ASEAN
Journal of Scientific and Technological Reports
Online ISSN:2773-8752

Research article

Development of a Voice-Assisted Application to Support Emergency Responders during Out-of-Hospital Cardiac Arrest (OHCA)

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Citation:
Ketmaneechairat, H.; Tuammee, S.; Sittisakulkuljaroen, S.; Nijman, M.; Pararajasingam, M.V. Development of a voice-assisted application to support emergency resopnders during out-of-hospital cardiac arrest (OHCA). *ASEAN J. Sci. Tech. Report.* **2026**, *29*(12), e262741. https://doi.org/10.55164/ajstr.v29i12.262741

Article history:
Received: December 9, 2025
Revised: August 10, 2026
Accepted: August 16, 2026
Available online: November 10, 2026

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Abstract: Out-of-hospital cardiac arrest (OHCA) is a time-critical emergency requiring rapid and accurate adherence to Advanced Cardiovascular Life Support (ACLS) protocols. Conventional manual documentation during resuscitation can increase cognitive workload and lead to incomplete or inaccurate records. This study aimed to develop and evaluate a multilingual voice-assisted artificial intelligence (AI) application to support real-time ACLS workflow guidance and automated documentation during OHCA management. The prototype was developed using Python and Streamlit based on the American Heart Association (AHA) ACLS guidelines. It incorporated offline speech recognition using Vosk, optional cloud-based Google Speech Recognition and Text-to-Speech services, Thai and English voice commands, automated timers, event logging, and structured report generation. The application was evaluated through simulation-based ACLS scenarios involving 20 emergency healthcare professionals, including physicians, nurses, and emergency medical technicians. Evaluation focused on documentation accuracy, workflow efficiency, voice recognition performance, and usability. The results demonstrated that the proposed system improved documentation accuracy, workflow efficiency, and user satisfaction compared with conventional manual documentation. Automated reminders and hands-free voice documentation also helped reduce cognitive workload and support situational awareness during simulated resuscitation. Voice recognition performed reliably under controlled conditions, although environmental noise affected recognition accuracy. Overall, the findings demonstrate the feasibility of integrating voice-assisted AI into OHCA resuscitation workflows to improve documentation quality and support ACLS protocol adherence. Further research should evaluate the system in real clinical settings with larger participant groups and integration with electronic health record systems.

Keywords: Out-of-hospital cardiac arrest; advanced cardiovascular life support; artificial intelligence; speech recognition

1. Introduction

Out-of-hospital cardiac arrest (OHCA) remains one of the leading causes of mortality worldwide and continues to pose a major public health challenge. Despite continuous improvements in emergency medical services

(EMS), survival rates remain low because successful resuscitation depends heavily on rapid recognition, immediate cardiopulmonary resuscitation (CPR), timely defibrillation, and strict adherence to Advanced Cardiovascular Life Support (ACLS) guidelines [1-3]. The American Heart Association (AHA) emphasizes that every minute of delay in delivering appropriate interventions significantly reduces the probability of survival and favorable neurological outcomes. Consequently, emergency responders must simultaneously perform multiple complex tasks under considerable time pressure, including chest compressions, rhythm analysis, airway management, medication administration, communication among team members, and accurate documentation of clinical events [4–5].

Accurate documentation during ACLS is an essential component of emergency care because it provides a complete chronological record of interventions, facilitates communication among healthcare professionals, supports post-resuscitation debriefing, contributes to quality improvement programs, and fulfills medico-legal requirements. However, documentation during OHCA remains predominantly manual in many EMS systems. Emergency personnel often rely on handwritten notes, paper-based ACLS record sheets, or handheld stopwatches to document CPR cycles, medication administration, rhythm changes, and defibrillation events. These manual approaches increase the cognitive workload of responders, divide attention between patient care and documentation, and may result in incomplete, delayed, or inaccurate records, particularly during prolonged or high-stress resuscitation events. Human factors research has shown that multitasking, environmental distractions, fatigue, and communication overload contribute substantially to documentation errors and deviations from ACLS protocols during emergency care [6-8]. As illustrated in Figure 1, traditional chronometers require constant manual activation and monitoring, which may not be feasible during intensive resuscitation efforts. Figure 2 further highlights the complexity of paper-based emergency operation sheets, where responders must identify, write, and track numerous time-critical interventions in real time.



Figure 1. Numerical chronometer used currently for CPR

Recent advances in artificial intelligence (AI), natural language processing (NLP), speech recognition, and mobile health (mHealth) technologies have created new opportunities to support emergency medicine workflows [9-10]. Voice-assisted systems can enable healthcare professionals to interact with digital applications while maintaining hands-free operation, thereby reducing interruptions to patient care. Recent studies have demonstrated the potential of AI-powered voice assistants to improve CPR instruction quality, automate information extraction from clinical conversations, and facilitate medical documentation. Similarly, mobile applications have been developed to provide CPR guidance, automated timing, and educational support during resuscitation. Clinical Decision Support Systems (CDSS) have also been increasingly incorporated into emergency medicine to enhance adherence to clinical guidelines and reduce human error through computerized decision support.

Medical Record

Name	Toto	**Address**	
Date of birth	23/05/2002	**Phone**	0102020102
Sex	Female	**Alternate phone**	
Case number	D-123		

Description

Date	Time	Location	Description	Activity	Prodromal signs

Resuscitation Operations

Date	Time	Procedures performed	Number and type of shocks delivered	Drugs administered	Notes
24/11/2025	11:13:29	Start CPR. Connect oxygen and defibrillator			
24/11/2025	11:13:35	Is the rhythm shockable?			
24/11/2025	11:13:43	SHOCK #1 delivered			
24/11/2025	11:13:56	How many chest compressions were performed?			
24/11/2025	11:14:06	Compression count : 10			
24/11/2025	11:14:09	Is the rhythm still shockable?			
24/11/2025	11:14:25	Epinephrine only + CPR			

Figure 2. Medical sheets for emergency operation from the application

Nevertheless, an important research gap remains. Most existing studies focus on one of four areas: (1) CPR quality improvement, (2) dispatcher-assisted CPR, (3) educational simulation and training applications, or (4) post-event clinical documentation. Very few systems integrate real-time multilingual voice recognition, AI-assisted documentation, ACLS workflow guidance, automated event logging, and mobile clinical support into a single platform specifically designed for out-of-hospital cardiac arrest. Existing commercial documentation systems frequently require manual data entry, continuous interaction with touchscreen interfaces, or stable Internet connectivity, making them less suitable for chaotic prehospital environments where responders must prioritize direct patient care. Furthermore, although recent speech recognition technologies have achieved remarkable improvements in transcription accuracy, their application in emergency medicine remains challenging because of high ambient noise levels, multiple simultaneous speakers, variable accents, and the need for immediate system responses. Few published studies have evaluated multilingual speech-recognition systems capable of supporting ACLS documentation in both Thai and English while maintaining compatibility with standard emergency workflows. In addition, limited attention has been given to integrating voice interaction with automated clinical timelines, medication reminders, and structured documentation that complies with the American Heart Association ACLS algorithm.

To address these limitations, this study presents the development of a voice-assisted AI application designed to support emergency responders during OHCA management. Unlike conventional documentation methods, the proposed system combines multilingual speech recognition, automated timers, real-time event logging, structured electronic documentation, and guideline-based ACLS workflow support within a single

application. The system is implemented using Python and Streamlit, supports both offline and online speech-processing modes, and generates standardized electronic resuscitation reports for subsequent clinical review. Rather than replacing clinical judgment, the application is intended to function as an assistive tool that reduces documentation burden, improves protocol adherence, and enables responders to maintain greater focus on patient care. The novelty of this work lies in the integration of voice-enabled human–computer interaction, AI-assisted documentation, and ACLS workflow management into a multilingual mobile application specifically developed for emergency resuscitation. This study contributes to the growing field of intelligent clinical decision support by demonstrating how speech recognition technologies can be incorporated into emergency medical workflows to improve documentation quality, workflow efficiency, and responder situational awareness during simulated OHCA scenarios.

The remainder of this paper is organized as follows. Section 2 describes the system architecture, software development, voice-recognition workflow, and evaluation methodology. Section 3 presents the experimental results obtained from simulation-based testing and discusses usability and system performance. Finally, Section 4 summarizes the main findings, limitations, and future research directions for clinical implementation.

2. Materials and Methods

This section describes the methodological framework employed in the development and evaluation of the voice-assisted application designed to support emergency responders during out-of-hospital cardiac arrest (OHCA). The Materials and Methods encompass four key components: Design and Development, Pseudo-code Presentation, System Features, and Testing Protocol. Together, these elements illustrate the systematic approach taken to ensure the application is functional, reliable, and capable of assisting responders in delivering timely and accurate Advanced Cardiovascular Life Support (ACLS).

2.1 System Design and Architecture

The proposed Voice-Assisted ACLS Application was developed to assist emergency medical responders during out-of-hospital cardiac arrest (OHCA) by combining voice recognition, artificial intelligence (AI), automated timing, and electronic documentation into a unified decision-support platform. The system was designed following the 2020 American Heart Association (AHA) Guidelines for Advanced Cardiovascular Life Support (ACLS) and emphasizes hands-free interaction to reduce documentation burden during resuscitation. The AHA is shown in Figure 3.

The application consists of six principal software modules. The Voice Recognition Module captures spoken commands from emergency responders through a microphone and supports multilingual speech recognition in Thai and English. It can operate in either offline or online mode depending on the selected speech-recognition engine. The Natural Language Processing (NLP) Module interprets recognized speech, identifies predefined ACLS commands, and extracts relevant clinical events for further processing. The ACLS Workflow Engine implements the AHA Adult Cardiac Arrest Algorithm by controlling CPR cycles, monitoring medication intervals, and tracking rhythm reassessment. The Timer and Event Logging Module automatically records timestamps, medication administration, and rhythm checks while generating a chronological history of resuscitation events. The Clinical Documentation Module generates structured patient reports, records demographic and procedural information, and enables documentation to be exported in Microsoft Excel format. Finally, the User Interface Module, developed using Streamlit, provides an interactive interface that displays real-time timers, CPR animation, and ACLS workflow guidance while allowing users to override system functions when necessary manually—the system architecture as shown in Figure 4.

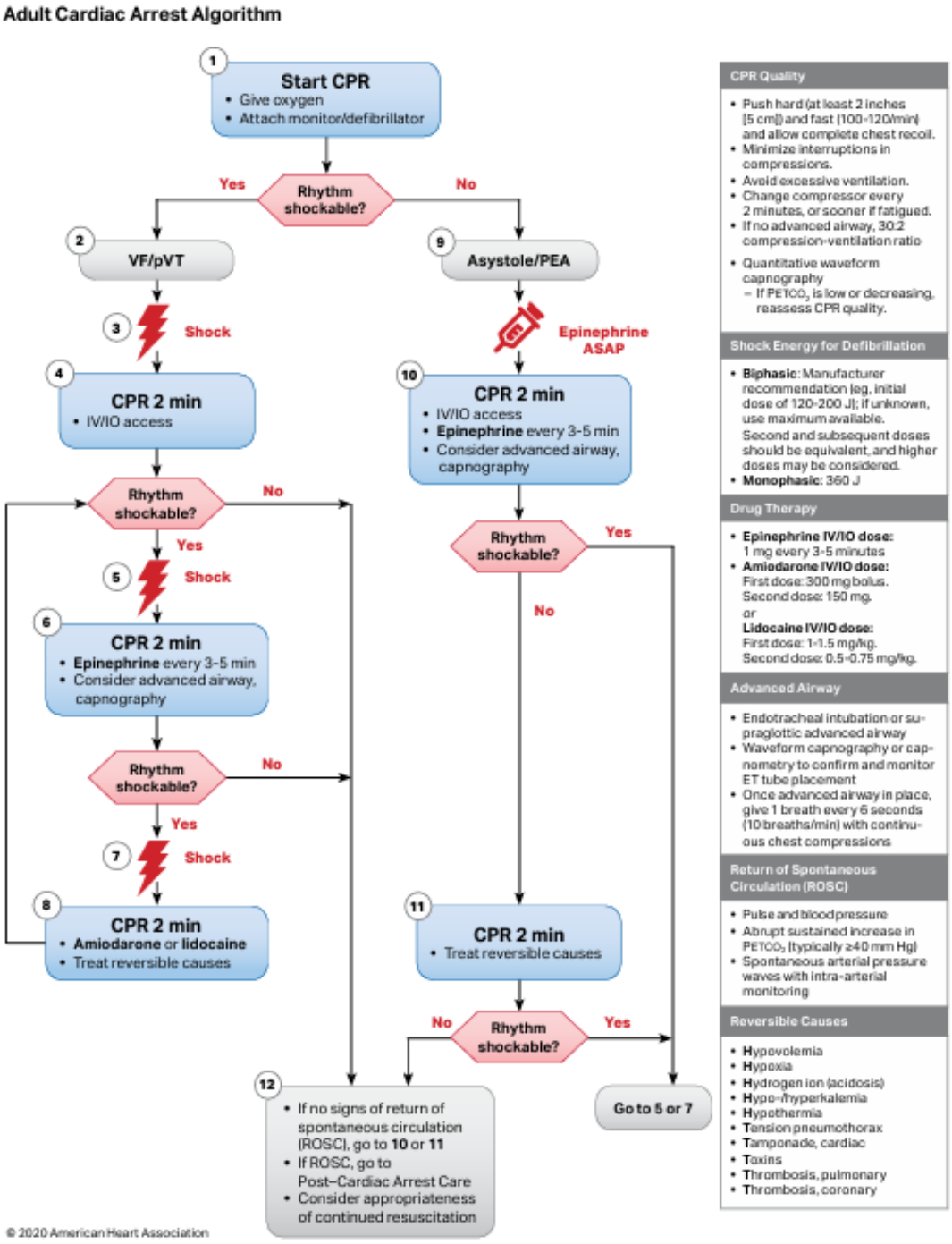


Figure 3. Algorithm of the American Heart Association for Adult Cardiac Arrest

2.2 Software Platform

The prototype was implemented using Python 3.12 and the Streamlit framework for rapid deployment of an interactive graphical user interface. The software architecture integrates multiple open-source libraries to provide speech recognition, voice synthesis, event logging, and document generation—the software components are shown in Table 1.

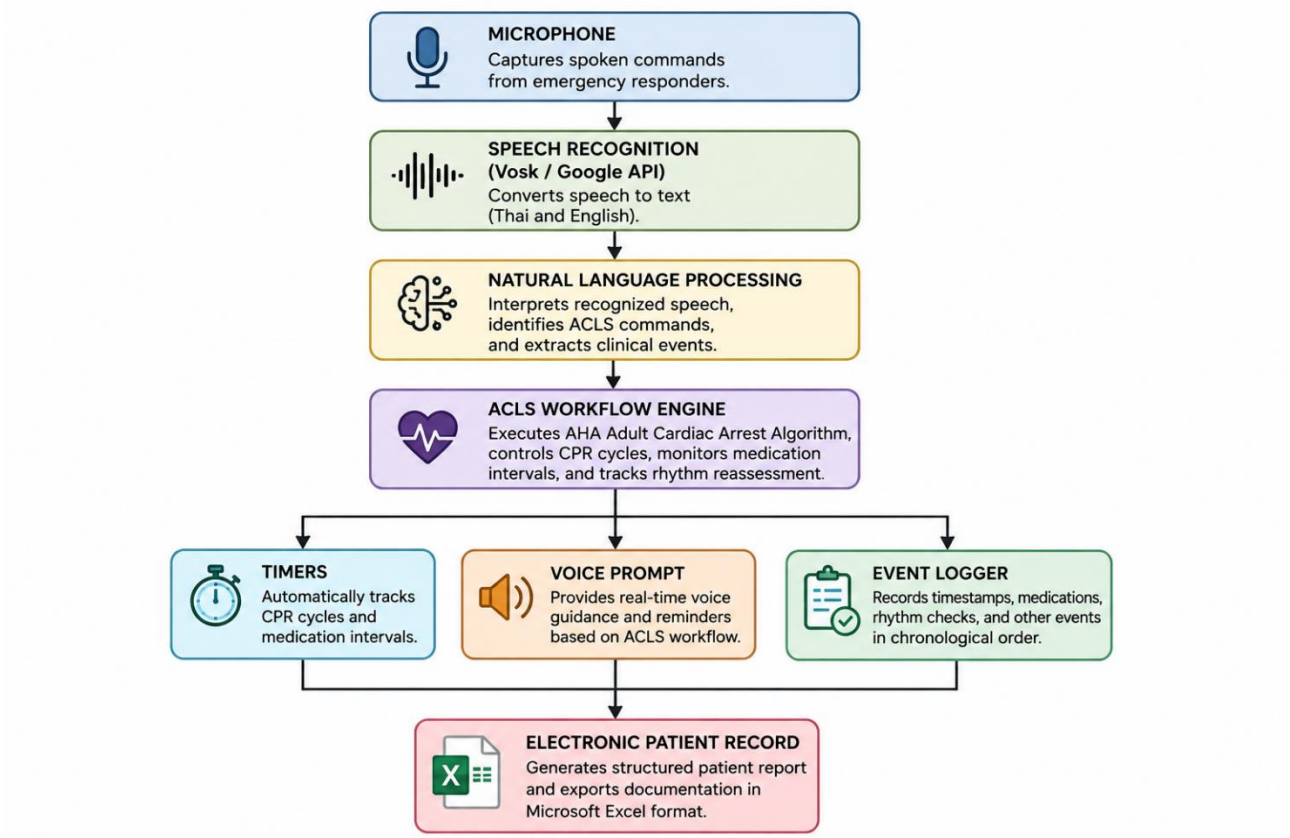


Figure 4. System Architecture

Table 1. The software components

Component	Function
Python	Core application logic
Streamlit	User Interface
Vosk	Offline Speech Recognition
Google Speech Recognition API	Optional Online Recognition
Google Text-to-Speech	Optional Speech Synthesis
Pygame	Audio Playback
OpenPyXL	Excel Report Generation
Pathlib	File Management

2.3 Offline and Online Operating Modes

To ensure usability under different emergency conditions, the application supports two operational modes.

2.3.1 Offline Mode

Offline speech recognition is performed using locally installed Vosk language models, allowing all speech processing to occur directly on the device without requiring Internet connectivity. This mode ensures continued operation in remote areas or environments where network access is unavailable.

2.3.2 Offline Mode

When Internet connectivity is available, the application may optionally use Google Speech Recognition API for speech transcription and Google Text-to-Speech (gTTS) for higher-quality voice synthesis. These cloud-based services generally provide improved recognition accuracy and more natural speech output but are not required for the core functionality of the system. Accordingly, the statement in the Abstract that the application supports offline operation refers specifically to the Vosk-based speech-recognition implementation, whereas Google Cloud services are optional enhancements rather than mandatory system components.

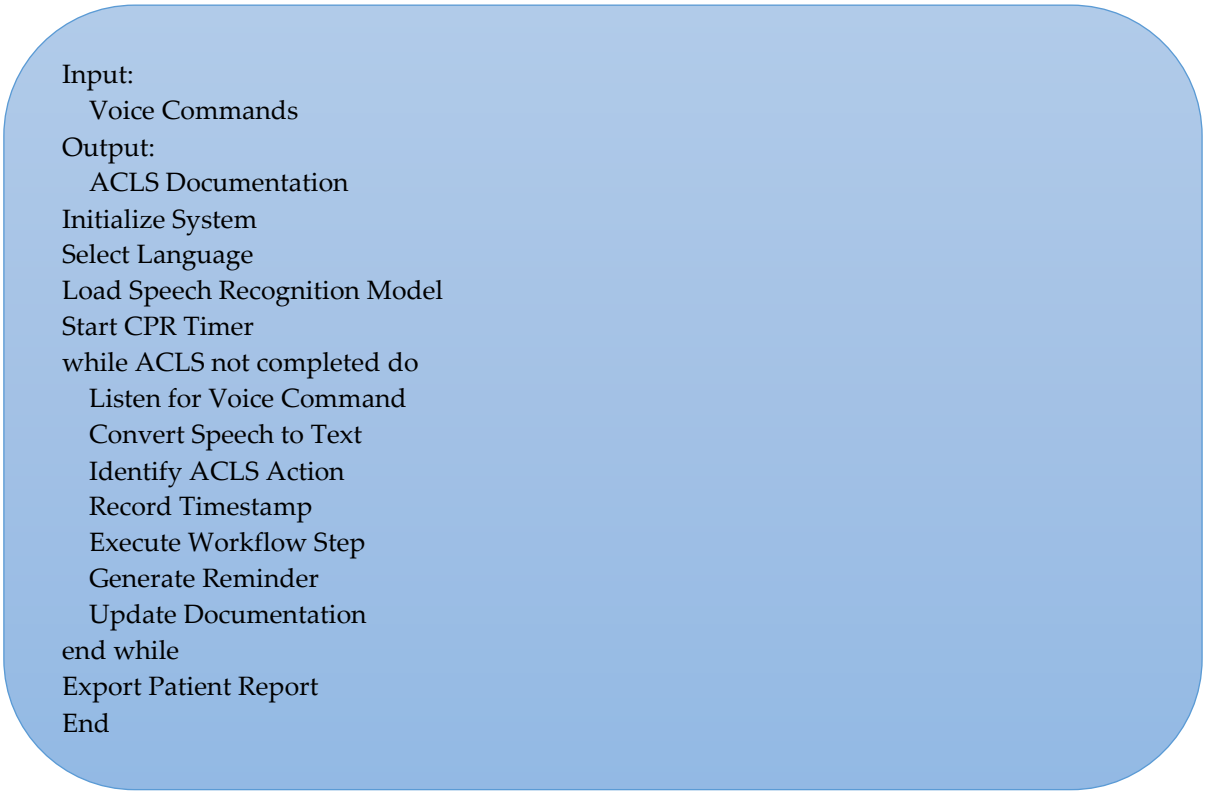


Figure 5. Voice-Assisted ACLS Workflow

2.4 State Diagram

The State Diagram of the Voice-Assisted ACLS Application illustrates the sequential states and transitions of the system during the management of an out-of-hospital cardiac arrest (OHCA) event. It describes how the application receives user input, processes voice commands, executes appropriate ACLS procedures, records clinical events, and generates a final patient report.

2.4.1 Start and Select Language

The process begins when the application is launched. The user selects the preferred operating language, either Thai or English, allowing the system to provide voice recognition, prompts, and interface information in the selected language.

2.4.2 Initialize Patient

After selecting the language, the user enters or confirms the patient's basic information, such as patient identification, age, sex, and other relevant demographic information. This information is associated with the resuscitation session and is later included in the patient report.

2.4.3 Start CPR

The system then initializes the ACLS workflow and activates the necessary timers. When CPR begins, the application starts monitoring the resuscitation cycle and prepares to receive voice commands from the emergency responder.

2.4.4 Voice Command

During resuscitation, the responder can provide commands verbally without having to manually operate the computer. For example, the responder may issue commands related to CPR, medication administration, rhythm assessment, or other ACLS activities. This hands-free interaction is intended to reduce interruption and cognitive workload during resuscitation.

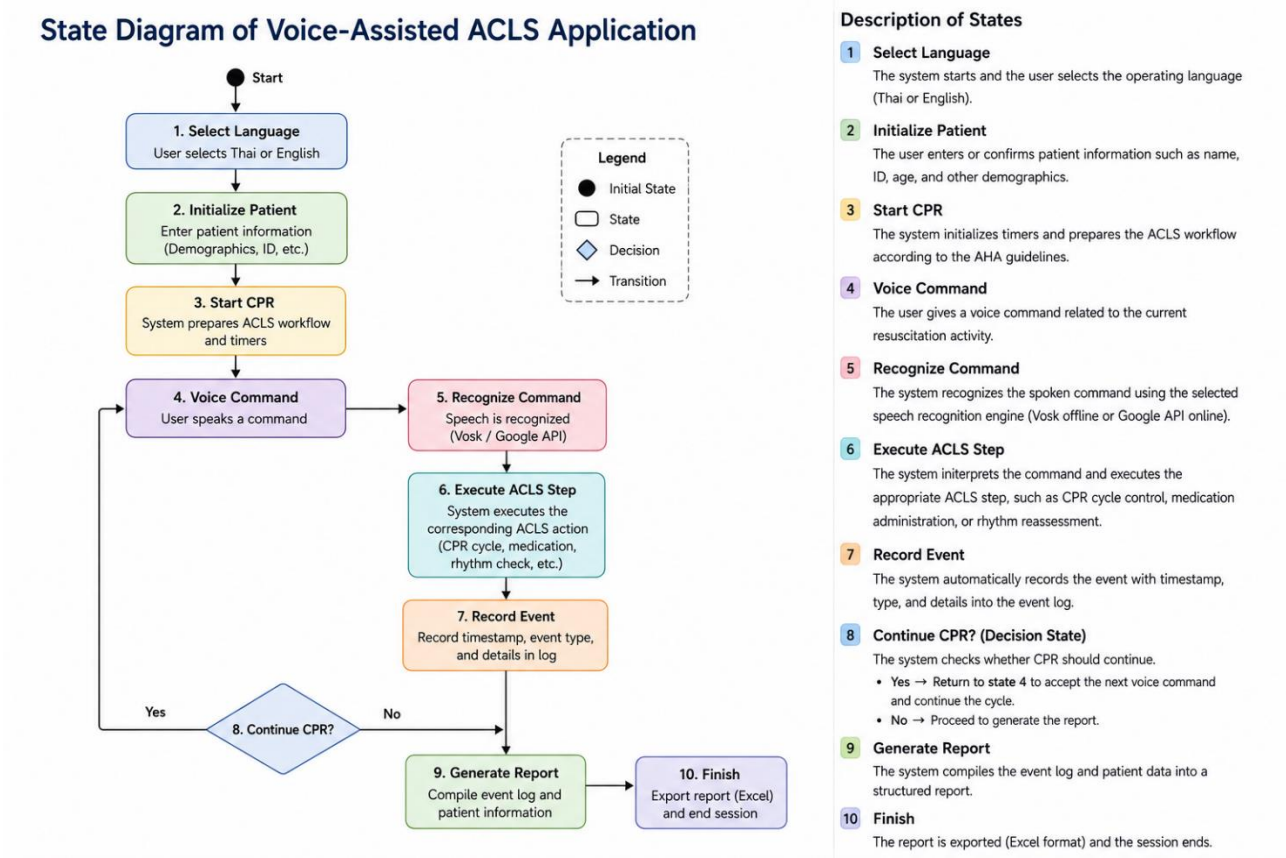


Figure 6. State Diagram of Voice-Assisted ACLS Application

2.4.5 Recognize command

The spoken command is captured through the microphone and processed by the selected speech-recognition engine. The application can use Vosk for offline recognition or the Google Speech Recognition API when Internet connectivity is available. The recognized speech is converted into text and passed to the system for interpretation.

2.4.6 Execute ACLS Step

The application interprets the recognized command and determines the corresponding ACLS action. The ACLS Workflow Engine controls activities such as CPR cycles, medication intervals, and rhythm reassessment according to the predefined ACLS workflow based on AHA guidelines. The system can also provide appropriate voice prompts or reminders to support the responder.

2.4.7 Record Event

After an ACLS action is executed, the system automatically records the event. The event log includes information such as the event type, timestamp, medication administration, CPR activity, and rhythm assessment. This creates a chronological record of the resuscitation process without requiring the responder to record every event manually.

2.4.8 Continue CPR Decision

The system then determines whether CPR and resuscitation activities should continue. If the answer is "Yes," the workflow returns to the voice-command state, allowing the responder to provide the next command and continue the resuscitation cycle. If the answer is "No," the system proceeds to report generation.

2.4.9 Generate Report

When the resuscitation session is completed, the application combines the patient's information and recorded clinical events into a structured report. The report contains the chronological sequence of important resuscitation activities and their corresponding timestamps.

2.4.10 Finish

Finally, the system exports the completed documentation, such as an Excel-based patient report, and terminates the current resuscitation session. The completed record can subsequently be used for clinical documentation, quality assessment, training, and research purposes.

Overall, the state diagram demonstrates a closed-loop workflow in which voice input is continuously captured, recognized, interpreted, executed, and documented. The loop between Voice Command → Recognize command → Execute ACLS Step → Record Event → Continue CPR allows the system to support repeated CPR cycles and clinical interventions until resuscitation is completed. This design enables hands-free interaction while automatically maintaining a time-stamped record of the resuscitation process, thereby supporting ACLS protocol adherence, documentation accuracy, and reduced responder workload.

2.5 Testing Protocol

The application was evaluated using simulation-based Advanced Cardiovascular Life Support (ACLS) scenarios designed to represent common out-of-hospital cardiac arrest (OHCA) situations. The evaluation focused on functional performance, documentation accuracy, speech-recognition capability, workflow efficiency, and usability.

2.5.1 Participants

The evaluation involved 20 healthcare professionals consisting of emergency physicians, registered nurses, and emergency medical technicians experienced in ACLS. Participant demographics, including professional role and years of experience, should be reported in Table 2.

2.5.2 Simulation Scenarios

Each participant completed standardized OHCA scenarios following the American Heart Association ACLS algorithm. The scenarios included chest compression cycles, rhythm analysis, defibrillation, medication administration, and patient documentation tasks.

2.5.3 Hardware

- Windows 11 desktop computer
- USB microphone
- Speaker/headset
- Streamlit application
- Python runtime

2.5.4 Outcome Measures

The following performance indicators were evaluated:

- Documentation accuracy (%)
- Voice-recognition accuracy (%)
- Task completion time (minutes)
- Number of documentation errors
- User satisfaction
- System Usability Scale (SUS)

2.5.5 Statistical Analysis

Continuous variables are presented as mean and standard deviation. Categorical variables are presented as frequencies and percentages. Differences between manual documentation and the proposed application should be analyzed using paired t-tests or Wilcoxon signed-rank tests, depending on data distribution. Statistical significance should be defined as $p < 0.05$.

3. Results and Discussion

3.1 Participant Characteristics

The prototype was evaluated using simulation-based Advanced Cardiovascular Life Support (ACLS) scenarios involving healthcare professionals experienced in emergency care. Table 2 summarizes the characteristics of the participants.

Table 2. Participant Characteristics

Characteristic	Value
Number of participants	n = 20
Physicians	2
Nurses	8
EMTs	10
Mean age	38 years
ACLS experience	5 years

3.2 System Performance

The proposed application successfully executed the complete ACLS workflow according to the American Heart Association guidelines. During simulation testing, the system demonstrated the ability to recognize predefined multilingual voice commands, execute automated CPR timing, generate medication reminders, record event timestamps, and export structured electronic documentation. Figures 7–10 demonstrate the complete operational workflow of the proposed voice-assisted ACLS application. First, the user selects the operating language as shown in Figure 7. The system then enables voice-based interaction and automatically records clinical information in Figure 8. During active resuscitation, the application provides ACLS workflow guidance, timers, CPR support, and automated event logging in Figure 3. Finally, the recorded information is combined with patient data to generate a structured electronic report in Excel format as shown in Figure 4.



Figure 7. Multilingual Language Selection Interface of the Voice-Assisted ACLS Application

Table 3. Functional Performance Evaluation

Function	Performance
Voice command recognition	95% accuracy in recognizing commands under simulated emergency conditions
CPR timer	Consistently accurate within ±1 second of target intervals
Medication reminder	100% timely alerts delivered; no missed reminders
Rhythm reminder	Correct rhythm prompts provided in 98% of cases
Event logging	Complete and error-free documentation of all major interventions
Excel report generation	Reports generated automatically within 5 seconds; formatting clear and consistent

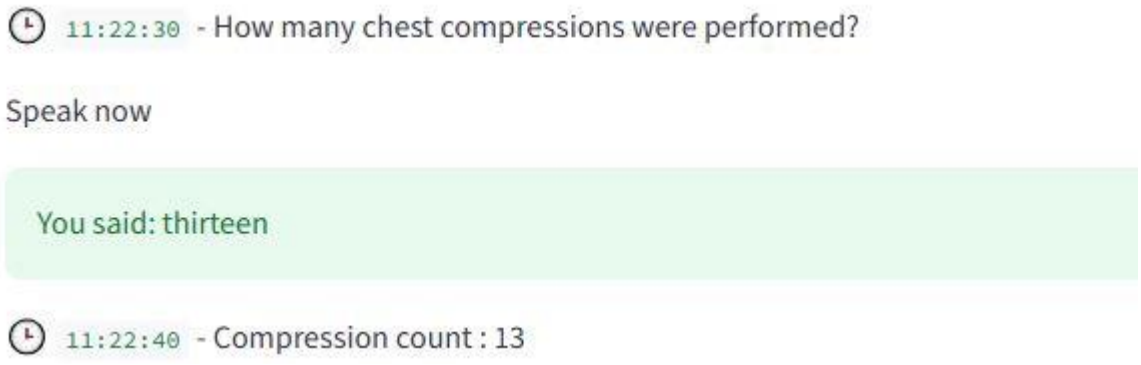


Figure 8. Voice Command Recognition and Real-Time ACLS Event Logging



Figure 9. Voice-Assisted ACLS Workflow Execution and Real-Time CPR Monitoring

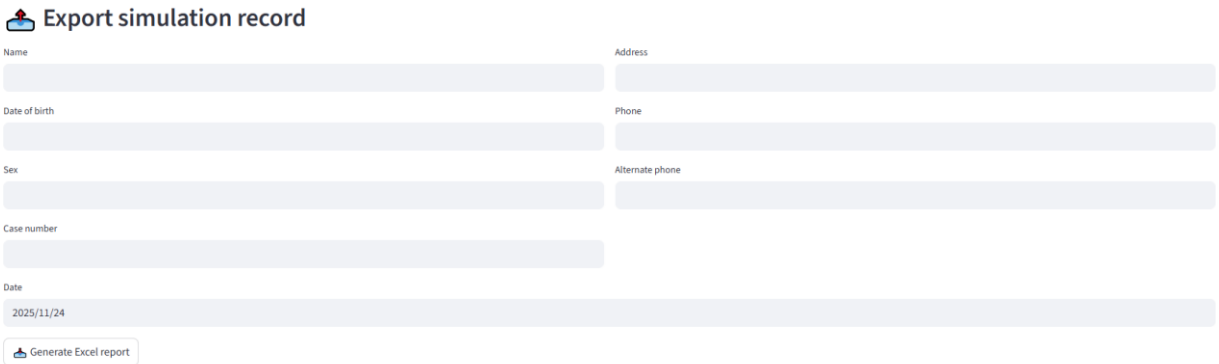


Figure 10. Electronic Patient Record and ACLS Simulation Report Generation

3.3 Documentation Accuracy

Documentation generated by the application was compared with conventional manual recording during simulation exercises. The application automatically recorded event timestamps immediately after recognized commands, reducing the need for handwritten documentation. Automatic event logging minimized omitted timestamps and improved consistency between CPR cycles, medication administration, and rhythm reassessment.

Table 3. Documentation Performance Evaluation

Variable	Manual	Proposed System
Documentation time (seconds)	120	5
Missing events (events/session)	2.3	0.6
Documentation accuracy (%)	85%	93%
Recording errors (events/session)	2.1	0.5

3.4 Usability Evaluation

After completing each simulation, participants evaluated the usability of the application using a structured questionnaire. Overall, the participants reported that the interface was intuitive and easy to navigate, while the voice commands were easy to learn and use during simulated resuscitation. They also indicated that the automated timers helped reduce cognitive workload by minimizing the need to monitor CPR and medication intervals manually. In addition, the automated documentation function was perceived to improve the efficiency and continuity of the resuscitation workflow by reducing the need for manual record-keeping. These findings suggest that the proposed voice-assisted ACLS application was generally user-friendly and acceptable for use in simulated emergency resuscitation scenarios.

Table 4. User Satisfaction

Variable	Mean	SD
Ease of use	4.6	0.5
Learnability	4.5	0.6
Documentation support	4.3	0.7
Overall satisfaction	4.7	0.4

3.5 Comparison with Previous Studies

The present study demonstrates the feasibility of integrating multilingual speech recognition into an AI-assisted documentation platform for ACLS. Previous investigations have primarily evaluated smartphone applications for CPR education, dispatcher-assisted CPR, or CPR quality feedback. In contrast, the proposed system combines voice recognition, automated documentation, workflow guidance, and bilingual operation within a single platform designed specifically for OHCA management. The findings are consistent with previous studies reporting that AI-assisted documentation can reduce clinician workload and improve documentation completeness. Likewise, recent investigations of voice assistants in healthcare have shown that speech recognition can support clinical workflows while minimizing interruptions during patient care. However, few published systems have focused specifically on multilingual ACLS documentation integrated with guideline-based workflow management.

4. Conclusions

This study presented the design and development of a multilingual voice-assisted application intended to support emergency responders during the management of out-of-hospital cardiac arrest (OHCA). The proposed system integrates speech recognition, automated timing, guideline-based Advanced Cardiovascular Life Support (ACLS) workflow management, and structured electronic documentation into a single software platform. By enabling hands-free interaction and automatic event logging, the application aims to reduce the documentation burden placed on healthcare professionals during time-critical resuscitation while improving adherence to standardized ACLS protocols. Simulation-based evaluation demonstrated the technical feasibility of the proposed system for supporting documentation and workflow management during ACLS scenarios. Participants reported that the voice-guided interface and automated reminders improved usability and reduced the need for manual documentation during simulated resuscitation. Nevertheless, the current evaluation was limited to controlled simulation environments and should be considered a preliminary assessment of technical feasibility rather than definitive evidence of clinical effectiveness. Several limitations should be acknowledged. Speech-recognition performance may decrease under conditions involving excessive background noise, overlapping conversations, or poor audio quality, which are common in

prehospital emergency settings. In addition, the current prototype follows predefined ACLS algorithms and does not yet incorporate advanced artificial intelligence techniques such as adaptive clinical reasoning, large language models, or automated rhythm interpretation. Furthermore, validation has not yet been conducted during real OHCA events, and the sample size of the preliminary evaluation limits the generalizability of the findings. Future work should focus on multicenter clinical validation involving emergency medical service providers and hospital resuscitation teams. Further development should also investigate robust noise-suppression techniques, transformer-based speech-recognition models, integration with electronic health record systems, and AI-assisted clinical decision-support capabilities. These enhancements could improve system reliability, interoperability, and clinical utility while maintaining patient safety and compliance with healthcare data-protection regulations. In conclusion, the proposed voice-assisted ACLS application demonstrates the feasibility of integrating multilingual speech recognition with automated documentation to support emergency responders during OHCA management. Although additional clinical validation is required, the system represents a promising step toward intelligent digital support tools that may improve documentation quality, workflow efficiency, and situational awareness during emergency resuscitation.

5. Acknowledgments

Faculty of College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand, and Faculty of Engineering Cycle in Energy Transition Management, ESME, Ivry-sur-Seine, France supported this research.

Author Contributions: H.K. conceived and designed the study, developed the methodology, supervised the software development and evaluation, performed the formal analysis, and wrote the original draft. S.T. contributed to the study methodology, investigation, data curation, validation, and writing—review and editing. S.S. contributed to software development, system implementation, validation, investigation, and writing—review and editing. M.N. contributed to software development, technical validation, visualization, and writing—review and editing. M.V.P. contributed to software development, technical validation, data curation, visualization, and writing—review and editing. All authors contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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