

Clinical Decision Support System for Resource-Limited Settings

Master's Project Proposal

Student Name: [Your Name]

Department: [Your Department]

Program: Master of Science in [Your Program]

Expected Graduation: [Month Year]

Project Title

AI-Powered Clinical Decision Support System with Offline Functionality for Resource-Limited Healthcare Settings

Faculty Advisors

Primary Advisor:

Dr. [Name], Professor of Data Analytics and Visualization
Department of [Department]

Secondary Advisors:

Dr. [Name], Professor of Natural Language Processing
Department of [Department]

Dr. [Name], Professor of Human-Computer Interaction
Department of [Department]

Executive Summary

This project proposes the development of an innovative clinical decision support system designed specifically for healthcare providers working in resource-limited settings. The system combines offline-first architecture, AI-assisted clinical decision making, and an intuitive user interface optimized for various devices including low-end tablets and smartphones. By addressing the critical challenges of intermittent connectivity, limited computational resources, and specialized clinical knowledge, this system aims to support healthcare providers in delivering quality care in underserved regions.

Background and Significance

Healthcare providers in resource-limited settings face significant challenges:

1. **Limited access to specialized medical knowledge** and up-to-date clinical guidelines
2. **Inconsistent internet connectivity**, preventing reliable use of cloud-based resources
3. **Constrained computational resources** and device availability
4. **High patient-to-provider ratios**, necessitating efficient workflows
5. **Limited access to diagnostic equipment**, increasing reliance on clinical judgment

The World Health Organization and other global health entities have identified clinical decision support systems as a critical tool for improving healthcare quality in underserved regions. However, most existing systems are designed for high-resource settings, requiring continuous internet connectivity and advanced devices.

This project addresses this gap by creating a purpose-built system that functions reliably offline, provides contextually relevant clinical guidance, and operates efficiently on available devices.

Project Objectives

1. Develop a Progressive Web Application (PWA) with comprehensive offline functionality
2. Implement an intelligent local-first data architecture with bidirectional synchronization
3. Integrate an AI-powered clinical decision support system using pre-trained models that can run locally
4. Design a responsive and intuitive user interface optimized for high-stress, resource-constrained environments
5. Incorporate WHO-aligned clinical guidelines and protocols for common conditions in resource-limited settings
6. Evaluate the system's performance, usability, and clinical utility through simulations and expert feedback

Methodology and Technical Approach

System Architecture

The proposed system will implement a local-first architecture with the following components:

1. **Frontend Framework:** Next.js for the progressive web application
2. **Local Database:** IndexedDB (via Dexie.js) for robust client-side data storage
3. **Synchronization Layer:** Custom bidirectional sync protocol with conflict resolution
4. **AI Integration:** Google's Generative AI (Gemini) with offline fallback mechanisms
5. **Clinical Knowledge Base:** Structured representation of WHO guidelines and protocols

Data Flow and Synchronization

The system will implement an intelligent synchronization strategy:

- Prioritize critical clinical data for synchronization
- Queue modifications while offline for later synchronization
- Implement version control to handle concurrent modifications
- Provide transparent sync status and conflict resolution

AI-Assisted Clinical Decision Support

The AI component will provide:

- Differential diagnosis suggestions based on patient symptoms and demographics
- Treatment recommendations aligned with WHO guidelines
- Adaptation to resource constraints (medication availability, diagnostic capacity)
- Natural language processing for clinical notes and symptom descriptions
- Fallback to rule-based recommendations when AI is unavailable

User Interface Design

The interface will be optimized for:

- High-stress, time-constrained environments
- Variable lighting conditions (indoor/outdoor use)
- Touch interfaces with potential for stylus input
- Minimal training requirements
- Voice input capabilities for hands-free operation in clinical settings

Evaluation Methods

The system will be evaluated through:

- Performance testing under various connectivity conditions
- Usability testing with healthcare providers
- Comparison of AI recommendations with clinical guidelines
- Simulation of clinical scenarios to assess decision support quality
- Expert review by healthcare professionals with experience in resource-limited settings

Innovation and Contribution

This project introduces several innovative aspects:

1. **Adaptive AI with resource awareness:** The system will tailor recommendations based on available resources, unlike traditional systems that assume optimal conditions.
2. **Intelligent offline synchronization:** Advanced prioritization algorithms will ensure critical data is synchronized first when connectivity is limited.
3. **Multimodal input optimized for clinical environments:** The system will support voice input and structured data capture designed specifically for clinical workflows.
4. **Context-aware knowledge retrieval:** Clinical guidelines will be indexed and retrieved based on relevance to the patient's presentation, available resources, and provider's expertise level.
5. **Visual differential diagnosis support:** Interactive visualizations will help providers understand diagnostic possibilities and treatment tradeoffs.

Timeline and Deliverables

Phase 1: Research and Planning (8 weeks)

- Comprehensive literature review
- Requirements gathering and system architecture design
- Clinical guideline selection and structuring
- Development of evaluation protocols

Phase 2: Core System Development (12 weeks)

- Development of offline-first data architecture
- Implementation of user interface components

- Integration of clinical knowledge base
- Basic synchronization functionality

Phase 3: AI Integration and Enhancement (8 weeks)

- Integration of generative AI capabilities
- Development of offline AI fallback mechanisms
- Implementation of multimodal input options
- Refinement of synchronization protocols

Phase 4: Testing and Evaluation (8 weeks)

- Technical performance testing
- Usability testing with simulated clinical scenarios
- Expert evaluation of clinical recommendations
- Iterative refinement based on feedback

Phase 5: Documentation and Presentation (4 weeks)

- Comprehensive system documentation
- Preparation of academic manuscript
- Development of demonstration materials
- Final project presentation

Required Resources

- Development hardware (laptop/desktop computer)
- Mobile devices for testing (various Android/iOS devices)
- Cloud hosting environment for backend services
- Google Generative AI API access
- Access to clinical guidelines and protocols
- Collaboration with healthcare providers for evaluation

Expected Outcomes and Impact

This project is expected to produce:

1. A fully functional progressive web application for clinical decision support
2. An innovative offline-first data architecture adaptable to other healthcare applications
3. Evaluation data on the effectiveness of AI-assisted clinical decision support in resource-limited settings
4. At least one academic publication in a relevant peer-reviewed journal
5. Open-source contributions to the healthcare informatics community

The potential impact includes:

- Improved quality of care in resource-limited settings
- Enhanced clinical decision-making for healthcare providers with limited specialized training
- More efficient use of scarce healthcare resources
- A model for future health information systems designed for challenging environments

Conclusion

This project addresses a critical need in global health informatics by creating a purpose-built clinical decision support system for resource-limited settings. By combining advanced technologies with practical design considerations, it has the potential to meaningfully impact healthcare delivery in underserved regions while advancing the fields of health informatics, artificial intelligence, and human-computer interaction.

References

[List of relevant academic sources, clinical guidelines, and technical references]