Enhancing Patient Safety with the MedAlert SYstem (MASY): A Low-Cost Timer for Medication Administration Alerts

Pavara Rodrego*[1]; Nipuni Fernando[1]; Nemali Wijekoon[2]; Dhanalie Wanigasekara[1]; Janeth Herath

[1]NSBM Green University

[2]Teaching Hospital, Peradeniya

pdrodrego@students.nsbm.ac.lk*; nipuni.f@nsbm.ac.lk; nemalicw@gmail.com;

dswanigasekara@students.nsbm.ac.lk; hmjbherath@students.nsbm.ac.lk

ABSTRACT

When it comes to patient safety, the timely administration of medication tends to be a critical factor in almost all the healthcare related environments, especially in hospital wards of any scale and clinics where multiple patients simultaneously require any form of medication. In many small to medium scale hospital wards and rural healthcare environments, where commercially available systems which are developed for patient management tend to be extremely costly to deploy due to many factors such as the scale of the facility and lack of staff with the necessary knowledge to run and maintain such a sophisticated system, staff always seem to rely on logbooks for the purpose of tracking the issued doses and the times at which these specific medications are issued. This process is prone to human error, inefficiency, data tampering, and lack of accountability. This paper therefore presents an economical solution addressing the issues mentioned above: the MedAlert System (MASY), which is a low-cost, standalone timer unit specifically designed and developed for healthcare settings. This system, based on the popular Arduino open-source platform, enables medical staff members to manage multiple medication timers simultaneously with no reliance on any logbooks or other external references. This system also offers both visual and auditory alerts to ensure that medication is always administered at the correct time. Unlike commercial patient monitoring systems implemented in large-scale hospitals, MASY can operate independently, with no reliance on servers or internet connections. Due to its simplicity, this system can be easily modified and implemented according to local workflows. This paper discusses the system's software, design, human machine interaction, and the future scope of the system's development. It is believed that implementing such a simple device has the potential to reduce missed or delayed medication doses and, in turn, improve patient safety in almost any setting.

KEYWORDS: *Alert System, Arduino, Digital Time Controls, Medication, Patient Safety*

1.0 INTRODUCTION

Medication safety continues to be a pressing issue in healthcare settings (World Health Organization, 2022). Administering medications at the right time is crucial, as delays can extend recovery and pose a threat to the medication safety in the patients (Nagar & davey, 2015). In many hospitals and clinics in rural areas, staff heavily rely on a manually maintained logbook to issue time sensitive medicine to patients, and it increases the potential risk factor for human error, missed dosages, and minimal accountability (Kaufmann et al., 2012). Integration of digital health tools to practice becoming a solid solution in addressing these drawbacks (Religioni et al., 2025).

1.1 Background

In large scale hospitals and private care centers, sophisticated patient monitoring systems exist. However, such systems are extremely costly, making it impractical to be implemented in small hospitals and rural clinics where resources are heavily constricted (Bates & Gawande, 2003). In such settings, medical staff rely on logbooks to issue medication to patients. This manual approach has disadvantages such as human error, omissions, data tampering, and inconsistencies which can affect patient safety (Koppel et al., 2018). More to add, a hospital ward is a busy environment where each staff member is held responsible for more than one patient, which increases the cognitive load on staff and in turn increases the risk of a wrong or

https://doi.org/10.54389/QQWC8290

missed dose (Kohn et al., 2000; Gurses et al., 2008). These missed doses will lead to poor therapeutic outcomes and prolong hospital stays which add costs to the healthcare system as well as to patients, whereas developing automated strategies which could be used at the patient's bedside lead to minimizing events of missed, early or late doses and reduce the length of hospital stays (Patel et al., 2019).

1.2. Problem Identification

The unavailability of a simple, affordable, and reliable system that will track and alert staff regarding medicine dosages creates a gap in current healthcare workflows in many hospitals world-wide since manual logbooks cannot offer automated reminders and rely on accurate maintenance. Existing systems are often too costly and complex to implement in wards with only a few patients. Additionally, usability challenges of such systems can hinder their effectiveness in improving patient safety (Pruitt et al, 2023). Therefore, there is a clear need for a simple and cost-effective system that can track multiple medication intervals simultaneously, provide clear visual and auditory alerts for medical staff, ensure accountability by being by the patient's bedside to dismiss alarms, and operate entirely on its own with no reliance on external connections. Hence, this project aims to develop an intuitive, user-friendly MedAlert System to bridge the gap between the aforementioned facts.

1.3. Objective

The objective of this project is to build a cost-effective timer unit which will be adaptable to any local workflow in hospital wards and care centers, especially in environments with limited resources with no reliance on external servers or other connections.

2.0 METHODOLOGY

This unit was built around similar concepts previously implemented by developers of the Arduino platform (Medicine Reminder with Arduino, 2023). It is also based on embedded system principles, in this case with the use of microcontroller-based automation for time-dependent tasks (Arduino, 2025). MedAlert System design and implementation took a methodical approach with the combination of hardware assembly and software development into a functional and cost-effective medical alert system to improve working conditions of medical staff.

2.1 Requirement Analysis

The project began by investigating the technical and functional specifications of an intuitive medical alert system. The key specifications were adjustable timers, visual and auditory alerts, low power usage, a simple user interface, and low-cost components. Comparison with commercial solutions and MASY was also done to decide missing features and guide future enhancement (Hayes et al., 2009).

2.2 System Design and Working Principles

2.2.1 System Design

System design was performed based on requirements with the Arduino Nano platform because it finds the balance between cost, portability, and functionality. The final design consists of an input interface with membrane buttons for timer usage, a 16x2 I2C LCD display, LED, and audio buzzer for alerts and user interaction, and a 5V power input. Modular construction was used to allow for future expansion (e.g., for more timers or communication modules).

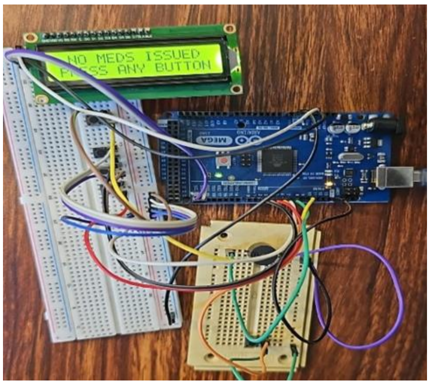

Figure 2.1- Apparatus in pre-development stage

2.2.2 Working Principles

(i) Microcontroller Systems

A microcontroller is an integrated circuit designed to manage specific operations in embedded systems. The MASY uses the Arduino Nano due to its low power usage, sufficient I/O capability, and compact size (Arduino, 2025). The use of an Arduino platform offers easy integration of peripherals, and software-programmable logic.

(ii) Timer Implementation

The timer operation is at the heart of MASY. Unlike real-time clocks (RTCs), MASY is based on countdown timers, which are implemented using the millis function. The function returns the number of milliseconds passed since the system started and supports non-blocking delay, such that different timers can be executed without inhibiting system operation (Banzi et al., 2014).

Figure 2.1 – How timers are displayed on MASY

(iii) Human-Machine Interface (HMI)

User operation is offered via membrane buttons and an LCD display. MASY's current button functionality is as follows. The three buttons that are mounted on the front of the unit (Red, Yellow, Green) are programmed to trigger individual timers and the blue button mounted in the front is to cycle between active timers. Another button is mounted in the underside of the unit to abort active timers if they are triggered accidentally. Plus, a button is mounted at the bedside of the patient which will be used to dismiss the alarms when the countdown timers hit zero. The use of I2C interface simplifies wiring and conserves microcontroller pins, providing for future expansion (Last Minute Engineers, 2020).

Figure 2.3 – MASY button layout (main unit)

Figure 2.4 – Model example of dismiss button mounting

(iv) Alert Mechanisms

When the timer runs out, LEDs and a buzzer are activated to provide visual and auditory feedback. This two-modality provides redundancy and enhances the chance of the user perceiving the alarm, which is important in a hospital setting. The alerts are triggered through digital output pins and manipulated in the program logic.

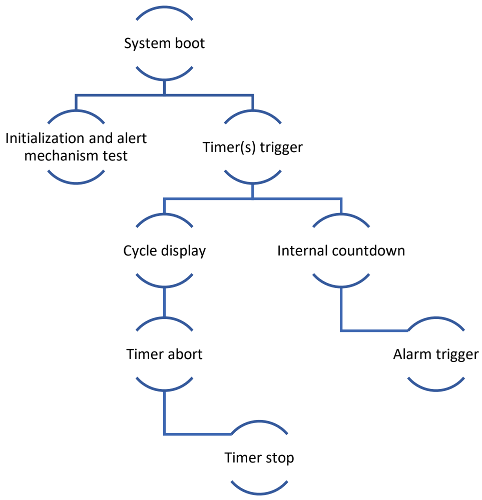

Figure 2.5 – Procedural framework of MASY

2.3 Testing and Validation

The complete system was subjected to a series of functional tests to validate timer independence and accuracy, visual and auditory alert functionality, user interface clarity and responsiveness. Any issues presented were resolved iteratively during development. All the testing and validation criteria were adopted from past literatures on similar projects (Mankhair et al., 2025; Naveen kumar et al., 2023; Ni et al., 2019)

3.0 RESULTS & DISCUSSION

3.1 Results

Tests proved that MASY was reliable under simulated clinical environments. MASY is equipped with three timers that are fully adjustable through the source code and can run simultaneously. Software strain tests proved that any timer can be triggered and run with accuracy with no interference to any other functions. This observation ensures that MASY can handle multiple timers accurately. A simple self-test was programmed at the startup of the system where all the components are triggered to detect any failures during startup which eliminates chances of hardware faults. Hardware was implemented so that off-the-shelf components can be used to cut costs. The system showed exceptional performance during each testing phase where no issues were detected. MASY was developed with no ties to costly component supply chains which makes it ideal for resource-constricted facilities where using advanced patient management systems is impractical. Arduino's form factor and programming language further justifies its sustainability and ease for deployment under any condition. MASY is modular, and development processes proved that the system can be assembled in many layouts. This versatility factor proved that it can be integrated into any workflow with necessary modifications. To sum up, MASY demonstrated strong hardware and software performance in a small form factor. It also proved to align with necessities of small healthcare facilities where the system is to be deployed, validating its effectiveness of replacing logbook systems of recording medication timing intervals.

3.2 Discussion

Strengths

According to Hayes et al., 2009, simple time-based reminders are effective in improving compliance with medications. MASY represents a significant step towards simple, adaptable medical reminder systems. Its design offered an operational and portable prototype that was particularly suited for medical settings such as hospital wards and single-bed treatment centers. The system is simple to use with clean controls ensuring ease of operation. The result is similar to the Medicine Reminder and Indicator system developed using the Arduino platform in India (Naveen kumar et al., 2023).

Figure 3.2 – Example for application of Med Alert system in a single-bed treatment center.

Microcontroller based medicine reminder alarm systems with automated medication boxes is reported to be cost-effective (Ni et al., 2019). Although MASY does not include a pill box component, it breaks cost barriers for institutions that are unable to access commercial solutions. MASY can be tailored to specific needs, which is particularly beneficial for small or underfunded clinics. MASY is advanced with comparative Performance. When compared to other commercial options in the market such as Med-Q and LiveFine, MASY has extra features like complete local workflow customizability.

Limitations

Despite its benefits, the current MASY prototype has several limitations. It lacks data logging capabilities, making it unsuitable for tracking patient compliance. Additionally, the absence of a Real-Time Clock (RTC) means the system relies solely on countdown timers rather than scheduled alerts. Its scalability is limited, supporting only a small number of timers with. Furthermore, the system does not include user authentication features such as password protection or RFID access, which are often essential in secure clinical environments.

Future Scope

MASY can be significantly enhanced through future developments. Adding an SD card module would allow data logging, while integrating a Real-Time Clock (RTC) module will enable precise alerts beyond basic countdown functionality. Incorporating communication technologies such as Bluetooth would support system expansion and remote monitoring. Furthermore, implementing security features like RFID tags or pin protection would help eliminate chances of unauthorized access. Collectively, these enhancements could transform MASY into a more robust and semi-automated medication management solution, extending its use in a wider range of clinical environments.

4.0 CONCLUSION

This paper presented MASY, a low-cost medication alert system designed to improve patient safety. MASY addresses the limitations of manual logbooks by providing a simple interface for managing multiple medication timers simultaneously, with both visual and auditory alerts. Based on the Arduino platform, MASY offers advantages in cost-effectiveness, portability, and adaptability to local workflows. Testing validated the system's reliable timer functionality and effective alert mechanisms. Future development could incorporate features like data logging, an RTC module, and enhanced security measures to expand its functionality and applicability. MASY represents a significant step towards improving patient safety, in resource-limited environments.

6.0 REFERENCES

1. Arduino. (2025). *Nano | Arduino Documentation*. Docs.arduino.cc.https://docs.arduino.cc/hardware/nano/
2. Banzi, M., Shiloh, M., & Ja'c. (2014). *The Open Source Electronics Prototyping Platform Make:*
3. *Getting Started with Arduino 3rd Edition*. https://barreirolab.com/wp-content/uploads/2016/12/c0ee2-make_getting_started_with_arduino_3e_9781449363338.pdf
4. Bates, D. W., & Gawande, A. A. (2003). Improving Safety with Information Technology. *New England*
5. *Journal of Medicine*, *348*(25), 2526–2534. https://doi.org/10.1056/nejmsa020847
6. Gurses, A.P., Carayon, P., & Wall, M. (2008). Impact of performance obstacles on intensive care nurses'
7. workload, perceived quality and safety of care, and quality of working life. *Health Services Research*, *16*,32-38. https://www.researchgate.net/publication/313568514_Impact_of_performance_obstacles_on_intensive_care_nurses
8. Hayes, T. L., Cobbinah, K., Dishongh, T., Kaye, J. A., Kimel, J., Labhard, M., Leen, T., Lundell, J.,
9. Ozertem, U., Pavel, M., Philipose, M., Rhodes, K., & Vurgun, S. (2009). A Study of Medication-Taking and Unobtrusive, Intelligent Reminding. *Telemedicine and E-Health*, *15*(8), 770–776. https://pmc.ncbi.nlm.nih.gov/articles/PMC2998278/
10. Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (2000). *To err is human: Building a safer health*
11. *system*. PubMed. https://pubmed.ncbi.nlm.nih.gov/25077248/
12. Koppel, R., Wetterneck, T., Telles, J. L., & Karsh, B.-T. . (2018). Workarounds to Barcode Medication
13. Administration Systems: Their Occurrences, Causes, and Threats to Patient Safety. *Journal of the American Medical Informatics Association*, *15*(4), 408–423. https://doi.org/10.1197/jamia.m2616
14. Kaufmann, J., Laschat, M., & Wappler, F. (2012). Medication Errors in Paediatric
15. Emergencies. *Deutsches Aerzteblatt Online*. https://doi.org/10.3238/arztebl.2012.0609
16. Last Minute Engineers. (2020, November 8). *Interface an I2C LCD with Arduino*. Last Minute
17. Engineers; Last Minute Engineers. https://lastminuteengineers.com/i2c-lcd-arduino-tutorial/
18. Mankhair, A., Rathi, G., Gole, S., Naphade, G., Patil, A., & Student. (2025). *Medicine Box Using*
19. *Arduino Uno*. *11*. https://ijirt.org/publishedpaper/IJIRT176886_PAPER.pdf?utm_source=chatgpt.com
20. *Medicine Reminder With Arduino*. (2023, January 21).
21. https://justdoelectronics.com/medicine-reminder-with-arduino/
22. Nagar, S., & davey, nicola. (2015). Reducing avoidable time delays in immediate medication

23. administration - learning from a failed intervention. *BMJ Quality Improvement Reports*, *4*(1), u206468.w2612. https://doi.org/10.1136/bmjquality.u206468.w2612
24. Naveen kumar Y, Vinod, Suresh, R., & N Jagadeeswaran. (2023). Movable Automatic Medicine
25. Reminder and Indicator Using Arduino. *Journal of Mines Metals and Fuels*, 173–179. https://doi.org/10.18311/jmmf/2022/31223
26. Ni, N., Hlaing, S., & San, S. (2019). Alarm System for Medicine Reminder Based on Microcontroller
27. of the Creative Commons Attribution License (CC BY 4.0). *International Journal of Trend in Scientific Research and Development (IJTSRD) International Journal of Trend in Scientific Research and Development*, *5*, 791–794. https://doi.org/10.31142/ijtsrd26518
28. Patel, C. N., Swartz, M. D., Tomasek, J. S., Vincent, L. E., Hallum, W. E., & Holcomb, J. B. (2019).
29. The Effects of Missed Doses of Antibiotics on Hospitalized Patient Outcomes. *The Journal of Surgical Research*, *233*, 276–283. https://doi.org/10.1016/j.jss.2018.08.015
30. Pruitt, Z. M., Kazi, S., Weir, C., Taft, T., Busog, D. N., Ratwani, R., & Hettinger, A. Z. (2023). A
31. systematic review of quantitative methods for evaluating electronic medication administration record and bar-coded medication administration usability. *Applied Clinical Informatics*, *14*(01), 185-198.
32. Religioni, U., Barrios-Rodríguez, R., Requena, P., Borowska, M., & Ostrowski, J. (2025). Enhancing
33. Therapy Adherence: Impact on Clinical Outcomes, Healthcare Costs, and Patient Quality of Life. *Medicina*, *61*(1), 153–153. https://doi.org/10.3390/medicina61010153
34. World Health Organization. (2022). *Medication without harm*. World Health Organization. https://www.who.int/initiatives/medication-without-harm