative work. Final submission of proposal before deadline.

Closing

Emergency department overcrowding remains a persistent challenge that negatively impacts patient safety, operational efficiency, and quality of care. Delays in triage and prolonged waiting times contribute significantly to adverse patient outcomes and increased rates of patients leaving without being seen. This proposal presents a structured research plan for the development and evaluation of a web-based remote emergency room triage and telemedicine system designed to support pre-hospital patient assessment and improve emergency department flow.

The proposed project adopts a mixed-methods research approach combining academic software prototyping with scenario-based simulation. By integrating remote triage, videobased clinician interaction, and human-in-the-loop override mechanisms, the system aims to address key limitations identified in existing digital triage solutions. The inclusion of cybersecurity and privacy considerations further ensures that the proposed architecture aligns with healthcare data protection standards and ethical research practices.

Through controlled simulations using synthetic patient scenarios, queues, and timestamped events, the project is expected to demonstrate measurable improvements in operational metrics, including average waiting time, patient throughput, and Left Without Being Seen

(LWBS) rates. The results of this research will contribute to the academic understanding of how remote triage systems can be safely and effectively integrated into emergency care workflows.

Overall, this project seeks to provide a technically sound and ethically responsible research prototype that demonstrates the potential of remote triage and telemedicine technologies to alleviate emergency department congestion. The findings from this study may inform future research, system design, and policy discussions related to the digital transformation of emergency healthcare services.

References

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