Original Article

Development and Pilot Testing of an Automated Vital Signs Documentation Extension Device (avd-ex) in Malaysian Healthcare

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ABSTRACT

OBJECTIVE: This study aimed to develop and evaluate the effectiveness of the Automated Vital Signs Documentation Extension Device (AVD-Ex) in improving the accuracy, efficiency, and timeliness of vital signs documentation in clinical settings.

METHODOLOGY: Researchers designed and built the AVD-Ex prototype in collaboration with postgraduate students, integrating it with hospital systems to automate vital signs recording. A time-motion study was conducted comparing manual documentation with AVD-Ex usage. Data on time efficiency was collected between June to August 2025.

RESULTS: In a pilot test involving 10 students, A preliminary evaluation revealed that AVD-Ex reduced documentation time by approximately 60%.

CONCLUSION: AVD-Ex demonstrates strong potential to transform vital signs documentation by automating data capture, improving accuracy, and supporting faster clinical decision-making. Its integration into routine practice could enhance patient safety and reduce nurses' workload.

KEYWORDS: Vital signs, automation, nursing workflow, prototype testing, clinical efficiency, AVD-Ex

INTRODUCTION

Monitoring vital signs is critical in urgent care settings. Timely documentation allows healthcare professionals to respond effectively. Manual recording, however, may cause delays and errors, elevating patient risk and impeding clinical decision-making[1]. The process of recording vital signs is frequently time-consuming and error-prone[2]. Research indicates that data omissions occasionally occur, potentially compromising patient safety[3]. Hospitals employ various devices to monitor vital signs. Monitors capable of tracking multiple vital signs are standard in intensive care units, operating rooms, and emergency departments[4]. In general wards, staff utilize devices such as pulse oximeters, heart monitors, and portable machines from manufacturers including Dinamap, Mindray, Philips, and Nihon Kohden[5]. However, respiratory rate is frequently estimated, leading to inaccuracies[6]. Manual data entry into electronic records further increases the likelihood of errors and delays[7]. Documenting vital signs for a single patient takes approximately 2.5 minutes, and an additional 7 minutes are needed to enter data for 10 patients[8.] These inefficiencies complicate nursing workflows and delay clinical decision-making, particularly when staffing is limited. Delayed data entry may impede early detection of patient deterioration and timely intervention, ultimately reducing care quality and increasing patient risk[9]. These issues underscore the necessity for more efficient digital systems. Automated vital sign recording can enhance accuracy and workflow efficiency.

Previous studies have highlighted the limitations of manual vital signs documentation, including transcription errors, workflow inefficiencies, and delayed clinical responses. A study by Dall'Ora et al.[6] found that each clinical staff member takes roughly 4 minutes to complete vital sign recordings for a patient. Therefore, such tasks can be daunting in a large ward if the process is repeated every few hours, where it is estimated that 900 minutes of nursing time are needed to properly capture vital signs in a 30-bed ward every 4 hours. Technologies such as electronic medical records and central monitoring systems have attempted to address these issues, but gaps remain in real-time data capture and integration. Research emphasized the need for automated solutions to improve accuracy and reduce workload[2,4]. Leenen et al.[10] demonstrated the feasibility of continuous monitoring of heart rate and respiratory rate via the SensiumVitals wearable device in postoperative abdominal surgical patients. While the systems improve patients' confidence in general care, nurses' responses are neutral on their usefulness. These ambivalent responses from nurses were attributed to the device being oversensitive and malfunctioning,

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which actually increased nurses' workload. Preferential bias has also been reported when keying in data from the vital sign monitor, such as a tendency to record numbers within the normal range and a preference to round off numbers to the nearest 5 or 10 [11]. Such consideration is crucial to ensure the device achieves its goal of helping nurses provide safe care whilst easing their workload.

Continuous monitoring of vital signs also helps detect serious adverse events earlier. This is crucial to ensuring patient safety, reducing hospital stays, and lowering medical costs. The initial sign of serious adverse events typically begins with significant vital sign deviation as early as 42.8 hours, warranting continuous assessment of the signals[12]. In a survey among nurses, continuous assessment is widely agreed to be beneficial for enhancing patient safety and assurance[13]. One early idea for continuous monitoring was to combine digital camera recordings of neonatal intensive care unit patients with video from vital sign monitors using a convolutional neural network[14]. However, the presence of a bulky camera can be a source of discomfort for patients due to privacy concerns. The use of imaging devices to capture various vital signs has been extensively studied and shown promising accuracy[15]. However, such systems, once commercialized, can be expensive to procure, especially if the existing vital sign monitor is functioning well.

Vital sign monitoring is a routine task performed by ward nurses to ensure patients' health remains stable. Depending on the patient's condition, vital sign monitoring can be performed more frequently. This process is often done manually, with nurses visiting patients from bed to bed, reading and recording vital sign data. Afterwards, the data is entered into the patient's database, adding to nurses' already demanding workload. The Automated Vital Signs Documentation Extension Device (AVD-Ex) prototype builds on these findings by automating documentation and supporting early warning protocols. The AVD-Ex helps to capture data directly from existing monitors. Through image processing and text recognition, AVD-Ex transfer vital sign data to electronic records in real time. This solution is designed to save time, minimize errors, and enable faster clinical decision-making. The primary advantages are to improve record accuracy, streamline workflows, and enable nurses to dedicate more time to patient care. It improves workflow efficiency by seamlessly integrating with hospital systems, reducing the time nurses spend on documentation and allowing them to focus more on patient care. Additionally, AVD-Ex supports early detection and escalation by providing timely data availability, facilitating the effective use of Early Warning Score (EWS) protocols and enabling faster clinical decision-making. The study aims to develop and evaluate a scalable, cost-effective prototype of the AVD-Ex that integrates seamlessly with existing hospital systems, focusing on improving clinical efficiency by reducing documentation errors and delays, while assessing its economic feasibility and scalability in Malaysian healthcare institutions.

METHODOLOGY

AVD Ex Prototype Development

The development of a scalable and cost-effective AVD -Ex prototype involves leveraging advanced technologies, such as image processing and Optical Character Recognition (OCR). The device will be designed to integrate seamlessly with existing hospital systems to ensure real-time data acquisition and documentation. Iterative prototyping will include hardware and software integration, followed by functionality testing to ensure accuracy, reliability, and compliance with clinical standards. We plan to use the open-source OpenCV image processing library and Tesseract OCR, highlighting our commitment to transparency and cost-effectiveness. This will be installed on Raspberry Pi 5. To prevent issues with the current hospital system, a mock database will be used to store AVD-Ex data using widely available database software such as Microsoft Access or open-source PostgreSQL. Furthermore, the final stages of the testing phase will be conducted using a non-live version of the hospital database system, with a copy made available for testing to ensure its compatibility with the hospital's current record systems.

Figure 1: Vital signs monitor with AVD Ex

How does AVD-Ex work? **Figure 1**

1. AVD-Ex is mounted in front of any existing vital signs monitor to capture the required data. Its core function is to automate the recording and transmission of patient vital signs directly into the Electronic Health Record (EHR) system.
2. QR or RFID patient tag to update patient information on the device.
3. AVD-Ex takes pictures of vital signs from a machine and uses a computer tool, Optical Character Recognition (OCR) engine for text recognition and extraction.
4. AVD Ex: transfer the data to the Electronic Health Records (EHR) using WiFi.
5. EHR updates patient data in real time.

Figure 2: Optical Character Recognition (OCR) capturing image from the Vital signs monitor screen

The picture shows a vital signs monitor, with the keywords detected by Tesseract highlighted in the red bounding box, and the corresponding information displayed in red text.

Figure 3: Vital signs capturing mechanism by AVD Ex to HER

AVD-Ex offers plug-and-play compatibility, allowing it to be easily mounted on existing monitors without system overhauls. It features automated real-time data capture of vital signs, eliminating the need for manual transcription. The device securely integrates with electronic health records (EHRs) via encrypted protocols, and its user-friendly interface is designed to minimize training time and encourage adoption among nurses and clinicians. **Figure 2 & 3**

Study Design

The preliminary observational study used a time-and-motion design to measure and compare the time required to record vital signs using both automatic and manual documentation methods. Using a within-subjects design with paired data, the same participants recorded vital signs in separate sessions, allowing direct comparison between the two recording methods.

Population and Sample

The preliminary study used convenience sampling with 10 university students. Student nurses used both automatic and manual documentation methods during equal observation periods to minimize bias.

Instrument

- *AVD-Ex prototype*
- *Stopwatches and observational tools for time measurement*

Data collection method

The AVD-Ex prototype was developed using modular hardware and software components compatible with existing hospital systems. The device automates the capture of vital signs and transmits the data in real time to electronic health records. A pilot study was conducted with 7 and 10 samples. A time-motion study compared manual documentation with AVD-Ex usage across multiple patient rounds. Data on time efficiency was collected and analyzed.

Data Analysis

Descriptive statistics and percentage reduction were calculated.

Ethical Statement

This project is already approved by the Research Management Committee with the EC no xxxx/xxxRIC/RIC/31012025.

RESULTS

Outcome of pilot study

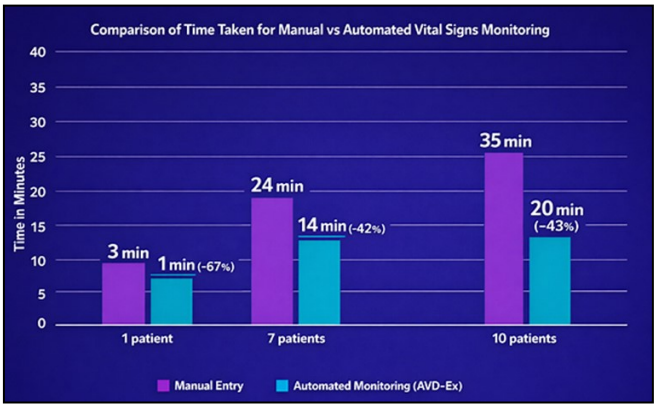

Figure 4: Comparison of Time taken for Manual entry vs AVD Ex system

Figure 4 illustrates a clear time-saving advantage of automated vital signs monitoring (AVD-Ex) over manual entry across different patient volumes. For a single patient, automation reduces the time from 3 minutes to 1 minute with a 67% improvement. As the number of patients increases, the efficiency remains substantial. As shown above, for 7 patients, time drops from 24 to 14 minutes (42% saved), and for 10 patients, from 35 to 20 minutes (43% saved). This demonstrates that automated systems not only streamline workflow but also scale effectively, offering consistent time reductions in clinical settings.

DISCUSSION

The findings from recent studies demonstrate that the Automated Vital Signs Documentation Extension Device (AVD-Ex) significantly improves documentation efficiency and accuracy[10]. By reducing the time spent on manual entry, nurses can allocate more time to direct patient care, potentially enhancing

patient outcomes[16]. The integration of real-time data supports early warning systems and bolsters clinical responsiveness[17]. However, limitations include the need for further testing in diverse clinical environments and long-term impact assessment[18]. The introduction of automated vital signs monitoring will help address Malaysia's challenges related to nurse-to-patient ratios by automating routine tasks, reducing burnout, and improving staff retention[19]. Real -time, error-free data capture enables early detection of patient deterioration, ultimately reducing adverse events and improving care outcomes [20].

The introduction of AVD-Ex has important implications for clinical practice. Automating vital sign documentation enhances data accuracy and minimizes transcription errors, thereby promoting patient safety and care quality[21]. Its seamless integration with hospital systems streamlines workflows, allowing healthcare professionals, especially nurses, to focus more on patient care rather than administrative tasks[22.] This enhanced efficiency enables quicker responses to changes in patients' conditions and supports effective use of Early Warning Score protocols, which are pivotal for timely clinical decisions [23.] Additionally, AVD-Ex is adaptable for resource-limited settings, improving staff efficiency and reducing workloads [24]. Overall, this technology fosters a more advanced approach to patient care and enhances healthcare delivery while aligning with national priorities for patient safety and early intervention, as outlined in Malaysia's Health White Paper (2023) and the MyDigital Blueprint [25].

Future research should explore scalability and integration with broader hospital IT infrastructure, emphasizing the importance of innovation in healthcare[26]. The challenge of identifying deteriorating patients in general wards is critical, as these individuals are often unrecognized and pose significant safety risks[27]. Physiological changes in patients develop gradually, with warning signs such as abnormal vital signs or changes in consciousness manifesting 6 to 8 hours or even earlier before critical deterioration[28]. Despite being observable during routine assessments, these warning signs are frequently overlooked or left unaddressed, leading to delays in intervention[29].

Vital signs monitoring remains a fundamental aspect of nursing practice, serving as the primary indicator for recognizing patients whose conditions are worsening [30]. Vital signs monitoring is a critical component of nursing practice because it provides the earliest and most reliable indicators of patient deterioration. Continuous assessment of parameters such as respiratory rate, heart rate, blood pressure, and temperature allows nurses to detect subtle changes that may precede serious adverse events, enabling timely interventions that improve patient outcomes. Evidence shows that abnormal vital signs often occur hours before clinical deterioration, and systematic monitoring significantly reduces the risk of unplanned ICU admissions and cardiac arrests. Considine et al. highlight that nurses' ability to recognize and respond to changes in vital signs is central to patient safety, underscoring the importance of integrating structured monitoring protocols into routine care[31].

Nurses rely on vital signs to determine whether patients require continued ward-level care or should be escalated to higher-acuity units, such as the ICU or HDU[32]. Nevertheless, delays, inaccuracies, and errors in manual vital sign documentation arise due to interruptions from emergencies or patient transfers[33].

National and institutional policies have been instituted to support early detection; for example, in 2019, Malaysia's Ministry of Health introduced Early Warning Scores (EWS) to enhance the early detection and escalation of deteriorating patient conditions[34]. EWS systems focus on key parameters like respiration rate, oxygen saturation, temperature, and blood pressure, reinforcing efforts to improve patient safety through early detection mechanisms[35]. KPJ Healthcare Berhad's adoption of EWS across its general and specialty units further underscores this institutional commitment[36]. However, the persistence of manual processes continues to burden healthcare providers and compromise efficiency[37]. Transitioning toward automated monitoring systems offers a promising solution, reducing workload, minimizing errors, and enabling nurses to dedicate more time to direct patient care, thereby strengthening the overall quality and safety of healthcare delivery[38.]

Future plans

Cost analysis: In addition, the AVD-Ex hopes to prolong the use of functioning vital sign monitors, saving financial and material costs for acquiring new vital sign monitors and ensuring the sustainability of healthcare practice. Cost-effectiveness: At RM 2,999 per unit, AVD-Ex offers a fraction of the cost of new vital signs monitor (up to RM 46,000 per unit). This makes adoption attractive for both private and public hospitals under budget constraints. A device cost analysis will be conducted in the future to help estimate financial benefits.

Error reduction rates: Automated systems like AVD-Ex enhance accuracy and reduce data entry errors by eliminating the risks associated with manual documentation. Unlike manual entry, which is prone to transcription mistakes and inconsistencies, AVD-Ex ensures reliable, real-time recording of vital signs, improving data integrity and supporting safer clinical decisions. Error reduction rates will also be examined in the future.

Nurses' *satisfaction:* Reducing nurses' workload is essential for improving patient care and staff well-being. By streamlining routine tasks such as vital signs documentation through automation and integrated systems like AVD-Ex, nurses can spend less time on administrative duties and more time attending to patients. This not only enhances efficiency but also helps prevent burnout and supports better clinical outcomes. Therefore, nurses'

satisfaction will also be measured in the future.

CONCLUSION

Real-time updates from automated systems like AVD-Ex enable quick access to patient data, supporting faster, more informed clinical decision-making. This immediate availability of vital signs enhances responsiveness, improves patient outcomes, and strengthens the effectiveness of early intervention protocols-Ex offers a promising solution to the challenges of manual vital signs documentation. Its ability to automate data capture, reduce errors, and improve workflow efficiency supports safer and more effective patient care. Continued development and testing will be essential to optimize its functionality and ensure widespread adoption in clinical settings.

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AUTHOR CONTRIBUTION

Kunjukunju A: Conceptualization of the project, Testing and data collection, Manuscript Writing Original Draft
Mustafa NFM: Testing and data collection
Idris AS: Conceptualization of the project, Prototype Design and Development, Testing and data collection, Manuscript Review & Editing
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Bakir AA: Conceptualization of the project, Prototype Design and Development
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