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Research Article

Validation of proRithm Device for Reduction of Patient Onboarding Time in Ambulances

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Abstract

Background: Efficient prehospital care requires timely patient onboarding in ambulances; however, this is frequently delayed by manual documentation and recording of vital signs. The proRITHM Integrated Remote Monitoring Platform is a wearable monitoring system that utilises the Internet of Things (IoT) to enhance ambulance workflows by automatically collecting physiological data, documenting it digitally, and transmitting it in real-time. This pilot study evaluated the efficiency of the program to reduce ambulance patient onboarding time.

Methods: We conducted a prospective, single-center, operational validation study of the proRITHM platform on 5 ambulances during 15 days. Twenty consecutive adult patients were enrolled who had been transported by participating ambulances. The patient onboarding time, defined as the time from first clinical contact until patient identification, clinical documentation, vital parameter acquisition and successful data transmission, was compared between the conventional manual workflow and the proRITHM-enabled digital workflow. Workflow components and Emergency Medical Technician (EMT) usability were also evaluated.

Results: The mean onboarding time was significantly lower with the proRITHM platform than with the conventional manual workflow (5.2 ± 1.17 vs 17.85 ± 10.19 minutes; $p < 0.001$), a mean reduction of 12.65 minutes (64.9%). Mean times for device connection, patient data entry, and vital acquisition were 0.88, 1.50, and 2.83 minutes, respectively. The usability evaluation of EMT showed a very high acceptance: 70% of participants found the platform very easy to use and 70% rated their overall satisfaction as very high. The system was successfully embedded into routine ambulance workflows with no significant operational disruption.

Conclusions: The proRITHM Integrated Remote Monitoring Platform improved the ambulance patient onboarding time significantly and showed excellent usability and operational feasibility. IoT-powered digital onboarding can boost the efficiency of prehospital workflows, allow for earlier communication with receiving hospitals, and lay the groundwork for future AI-driven decision support in emergency medical services. Its impact on patient outcomes and utilisation of healthcare resources needs to be assessed in larger multi-center studies.

Keywords: Prehospital Care; Ambulance; Remote Patient Monitoring; Internet of Things; Wearable Devices; Digital Health; Emergency Medical Services; Workflow Efficiency; Artificial Intelligence

Introduction

Ambulance-based patient onboarding represents a critical initial step in pre-hospital care and includes multiple sequential processes such as patient identification, clinical data collection, recording of vital parameters, and documentation of patient information. These steps are essential to ensure continuity of care between prehospital and hospital teams and to enable appropriate clinical decision-making during patient transport [1,2].

In the current workflow, onboarding is primarily performed manually by Emergency Medical Technicians (EMTs). This process involves recording demographic details, obtaining relevant clinical history, and measuring vital signs such as heart rate, blood pressure, respiratory rate, and oxygen saturation using conventional devices, followed by manual documentation. These activities require multiple sequential steps and depend largely on manual recording and documentation by EMTs [3,4].

The time required to complete these onboarding activities can represent a considerable portion of the total pre-hospital care process and may contribute to delays in patient transport and initiation of definitive treatment, particularly in time-sensitive conditions such as acute coronary syndromes, stroke, trauma, and sepsis. Additionally, manual documentation processes may increase EMT workload and introduce variability in the completeness and accuracy of patient information [5,6].

Advances in Internet-of-Things (IoT)-enabled remote monitoring technologies have created new opportunities to improve pre-hospital workflows by enabling automated acquisition and transmission of physiological data. Portable wearable monitoring devices can facilitate rapid collection of vital parameters and enable real-time transmission of patient information to centralized monitoring systems and receiving hospitals [7,8].

The proRithm Integrated Remote Monitoring Platform is a portable multiparameter monitoring system designed to support rapid patient assessment and digital documentation in pre-hospital environments. The system utilizes wearable sensors and mobile connectivity to enable rapid acquisition of physiological parameters, automated documentation, real-time wireless transmission of clinical data, integration with remote monitoring platforms, and structured digital patient onboarding. By reducing dependence on manual recording and paper-based documentation, the proRithm platform has the potential to streamline ambulance workflows and reduce patient onboarding time [9,10].

A previous validation protocol conducted at KIIMS Hospital evaluated the performance of the proRithm device during physiotherapy activities and demonstrated its capability for continuous multiparameter monitoring and real-time data transmission. The study established the technical feasibility and clinical usability of the platform.

The current study builds upon this prior validation work and extends the application of the proRithm system to ambulance-based patient onboarding in real-world emergency transport settings. Unlike the earlier validation study, which focused primarily on physiological monitoring performance, the present study evaluates operational efficiency and workflow optimization. Specifically, it investigates whether implementation of the proRithm Integrated Remote Monitoring Platform can significantly reduce the time required for patient onboarding while maintaining completeness of clinical data collection. Therefore, this study was conducted to evaluate the feasibility and impact of implementing a digital IoT-enabled onboarding workflow in ambulance services, with the primary objective of demonstrating measurable reduction in patient onboarding time and improved operational efficiency.

Study objectives and endpoints

Primary objective

The primary objective of this study is to evaluate the effectiveness of the proRithm Integrated Remote Monitoring Platform in reducing the time required for patient onboarding in ambulance settings, compared with the existing manual onboarding process performed by Emergency Medical Technicians (EMTs).

Patient onboarding in the ambulance includes sequential activities such as patient identification, entry of clinical information, acquisition of vital parameters, and completion of initial documentation. The study aims to determine whether implementation of a digital IoT-enabled onboarding workflow using proRithm can significantly reduce the time required to complete these processes while maintaining completeness and quality of clinical documentation.

Primary endpoint

The primary endpoint of the study will be:

Mean patient onboarding time per patient (in minutes).

Defined as the time interval between

Start Point: First clinical contact of the EMT with the patient and initiation of onboarding activities

End Point: Completion of patient onboarding, defined as:

- Successful entry of patient demographic information
- Completion of clinical information entry
- Recording of vital parameters
- Successful transmission and storage of patient data in the proRithm system

The primary analysis will compare:

Manual onboarding time vs proRithm-enabled onboarding time

The outcome will be expressed as:

- Mean onboarding time (minutes)
- Percentage reduction in onboarding time

Secondary objectives

Operational objectives

The operational objective of the study is to evaluate the usability and feasibility of the proRithm platform in real-world ambulance environments.

This includes assessing the experience of Emergency Medical Technicians (EMTs) while using the system during patient onboarding.

Ease of use and usability

To evaluate EMT experience and usability of the proRithm platform in ambulance environments.

This includes assessment of:

- Ease of device application
- Ease of mobile application use
- Ease of patient data entry
- Overall user satisfaction

Usability was assessed using a structured Likert-scale questionnaire.

Technical objectives

The technical objectives of the study are to evaluate the performance of individual components of the proRithm onboarding workflow and to identify operational bottlenecks.

These include measurement of time required for the following steps.

Device connection time

Time required for:

- Device activation
- Bluetooth pairing
- Establishment of communication between device and mobile application

Measured from

Device power-on → Successful connection confirmation.

Patient data entry time

Time required for entry of patient information into the mobile application, including:

- Patient identification
- Demographic details
- Clinical information

Measured from:

Opening patient form → Completion of data entry

Vital parameter acquisition time

Time required for acquisition of physiological parameters using the proRithm device, including:

- Heart rate
- Respiratory rate

- Blood pressure
- SpO_2
- ECG
- Skin temperature

Measured from:

Device placement → Availability of valid readings

Data transmission time

Time required for transmission and storage of patient data from the mobile application to the cloud-based monitoring platform or command center.

Measured from:

Completion of vital recording → Successful upload confirmation

Study design

Study type

This study is a prospective, single-center clinical and operational validation study to evaluate the effectiveness of the proRithm Integrated Remote Monitoring Platform in reducing ambulance patient onboarding time compared with the conventional manual onboarding workflow.

The study was an open-label clinical and operational validation study, in which Emergency Medical Technicians (EMTs) will perform patient onboarding using both the conventional manual method and the proRithm-enabled digital workflow. The study focuses on evaluating workflow efficiency and operational feasibility in real-world ambulance environments.

This is a non-interventional workflow validation study, and no modification of routine patient treatment or clinical management will be undertaken as part of the study.

Study setting

The study was conducted in ambulance services integrated with the remote monitoring command center.

All participating ambulances were equipped with:

- proRithm wearable monitoring devices
- Mobile application interface
- Internet connectivity for data transmission
- Access to the remote monitoring platform

Study duration

The study was conducted over a period of 15 days.

Number of ambulances

Five ambulances participated in the study.

Each ambulance was equipped with:

- One proRithm device
- Mobile application access
- Data connectivity

Ambulances have operated under their routine service schedules during the study period.

Sample size

- Twenty consecutive patients were enrolled during the study period. All eligible patients transported by participating ambulances during the pilot period were included.
- No formal sample size calculation has been performed, as this study is exploratory and intended to generate preliminary operational data for future larger-scale studies.

Inclusion criteria

Patients eligible for study participation include:

- All patients transported by participating ambulances
- Patients for whom onboarding is performed by EMTs
- Adult patients aged ≥18 years

Exclusion criteria

Patients were excluded if:

- Immediate life-saving transport is required (e.g., cardiac arrest)
- Device placement is not feasible
- Patient refuses monitoring (if consent required)

Device technical details

proRithm system components

The proRithm Integrated Remote Monitoring Platform consists of

- **Wearable Monitoring Device:** The wearable monitoring device is a portable multiparameter monitoring system designed for rapid deployment in prehospital environments.

Sensors included

- ECG sensor
- Photoplethysmography (PPG) sensor
- Temperature sensor
- Oxygen saturation (SpO_2) sensor

Derived physiological parameters

The system generates the following physiological parameters:

- Heart Rate (HR)
- Respiratory Rate (RR)
- Blood Pressure (Cuffless estimation)
- Oxygen Saturation (SpO_2)
- Electrocardiogram (ECG)
- Skin Temperature

Device placement

The proRithm wearable device was placed on the patient's chest in the Lead II ECG position, typically located approximately two fingerbreadths below the left clavicle along the mid-clavicular line.

This placement is consistent with the previously validated protocol and ensures optimal signal acquisition.

Signal acquisition and processing

Raw signal acquisition

The device continuously captures:

- ECG waveform signals
- PPG waveform signals

Signal processing

Captured signals undergo automated processing, including:

- Motion artifact reduction
- Digital signal filtering
- Noise suppression
- Pulse transit time estimation
- Algorithm-based blood pressure estimation

The processing algorithms are designed to ensure stable signal acquisition in dynamic ambulance environments.

Accuracy performance

The proRithm system is designed to achieve: ≥95% accuracy for vital parameter estimation based on prior validation studies.

Data transmission architecture

The proRithm platform uses a multi-step data transmission process.

Step 1 – Device to Mobile Application

- Data is transmitted from the wearable device to the mobile application using: Bluetooth low energy (BLE).

Step 2 – Mobile Application to Cloud Server

Data is transmitted from the mobile application to the secure cloud platform via:

- 4G mobile network
- Wi-Fi network

Step 3 – Cloud to Command Center

- Patient data becomes available on the remote monitoring dashboard in real time.
- This enables remote viewing and monitoring by authorized healthcare personnel.

Report generation

The proRithm system generates automated digital reports containing patient vital parameters.

Typical report generation time: ≤300 seconds based on prior validation studies.

Study workflow

Manual workflow (Baseline)

Under the existing workflow, EMTs perform patient onboarding manually.

The steps include:

- Patient identification
- Collection of clinical history
- Measurement of vital parameters using conventional devices
- Manual documentation

The average time required for completion of these steps is approximately: 18 minutes per patient.

proRithm Workflow (Intervention)

Under the intervention workflow, EMTs will use the proRithm system.

Step 1 – Device Application

- The wearable device is attached to the patient.
- Estimated Time: 1–2 minutes

Step 2 – Patient Data Entry

- EMTs enter patient information into the mobile application.
- Estimated Time: 2–3 minutes

Step 3 – Vital Acquisition

- The device records physiological parameters.
- Estimated Time: 3–5 minutes

Step 4 – Automated Report Generation

- Vital parameters are processed and uploaded.
- Estimated Time: ≤5 minutes

Expected Total Onboarding Time

- Estimated onboarding time using proRithm: 8–12 minutes

Definition of onboarding time

Onboarding time is defined as the total time required to complete patient onboarding activities.

Start Time

Defined as:

Time of first clinical contact between EMT and patient.

This includes initiation of onboarding activities.

End Time

Defined as completion of onboarding, including:

- Device successfully connected
- Patient information entered
- Vital parameters recorded
- Data successfully transmitted

Onboarding time calculation

Onboarding Time = End Time − Start Time

Data collection

Data will be recorded in a structured Case Record Form (CRF).

Variables collected

- Patient number
- Ambulance ID
- Date
- Start time
- End time
- Onboarding time
- Method used
- Remarks

Statistical analysis

Statistical analysis will be primarily descriptive.

Variables analyzed

- Mean onboarding time
- Median onboarding time
- Standard deviation
- Minimum and maximum values

Primary comparison

Comparison will be performed between:

Manual onboarding vs proRithm onboarding

Primary Outcome Calculation

Time Reduction = Manual Time – proRithm Time

Results

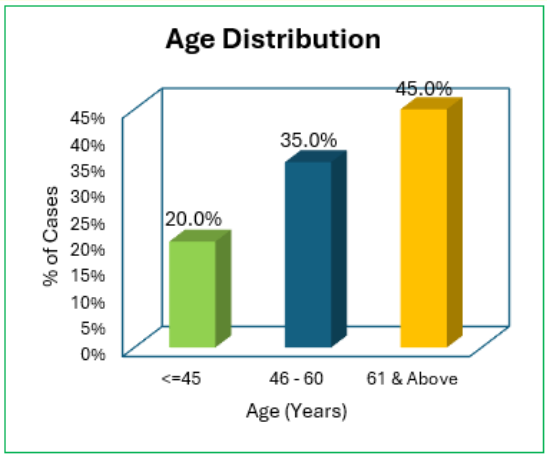

Figure 1: Age Distribution of Study Population.

Figure 1 represents the age distribution of the study population. The age distribution of the study participants shows that the majority of patients belonged to the older age groups. Patients aged 61 years and above constituted the largest proportion (45%) of the study population. This was followed by patients in the 46–60 years age group, accounting for 35% of the cases. The ≤45 years age group represented 20% of the total patients.

Overall, the findings indicate that a substantial proportion of ambulance transports involved middle-aged and elderly patients, reflecting the higher likelihood of acute medical conditions requiring emergency care in these age groups.

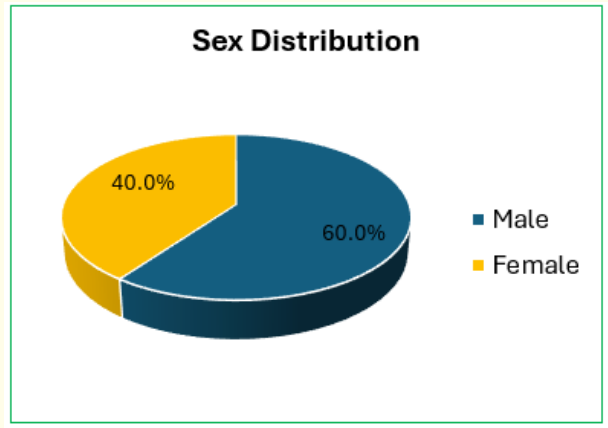

Figure 2: Gender Distribution of Study Population.

Figure 2 represents gender distribution of the study population. The sex distribution of the study population showed a predominance of male patients. Males constituted 60% of the total cases, while females accounted for 40% of the patients included in the study.

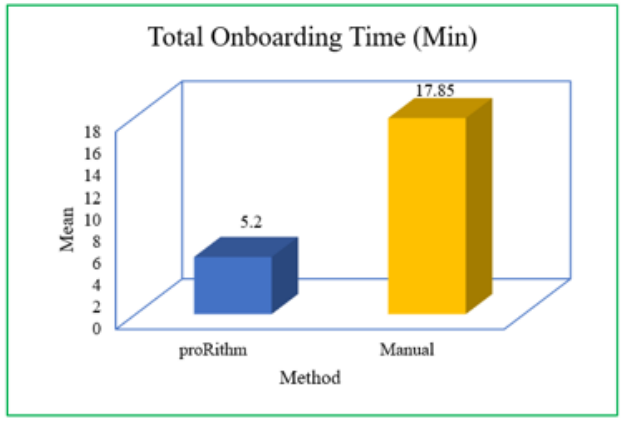

Figure 3: Total Onboarding Time (Min).

Method	Total Onboarding Time (Min)		P Value (Paired t-test)
	Mean	Std.	
proRITHM	5.2	1.174	<0.001
Manual	17.85	10.189	

Table 1: Shows Mean ± Standard deviation (SD) of the total onboarding time for both methods.

Figure 3 shows the comparison of total onboarding time between the conventional manual method and the proRITHM™ onboarding system. Table 1 summarizes the mean ± standard deviation (SD) of the total onboarding time for both methods.

A total of 20 cases were analyzed to evaluate the reduction in onboarding time after implementation of the proRITHM™ platform. The mean reduction in onboarding time was 12.65 minutes, with a median reduction of 7.50 minutes. The percentage reduction in onboarding time showed a mean reduction of 64.915%, with a median reduction of 61.80%. The reduction ranged from 4 minutes to 33 minutes, indicating variability in operational conditions during ambulance onboarding. The interquartile range (IQR) showed that 50% of cases experienced a reduction between 5.50and 20.50 minutes, corresponding to a 55.15% to 76.83% reduction in onboarding time.

Comparison of onboarding time between methods

The mean total onboarding time using the proRITHMTM system was 5.2 ± 1.174 minutes, whereas the manual onboarding process required 17.85 ± 10.189 minutes. Statistical comparison using a paired t-test demonstrated a highly significant reduction in onboarding time with the proRITHMTM platform ($p < 0.001$).

		Age (Years)	proRITHM Device Connection Time for Device group (min)	proRITHM Patient Data Entry Time (min)	proRITHM Vital Acquisition Time (min)	proRITHM Total Onboarding Time(Min)	Manual Vital Recording Time(Min)	Manual Documentation Time(Min)	Manual Total Onboarding Time(Min)
N	Valid	20	20	20	20	20	20	20	20
	Missing	0	0	0	0	0	0	0	0
Mean		58.60	.875	1.500	2.825	5.200	5.35	12.50	17.85
Std. Error of Mean		3.594	.1196	.1308	.0547	.2626	.534	2.025	2.278
Median		58.50	.500	2.000	3.000	5.500	5.00	9.00	13.50
Mode		52[a]	.5	2.0	3.0	6.0	5	5	10
Std. Deviation		16.074	.5350	.5849	.2447	1.1743	2.390	9.058	10.189
Variance		258.358	.286	.342	.060	1.379	5.713	82.053	103.818
Range		66	1.5	1.5	.5	3.5	12	26	32
Minimum		25	.5	.5	2.5	3.5	3	4	8
Maximum		91	2.0	2.0	3.0	7.0	15	30	40
Percentiles	25	50.50	.500	1.000	2.500	4.000	4.25	5.00	10.00
	50	58.50	.500	2.000	3.000	5.500	5.00	9.00	13.50
	75	71.25	1.000	2.000	3.000	6.000	5.00	22.25	27.25

Table 2: Descriptive statistics of patient age and onboarding workflow time components for proRithm-assisted and manual onboarding methods.

Table 2 presents the descriptive statistics for patient age and the different workflow components involved in ambulance patient onboarding using the proRithm device and the conventional manual method. A total of 20 patients were included in the analysis.

The mean age of the study population was 58.6 ± 16.07 years, with ages ranging from 25 to 91 years.

For the proRITHM™-enabled workflow, the mean device connection time was 0.88 ± 0.54 minutes, the patient data entry

time was 1.50 ± 0.58 minutes, and the vital acquisition time was 2.83 ± 0.24 minutes. The overall total onboarding time using the proRITHM™ system was 5.20 ± 1.17 minutes.

In comparison, under the manual workflow, the mean vital recording time was 5.35 ± 2.39 minutes, and the manual documentation time was 12.50 ± 9.06 minutes. The total onboarding time for the manual process was 17.85 ± 10.19 minutes.

Overall, the results demonstrate that the proRITHM™-assisted onboarding workflow required substantially less total time compared with the conventional manual onboarding process, indicating improved efficiency in ambulance patient onboarding.

Figure 4-7 represents the usability scores.

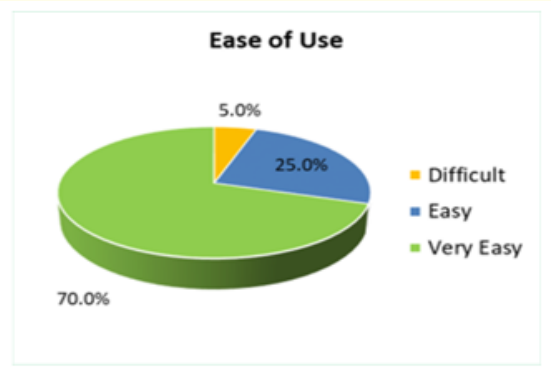

Figure 4: Ease of Use.

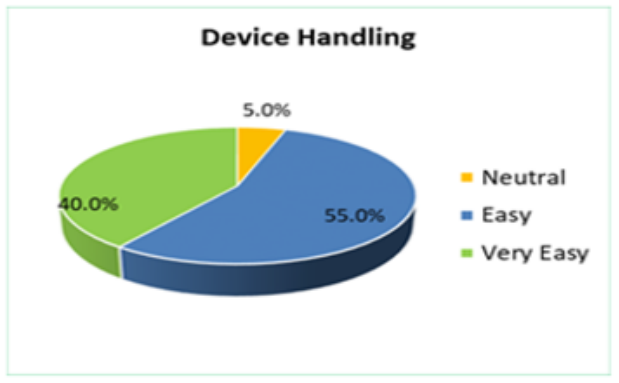

Figure 5: Device Handling.

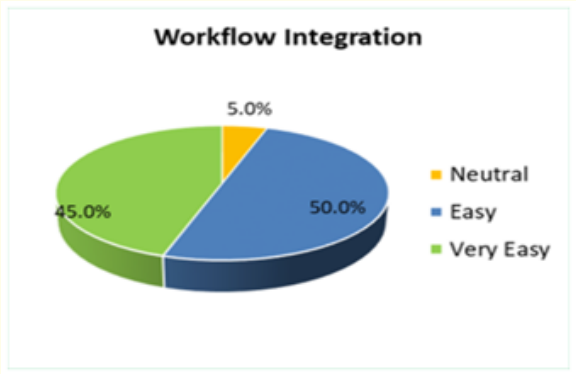

Figure 6: Workflow Integration.

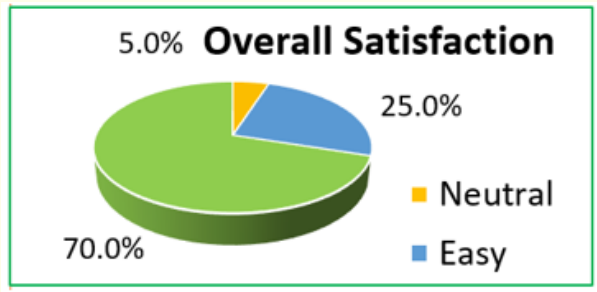

Figure 7: Overall Satisfaction.

Usability assessment of the proRithm platform

Usability of the proRithm platform was evaluated using a structured Likert-scale questionnaire assessing ease of use, device handling, workflow integration, and overall satisfaction among Emergency Medical Technicians (EMTs).

Ease of Use: The majority of EMTs reported that the device was very easy to use (70%), while 25% reported it as easy and 5% reported difficulty in using the system.

Device Handling: Regarding device handling, 55% of EMTs rated it as easy, 40% rated it as very easy, and 5% reported a neutral experience.

Workflow Integration: For integration into the ambulance workflow, 50% of EMTs rated the system as easy to integrate, 45% reported it as very easy, and 5% reported a neutral response.

Overall Satisfaction: Overall satisfaction with the proRithm platform was high, with 70% of EMTs reporting very high satisfaction, 25% reporting satisfaction, and 5% reporting a neutral experience.

These findings indicate that the proRithm platform demonstrated high usability and was well accepted by EMTs in the ambulance environment.

Discussion

This prospective pilot study evaluated the effectiveness of the proRITHM Integrated Remote Monitoring Platform in improving ambulance-based patient onboarding workflows. The findings demonstrated a significant reduction in patient onboarding time when compared with the conventional manual process. The mean onboarding time decreased from 17.85 ± 10.19 minutes using the traditional workflow to 5.20 ± 1.17 minutes with the proRITHM platform, representing a mean reduction of 12.65 minutes ($p < 0.001$). These findings indicate that digital integration of physiological monitoring, automated documentation, and real-time data transmission can substantially improve workflow efficiency during prehospital emergency care [11].

Efficient patient onboarding is an essential component of emergency medical services because delays during patient assessment and documentation may postpone definitive treatment, particularly for time-sensitive conditions such as acute coronary syndrome, stroke, major trauma, and sepsis [1,2]. Previous studies have demonstrated that prehospital documentation and manual recording of vital signs contribute significantly to Emergency Medical Technician (EMT) workload and may introduce delays or omissions during patient handover [12]. The automated workflow provided by the proRITHM platform minimizes these manual processes by enabling rapid acquisition of physiological parameters and simultaneous electronic documentation, thereby improving operational efficiency and reducing the administrative burden on frontline providers. These findings are consistent with previous reports demonstrating that digital health technologies, wearable monitoring systems, and IoT-enabled healthcare platforms improve workflow efficiency and facilitate continuity of patient care [13].

A detailed analysis of the workflow components demonstrated that device connection, patient data entry, and acquisition of vital parameters required only 0.88, 1.50, and 2.83 minutes, respectively. In contrast, the conventional workflow required substantially longer periods for manual vital recording and documentation. Although manual measurement of vital signs alone required approximately 5.35 minutes, documentation accounted for the greatest proportion of the onboarding process, requiring an average of 12.50 minutes. These observations suggest that the principal advantage of the proRITHM platform lies not only in automated physiological monitoring but also in digitizing documentation, minimizing transcription errors, and reducing repetitive manual data entry [14].

The usability assessment further demonstrated high acceptance of the platform among EMTs. More than two-thirds of users rated the system as very easy to use, and the majority reported favorable experiences regarding device handling, workflow integration, and overall satisfaction. User acceptance is a critical determinant of successful implementation of digital healthcare technologies, particularly in high-pressure prehospital environments where workflow disruptions may negatively affect adoption [15,16]. The favourable usability scores observed in the present study indicate that the system can be incorporated into routine ambulance operations with minimal additional training.

The present study has several practical implications. Integration of wearable monitoring devices with cloud-based remote monitoring platforms enables early acquisition and transmission of physiological information even before hospital arrival. Such capability may facilitate earlier clinical decision-making, improve communication between ambulance teams and receiving hospitals, and support centralized monitoring by remote command centres [17,18]. Furthermore, continuous digital acquisition of structured physiological data provides a robust foundation for future artificial intelligence (AI), machine learning, and predictive analytics applications in prehospital emergency care. High-quality real-time datasets generated through automated monitoring may support the development of intelligent triage systems, early warning models, and clinical decision support tools, thereby aligning digital prehospital workflows with emerging data science applications [19,20].

Nevertheless, this study has several limitations. The study was conducted as a single-center pilot involving only 20 patients,

which limits the generalizability of the findings. The study primarily evaluated operational workflow efficiency rather than patient-centered clinical outcomes such as mortality, morbidity, or treatment delays. Additionally, variations in ambulance transport conditions, network connectivity, and patient complexity may have influenced onboarding times. Larger multicenter studies involving diverse emergency medical service settings are warranted to validate these findings and evaluate the impact of digital onboarding on clinical outcomes and healthcare resource utilization.

In conclusion, implementation of the proRITHM Integrated Remote Monitoring Platform significantly improved ambulance patient onboarding efficiency by reducing manual documentation time and accelerating acquisition of physiological data. The platform was well accepted by EMTs and demonstrated excellent operational feasibility. These findings support the integration of IoT-enabled digital monitoring platforms into prehospital emergency care and provide a foundation for future multicenter studies evaluating their impact on patient outcomes, healthcare efficiency, and AI-driven emergency medical services.

Key findings of the study

The implementation of the proRithm Integrated Remote Monitoring Platform demonstrated measurable operational benefits in ambulance-based patient onboarding.

- icant reduction in onboarding time compared with the manual workflow
- Mean time reduction of 12.65 minutes
- Average reduction of 64.915% in onboarding time
- High usability and acceptance among EMTs
- Improved efficiency of patient data capture and vital parameter acquisition

Conclusion

The findings of this pilot study demonstrate that the proRithm platform significantly improves the efficiency of ambulance patient onboarding workflows. Improving patient survival and clinical outcomes through rapid detection and intervention during the golden hour of cardiac and respiratory emergencies. The system enabled faster acquisition of patient information and vital parameters compared with conventional manual methods.

The implementation of a digital, device-assisted onboarding workflow resulted in a substantial reduction in onboarding time while maintaining usability and operational feasibility in real-world ambulance environments.

These results support the potential role of IoT-enabled remote monitoring platforms in improving prehospital workflow efficiency and digital documentation in ambulance services.

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Conflict of Interest

No conflict of interest.

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