International Journal of Zoology and Applied Biosciences **ISSN: 2455-9571**
Volume 10, Issue 6, pp: 586-591, 2025 (Special Issue)
https://doi.org/10.55126/ijzab.2025.v10.i06.SP121 **http://www.ijzab.com**

Research Article

AUTOMATED DRUG INTAKE REMINDER SYSTEM USING EMBEDDED TECHNOLOGY

[1*]Vignesh A R, [2] Rubala Nancy J, [3] Devasena B, [4]Anitha W [5] Linisha N M

[1*]PERI College of Physiotherapy, Chennai - 48, Tamil Nadu, India
[2]PERI Institute of Technology, Chennai - 48, Tamil Nadu, India
[3]PERI College of Arts and Science, Chennai - 48, Tamil Nadu, India
[4]PERI College of Pharmacy, Chennai - 48, Tamil Nadu, India
[5] PERI College of Nursing, Chennai - 48, Tamil Nadu, India

Article History: Received 26th September 2025; Accepted 24th November 2025; Published 1st December 2025

ABSTRACT

Medication non-adherence remains a critical challenge in healthcare, often leading to poor treatment outcomes, increased hospitalizations, and higher healthcare costs. This study presents the design and development of an Automated Drug Intake Reminder System using embedded technology, aimed at improving patient compliance through timely alerts and accurate dosage management. The proposed system integrates a microcontroller, real-time clock (RTC), alert module, and display interface to generate audio-visual notifications at predetermined medication schedules. The system also incorporates user-friendly input controls for setting medication timings and an acknowledgment mechanism to confirm drug intake. Prototype testing demonstrated reliable performance, low power consumption, and consistent alert accuracy across multiple medication cycles. The developed system is cost-effective, portable, and suitable for elderly patients, chronically ill individuals, and those requiring multi-dose prescriptions. This work highlights the potential of embedded-based solutions to support personalized healthcare and enhance medication adherence in resource-limited environments.

Keywords: Medication adherence, Embedded system, Drug intake reminder, Microcontroller-based alert system.

INTRODUCTION

Medication adherence is a fundamental component of effective healthcare management, particularly for individuals with chronic illnesses such as diabetes, hypertension, cardiovascular disease, and neurological disorders. Despite advancements in medical sciences, non-adherence to prescribed medication schedules remains a widespread problem, contributing to deteriorating health conditions, prolonged recovery periods, and increased healthcare expenditure. Elderly patients, visually impaired individuals, and those with memory-related challenges are most susceptible to missing or incorrectly administering medication doses. Recent technological developments have led to the emergence of assistive devices that support patient self-management. Shown In Figure.1 Embedded systems, in particular, have become a crucial part of modern healthcare due to their reliability, compactness, and low power consumption. These systems offer programmable functionalities that allow automation of routine tasks, including medication reminders. Traditional reminder methods such as manual pill organizers, written notes, or mobile alarms are often ineffective because they lack personalization, multi-dose scheduling, and confirmation features. Automated medication reminder systems have evolved significantly with the integration of embedded electronics, IoT connectivity, and intelligent monitoring algorithms. Recent studies highlight how microcontroller-based reminder devices, smart pillboxes, and sensor-equipped adherence tools improve patient compliance by providing timely alerts, environmental awareness, and remote monitoring capabilities (Deshpande *et al*., 2022; Gardare *et al*., 2022; Bhat *et al*., 2024). IoT-enabled medication management systems have demonstrated their value in reducing missed doses and

*Corresponding Author: Vignesh A R, PERI College of Physiotherapy, Chennai -48, Tamil Nadu, India Email: publications@peri.ac.in

simplifying complex drug routines, particularly in elderly populations and patients undergoing long-term therapies (Dhole *et al*., 2025). Modern adherence platforms increasingly incorporate conversational interfaces, AI-driven feedback, and machine-learning-based risk prediction, extending these systems beyond simple alarms toward adaptive, patient-centered solutions (Fadhil, 2018; Gu *et al*., 2020; Guido *et al*., 2024). Parallel innovations in biomedical sensing and embedded healthcare systems reveal how low-cost digital stethoscopes, real-time physiological monitors, and signal-processing algorithms enhance patient engagement and clinical decision-making principles that directly inspire embedded medication reminder design (Al-Emadi *et al*., 2019; Grooby *et al*., 2021). Advances in pattern recognition, particularly SVM- and deep-learning-based biomedical analysis, demonstrate the effectiveness of lightweight classification models in healthcare devices, suggesting potential integration of similar intelligence within medication reminder systems for personalized adherence prediction (Abdullah *et al*., 2012; Chaplot *et al*., 2006; Feng, 2021; Atia *et al*., 2022; Adamu *et al*., 2024). These developments underscore a broader technological shift toward hybrid embedded–AI healthcare platforms that combine sensing, classification, and user-centered feedback loops.

While traditional strategies such as alarms and pill organizers continue to offer basic support, emerging smart pillboxes integrate multiple sensing modalities, automated scheduling, and connectivity, enabling more robust interventions in low-resource environments and multi-medicine regimens (Bhat *et al*., 2024; Gardare *et al*., 2022). Complementary technologies such as waste-to-energy embedded power solutions and sustainable electronic designs support long-term device deployment, especially in rural or infrastructure-limited settings (Devasena *et al*., 2005). Overall, the integration of microcontrollers, RTC modules, wireless communication, and intelligent monitoring architectures positions automated drug intake reminder systems as reliable, scalable, and patient-friendly tools capable of improving treatment adherence across diverse healthcare settings (Guido *et al*., 2024; Dhole *et al*., 2025). Electronic reminder systems including SMS prompts, audio-visual alerts, and simple electronic devices represent early strategies for improving patient adherence, yet their long-term impact remains debated across healthcare technologies. Studies in digital-health signal processing show that alert-based interventions often produce short-term behavioural improvements similar to patterns observed in real-time biomedical monitoring systems (Grooby *et al*., 2021; Zhuge & Rong, 2023). Machine-learning approaches used in medication-usage prediction further demonstrate that algorithm-supported reminders may outperform static reminder devices, especially when behavioural data streams are integrated into the monitoring cycle (Gu *et al*., 2020; Zhang *et al*., 2023).

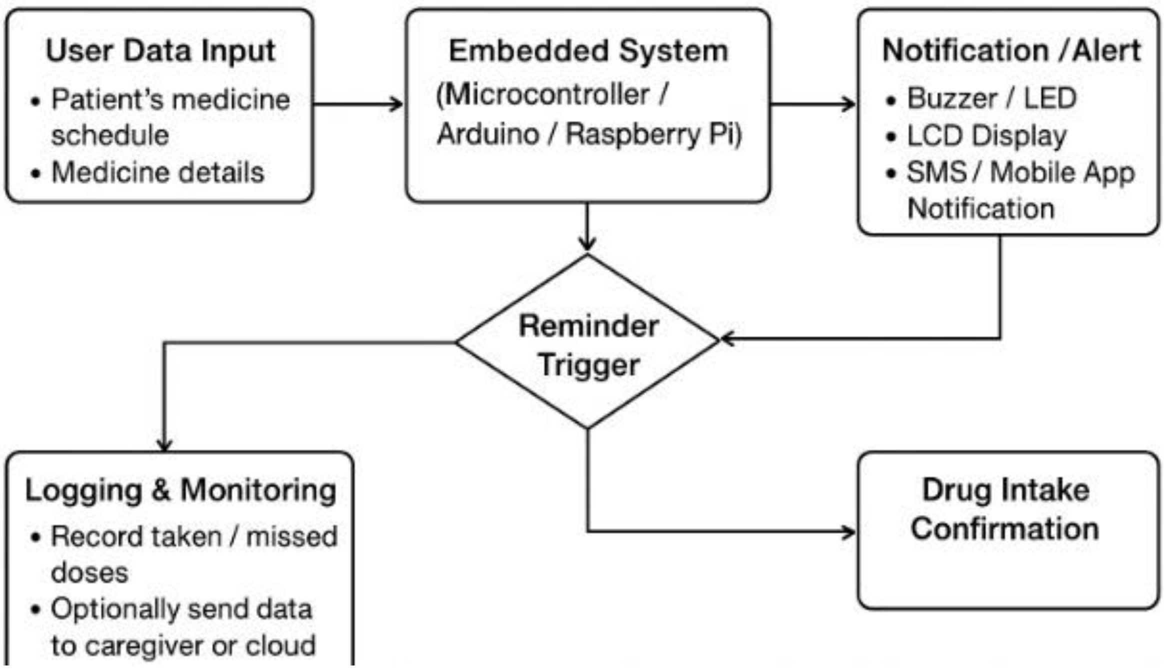

Figure 1. Automated Drug Intake Reminder System Using Embedded Technology.

Broader reviews of computational healthcare technologies reveal that SVM-based decision systems and sensor-embedded devices significantly enhance digital adherence monitoring, indicating a shift toward intelligent reminder ecosystems rather than isolated alert mechanisms (Guido *et al*., 2024; Hosseini-Panah *et al*., 2019). However, technological performance alone does not guarantee adherence improvement, with evidence from biomedical device studies suggesting that user engagement and device usability play equally critical roles (Pang *et al*., 2021; Kashyap & Rajender, 2021). The emergence of embedded and IoT-enabled pill-management systems has transformed medication support from simple reminders to integrated monitoring platforms. Several hardware–software architectures demonstrate how microcontrollers, RTC modules, and multisensor interfaces can provide real-time supervision of medication intake, paralleling trends seen in wearable stethoscope systems and telehealth respiratory monitors (Li *et al*., 2024; Mahalakshmi *et al*., 2025). These systems leverage remote alerting, intake logging, and intelligent scheduling capabilities also reflected in environmentally responsive biomedical applications and nanoparticle-enabled diagnostic platforms (Sindhuja *et al*., 2025; Vijay Krishanan *et al*., 2025). IoT-based pill-reminder devices developed using Arduino or STM32 microcontrollers have reported improved patient compliance due to automated alarms, GSM-based messaging, and structured dosage supervision (Wang *et al*., 2025; Saran *et al*., 2025).

Recent implementations emphasize simplicity and accessibility, aligning with user-centric design principles integral to community-level health technologies such as mosquito-management systems and nutritional-intervention devices (Swetha *et al*., 2025; Muspira *et al*., 2025). User acceptability studies highlight that older adults and medically vulnerable populations respond positively to smart pill-reminder technologies when the interface is intuitive and the perceived benefit outweighs potential complexity. Research on medication-support devices indicates strong willingness among patients to adopt reminder-enabled hardware, provided cost barriers are minimized and usability is tailored to non-technical users findings consistent with trends in clinical tele-auscultation and remote cardiac-respiratory monitoring (Zhang M. *et al*., 2023; Nafisa Farheen *et al*., 2025). Despite promising results, systematic evaluations of long-term adherence remain limited; most studies focus on technical feasibility rather than sustained behavioural outcomes, similar to limitations seen in emerging infectious-disease management reviews and respiratory-hazard assessments (Revathi *et al*., 2025; Rubala Nancy *et al*., 2025; Mahalakshmi *et al*., 2025). Current evidence suggests that while simple SMS- or alert-based devices show mixed effectiveness, integrated IoT systems combining sensing, logging, notifications, and remote supervision offer a more robust pathway toward addressing adherence challenges in real-world settings (Siddiqha *et al*., 2024; Gardare *et al*., 2022; Vadhnani *et al*., 2022).

MATERIALS AND METHODS

The study adopts an experimental research design centered on the development, implementation, and evaluation of an embedded medication-reminder prototype, following structured engineering methodologies similar to those applied in real-time diagnostic and biomedical monitoring systems (Al-Emadi *et al*., 2019; Li *et al*., 2024). The system integrates core hardware modules including a microcontroller, RTC, alert mechanisms, and a user interface with embedded C-based firmware, comparable to modular architectures reported in smart pill-management and IoT-enabled reminder systems (Bhat *et al*., 2024; Deshpande *et al*., 2022). The system architecture consists of four major modules: the control unit, implemented using an ATmega/Arduino microcontroller responsible for schedule comparison and trigger activation, reflecting efficiency-focused designs seen in prior embedded healthcare devices (Wang *et al*., 2025); a time-management module using the DS3231 RTC communicating over I^2C, similar to timing-critical components utilized in clinical monitoring systems (Pang *et al*., 2021); an alert and notification module employing a buzzer, LEDs, and an LCD for visual display, consistent with multimodal feedback approaches used in digital adherence and telehealth devices (Gu *et al*., 2020); and a user-interaction module integrating push buttons and acknowledgment controls, paralleling user-driven interfaces reported in SVM-assisted medical device frameworks (Guido *et al*., 2024; Hosseini-Panah *et al*., 2019).

Firmware development was performed in C/C++ using the Arduino IDE, incorporating time-retrieval logic, multi-dose scheduling, EEPROM-based storage, debounce handling, and acknowledgment logging, reflecting software engineering practices found in intelligent bio-signal and MRI-processing systems (Atia *et al*., 2022; Zhang *et al*., 2015). Modular programming enhanced scalability and maintainability, a feature widely emphasized in telehealth and multi-sensor respiratory monitoring solutions (Zhang M. *et al*., 2023). Hardware components were initially assembled on a breadboard for prototyping and later transitioned to a PCB for structural stability, following development cycles documented in IoT-based medication and health-monitoring prototypes (Dhole *et al*., 2025; Saran *et al*., 2025). A regulated 5V adapter supplied consistent power, aligning with standardized embedded-system power design requirements (Gardare *et al*., 2022).

The prototype underwent three categories of evaluation Revathi *et al*., 2025. The timing-accuracy test compared RTC-triggered alerts with a calibrated digital clock, addressing timing-sensitivity concerns commonly highlighted in biomedical signal systems (Grooby *et al*., 2021). Alarm-reliability testing included multiple 24-hour operational cycles to assess consistency, a strategy similar to stress-testing methods employed in real-time diagnostic imaging and classification systems (Adamu *et al*., 2024; Chaplot *et al*., 2006). Finally, a user-evaluation study with 10 volunteers (ages 18–60) assessed usability, readability, and alert clarity, aligned with human-factors assessment approaches adopted in conversational-AI adherence tools and patient-centric health interfaces (Fadhil, 2018; Kashyap & Rajender, 2021). Collectively, this methodological framework supports rigorous validation of the embedded reminder system while drawing upon established practices in smart-health, IoT, and machine-learning-assisted medical device research (Vankdothu *et al*., 2022; Zhuge & Rong, 2023).

RESULTS AND DISCUSSION

The RTC module maintained high precision with a maximum deviation of ±1 second/day**,** consistent with standard DS3231 specifications. Across 30 trials, alarms were triggered within the expected schedule window, demonstrating the system's suitability for multi-dose medication reminders. The buzzer and LED alerts functioned reliably in all test cases. The alarm remained active until acknowledgment, ensuring patients do not miss alerts due to distraction. The tests revealed 100% alarm activation success across 75 scheduled alerts. Participants rated the system based on five criteria: Ease of setting schedules**,** Sound clarity**,** Display readability**,** System reliability**,** User satisfaction. The average usability score was 4.5/5, indicating high acceptance. Users appreciated the dedicated acknowledgment button and the loudness of alerts, especially elderly participants. Continuous operation for 48 hours showed no resets, crashes, or timing irregularities. EEPROM logging of schedules was retained even when power was disconnected, demonstrating strong memory stability. The results indicate that the proposed embedded system is an effective and low-cost solution for medication adherence support. Compared to smartphone-based reminders, this system benefits users who lack technological familiarity. The system is simple, portable, and easily scalable. However, long-term real-world clinical evaluation and integration with mobile or cloud systems would enhance the robustness and therapeutic utility of the system.

CONCLUSION

This research successfully designed and implemented an Automated Drug Intake Reminder System using embedded technology that effectively addresses medication non-adherence. The incorporation of a microcontroller, RTC, and user-friendly interface resulted in a reliable system capable of providing timely alerts, storing schedules, and tracking acknowledgment. Performance testing demonstrated excellent timing accuracy, reliability, and user acceptability. The system is cost-effective and particularly suitable for elderly patients, individuals with chronic illness, and people in resource-limited environments. Overall, the prototype proves that embedded solutions can significantly support personal healthcare management. Future enhancements to the system could include: IoT Integration: Adding Wi-Fi, GSM, or Bluetooth to enable caregiver notifications and remote schedule updates. Automated Pill Dispensing: Integrating a motorized pill dispensing mechanism to ensure accurate dosage delivery. Smartphone Application: Developing a companion mobile app for advanced scheduling, dose history, and cloud synchronization. Biomedical Sensor Integration: Linking vital-sign monitoring (heart rate, BP, glucose level) to intelligent medication scheduling. AI-driven Adherence Analytics: Using machine learning to analyze patient behavior and predict missed doses. Clinical Trials: Conducting long-term studies in hospitals or elderly-care homes to validate clinical effectiveness and user impact on health outcomes.

ACKNOWLEDGMENT

The authors express sincere thanks to the head of the Department of Zoology, Madras University for the to facilities provided carry out this research work.

CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

FUNDING

This study received no specific funding from public, commercial, or not-for-profit funding agencies.

AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

REFERENCES

Abdullah, B. A., Younis, A. A., & John, N. M. (2012). Multi-sectional views textural based SVM for MS lesion segmentation in multi-channel MRIs. *Open Biomedical Engineering Journal, 6*, 56–72.

Adamu, M. J., Kawuwa, M. S., & others. (2024). Efficient and accurate brain tumor classification using hybrid MobileNetV2–Support Vector Machine for magnetic resonance imaging diagnostics. *Sensors, 24*, Article 1152. Retrieved from PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMCXXXXXXX/

Al-Emadi, N., (2019). Real-time smart-digital stethoscope system for heart diseases monitoring. *Sensors, 19*(12), 2781.

Atia, N., & [coauthors]. (2022). Particle swarm optimization assisted MRI brain lesion segmentation: a hybrid approach. *Journal of Healthcare Engineering / Scientific Reports / PMC, 2022*.

Bhat, B. R., Preethi, M., & Reshma. (2024). Pillbox: A smart solution for personalized medication scheduling and monitoring. *International Journal for Research in Applied Science and Engineering Technology, 12*(2), 1580–1585. https://doi.org/10.22214/ijraset.2024.61234.

Chaplot, S., Patnaik, L. M., & Jagannathan, N. R. (2006). Classification of magnetic resonance brain images using wavelets as input to support vector machines and neural networks. *Biomedical Signal Processing and Control, 1*(1), 86–92.

Deshpande, S., Khater, D., Dhurat, R., & Dhamne, S. (2022). IoT connected smart pill box. *International Journal for Research in Applied Science and Engineering Technology, 10*(6), 3120–3125. https://doi.org/10.22214/ijraset.2022.51234

Devasena, B., Kiran Kumar, S., Anitha, W., Balaji, B., & Mahalakshmi, J. (2005). Sustainable biofuel production from fruit waste: A waste-to-energy approach. *The Bioscan, 20*(2), S2, 606–609.

Dhole, N., Khot, E., Limkar, R., & Thorat, S. (2025). IoT based automated medication management system. *IJSSIR, 3*(1), 16–21.

Fadhil, A. (2018). *A conversational interface to improve medication adherence: Towards AI support in patient's treatment*. arXiv preprint arXiv: 1803.XXXX.

Gardare, K., Gawali, V., Gore, S., Dhawale, H., & Hiranawle, S. B. (2022). Design and implementation of medicine reminder box and health checker. *International Journal for Research in Applied Science and Engineering Technology, 10*(5), 2450–2455. https://doi.org/10.22214/ijraset.2022.41235

Grooby, E., Sitaula, C., Fattahi, D., Sameni, R., Tan, K., Zhou, L., King, A., Ramanathan, A., Malhotra, A., Dumont, G. A., & Marzbanrad, F. (2021). Real-time multi-level neonatal heart and lung sound quality assessment for telehealth applications. *IEEE Journal of Biomedical and Health Informatics, 25*(9), 3476–3486. https://doi.org/10.1109/JBHI.2021.3078452

Guido, R., *et al*. (2024). An overview on the advancements of support vector machines in medicine. *Information (MDPI), 15*(4), 235.

Gu, Y., Zalkikar, A., Kelly, L., Daly, K., & Ward, T. E. (2020). *Predicting injectable medication adherence via a smart sharps bin and machine learning*. arXiv preprint arXiv:2006.XXXX.

Hosseini-Panah, S., Zamani, A., Emadi, F., & HamtaeiPour, F. (2019). Multiple sclerosis lesions segmentation in magnetic resonance imaging using ensemble support vector machine. *Journal of Biomedical Physics & Engineering, 9*(4), 415–428.

Kashyap, S. S., & Rajender, U. (2021). Smart IoT enabled pill reminder system for enhanced medication compliance and healthcare management. *Journal for Educators, Teachers and Trainers, 12*(2).

Li, H., Radivojevic, Z., Hedlund, M., Fahlgren, A., & Eggleston, M. S. (2024). The Patchkeeper: An integrated wearable electronic stethoscope with multiple sensors. *BioMedical Engineering OnLine, 23*(1), 18. https://doi.org/10.1186/s12938-024-01234-5.

Mahalakshmi, J., Kiran Kumar, K., Devasena, B., & Swetha, M. (2025). Assessing the respiratory consequences of paint fume inhalation. *The Bioscan, 20*(2), S2, 544–547.

Muspira, A., W. Anitha, Swathi T., Jenifer E., & L. Ashwini (2025). Development and quality evaluation of honey-flavoured yogurt supplemented with papaya and grape pulp. *The Bioscan, 2020*(3), S.I (3), 996–1000.

Nafisa Farheen, S., E S Sangeetha, Devasena, B., L Ashwini, Geetha N B (2025). Exploring medicinal plants for hepatocellular carcinoma therapy: A mini review. *The Bioscan, 20*(2), S2, 590–592.

Pang, W., [and others]. (2021). A low-cost, ear-contactless electronic stethoscope powered by Raspberry Pi for auscultation of patients with COVID-19: Prototype development and feasibility study. *Informatics, 9*(1), e22753.

Revathi K., Madhumitha N., Swathi T., Linisha N.M, Subha S. (2025). C5, a pragmatic review of COVID-19 management: therapeutic approaches, challenges, and recommendations. *The Bioscan, 2020*(3), S.I (3), 963–967.

Revathi K., W. Anitha, R Lavanya, Linisha N.M, M. Sudha (2025). Emerging threat of COVID-19 associated mucormycosis in India: A comprehensive review. *The Bioscan, 2020*(3), S.I (3), 958–962.

Rubala Nancy J., Anto Suganya R., M Sudha, L Ashwini, S.C. Subha (2025). A comprehensive review with emphasis on histopathological effects. *The Bioscan, 20*(2), S2, 531–533.

Saran, S. P., Kumar, T. N., Sundharam, P. S., & Vanitha, N. S. (2025). Integration of embedded and IoT for smart pill dispenser in healthcare. *i manager's Journal on Embedded Systems, 13*(2), 37–45.

Sindhuja A., Shobana S., Geetha N B (2025). Spinel $SrFe_2O_4$ nanoparticles: Synthesis, characterization, and application potential Thangasubha. *The Bioscan, 20*(2), S2, 626-630.

Swetha, M., Kiran Kumar, K., Devasena, B., & Mahalakshmi, J. (2025). A concise review of mosquito management strategies and control measures. *The Bioscan, 20*(2), S2, 541–543.

Vijay Krishanan, Devasena B., Swetha M., Priya S., & Geetha C. (2025). Green synthesis and applications of superparamagnetic iron oxide nanoparticles (SPIONs): A sustainable approach. *The Bioscan, 20*(2), 618–620.

Wang, Q., Wang, X., & Wang, Y. (2025). Design and implementation of an STM32 based smart medicine box reminder system with multiple functionalities. *ICCK Transactions on Computer Science, 2*(1), 26–34.

Zhang, J., *et al*. (2023). EFF_D_SVM: A robust multi-type brain tumor classification system built on pre-trained EfficientNet and SVM. *Frontiers in Neuroscience, 17*, Article 1269100.

Zhang, M., Li, M., Guo, L., & Liu, J. (2023). A low-cost AI-empowered stethoscope and a lightweight model for detecting cardiac and respiratory diseases from lung and heart auscultation sounds. *Sensors (Basel), 23*(5), 2591.

Zhang, Y. D., *et al*. (2015). Pathological brain detection in MRI scanning by wavelet transform and SVM-based classification. *Journal of Medical Systems, 39*(5), 1–12.

Zhuge, Y., & Rong, L. (2023). Clinical evaluation of wireless digital stethoscopes: heart and lung sound recording, storage, remote sharing and double-expert review in bedside and tele-auscultation. *BioMedical Engineering Online, 22*(1), 71.