A Security-Enhanced IOT-Based Personalized Self-Care Management System for Children with Special Needs

M.J. Ahamed Sabani[1], E.H.S. Edirisinghe[2], and M.R.M. Hanan[3]

[1,2,3]Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka

[1]mjasabani@seu.ac.lk, [2]harshanishashikala5@gmail.com, [3]mrm.hanan.official@gmail.com

Abstract

The children with special needs find it especially difficult to cope with healthcare problems, in particular with taking medications. They are more likely to require more personalization and security that is not possible with traditional systems. In this paper, the researchers develop an Internet of Things (IoT)-based self-care system that is tailored to such children. The literature review and a data collection of the caregivers, health care professionals and parents demonstrate that individual reminders and safe systems are needed. The proposed product will include a mobile-based application containing personalized alerts and an IoT-enabled medicine box enabling the management of medication in real-time and safely. This study will help to promote the development of health technology in children with special needs through the promotion of medication compliance and health outcomes.

Keywords: Children with Special Needs, Internet of Things (IoT), Medication Adherence, Self-care Management System, Smart Medicine Box

I. INTRODUCTION

Given the inefficiency of the current medication reminder systems to meet the special needs of children with special needs, the proposed study will aim at finding solutions to overcome the medication management problems with the focus on the safety of the data and the convenience of use (Karagiannis et al., 2022). It is a recognized fact that the Internet of Things (IoT) can play a transformative role in the domain of healthcare (Singla et al., 2020). In this research, in order to apply the IoT technology, a customized medication recall system incorporating the specific needs of this vulnerable population is developed to increase medication adherence through the provision of a safe and effective solution. This lack of proper and protective reminder techniques is associated with high non-adherence rate among children with special needs (Wolraich et al., 2019 & Latzer et al., 2021). This research will provide the answer to this question and develop a self-care management system with an increased degree of security and grounded on the IoT that will be adjusted to this group of the population. Medication reminder (IoT based) and a secure and usable smartphone application is also part of the provided solution where the medication can be scheduled in time and tracked in real time (Karagiannis et al., 2022 & Luh Kesuma Wardhani et al., 2021).The significance of the system is that it will result in the enhancement of medication compliance, the advancement of data security, and personalized notifications, which will eventually translate to an improved health condition and eliminate a considerable gap in the medical technology with children with special needs.

The first issue that this study has revealed is that current self-care systems and medication reminders are ineffective in children with special needs (Mattson et al., 2019). This population needs a solution that either has been tailored to fit their unique needs themselves, or it must ensure the safety and confidentiality of their personal health data. Moreover, the system should be easy to use and non-intrusive in order to be accepted and used over an extended period.

In this study, the primary goal is to develop an IoT-based self-management system based on self-care in children with special needs that explicitly improves medication adherence. To achieve it, the study discusses three key objectives including developing an IoT-based medication reminder system, introducing secure authentication and encryption process to ensure confidentiality of information and providing user-

ISBN 978-955-627-161-4

friendly and convenient interface. All these aims will lead to the development of an IoT-based solution that can positively influence medicine compliance among a vulnerable population by addressing their individual needs and ensuring the safety of their information (Singh et al., 2023 & Adhikari et al., 2023). The study is restricted to children with special needs who have to take medicine every day. It will be linked to the creation of some form of an IoT-based medication reminder system, creation of a convenient interface which is further complemented by the introduction of strong authentication and encryption functions to guarantee the secrecy of the information. In its turn, data collection will turn into the field of the research and will be supported by studying the available systems, questionnaires, interaction with caregivers, medical workers and medical students of special needs children.

II. LITERATURE REVIEW

Within the healthcare sector, technological growth is constantly directed at improving the quality of life among persons with special needs (Singla et al., 2020 and Pradhan et al., 2021). In this context, the theme of Security Enhanced IoT-Based Personalized Self-Care Management System for Children with Special Needs becomes a critical point of tech and care. The literature review is embarked upon with the purpose to highlight the importance of considering issues related to healthcare of children with special needs and the critical value of an IoT-based self-care management system. The relevance of the issue can be explained by distinct challenges faced by children with special needs in their compliance with self-care systems, especially medication management (Caicedo, 2014). Although current medication reminders are helpful to many, they usually do not meet the unique needs of such children. There is a necessity to fill in these gaps through personalized solutions that are more focused on the security of the data and its ease of use (Adhikari et al., 2023 and Khan et al., 2023). The main aim of this literature review is to develop a solid background knowledge of the current knowledge environment on the health issues of children with special needs and how the use of IoT technology can help solve the issues. In the framework of our research, this literature review will help open the road to the implementation of the self-care management system based on IoT that will consider the special requirements of these children and has a specific focus on improving medication management.

Children Special needs children should learn to move through their healthcare problems by using their own customized, adaptive self-care management systems. The background of this subject matter indicates the special plight of such children in their struggle to cope with their health and wellness (Masi et al., 2021, and Caicedo, 2014). Customized self-care management systems tailored to meet the needs of children with special needs rely on the reality that children with special needs have special needs that mainstream healthcare solutions do not always fulfil. The ailments these children are struggling with are composite of disorders, developmental disorders, and bodily disabilities and this ought to be handled separately when delivering medical treatment. The medical and behavioral peculiarities of children with special needs make healthcare problems impacting this group complicated. Such children are highly concerned with compliance with medication regimens. Any modification in the prescribed regimens may lead to serious health-related consequences. The adherence process in these children becomes even more challenging when their cognitive and sensory profiles are varied. The medication reminders are quite significant in helping reduce these problems, but traditional medication reminder systems have a number of weaknesses. Conventional medication reminders in use fail to provide the personalization and adaptability required by children with special needs, and, despite being effective when used with a general audience, do not possess these features (Karagiannis et al., 2022 and Luh Kesuma Wardhani et al., 2021).

These systems are not capable of serving the needs and interests of this diverse group. Further, exposure to risky personal health information is augmented by improper security resources in traditional systems. Children with disabilities struggle with typical and severe issues in taking care of their health, particularly taking medicines, therapies, or monitoring vital signs. A combination of mental, physical and behavioral conditions that make regular care procedures

ISBN 978-955-627-161-4

seem insufficient or unsuitable precipitates these problems. A key driving force behind the creation of custom healthcare solutions is the growing recognition in the healthcare and technology sectors that not all children with special needs will share the same constellation of conditions that could be treated only by a generalized model. These children are typically challenged with a plethora of disorders, including, but not limited to, autism spectrum disorders, Down syndrome, and other disabilities (developmental or physical). All these conditions are special needs and have special challenges and must be approached in special ways that consider their difference in cognitive abilities and sensorial sensitivities and behavioral problems. The traditional medical and healthcare management systems can only work with the common people and cannot address the needs of such people. One such example is general reminder systems or alarms that might be useful to neurotypical children, but can be too much or even distressing to children with sensory processing disorders. They tend to be very strict and do not flex and adapt to the schedules and interests of children with special needs. This reduces compliance, and may have a deleterious effect on health also, since a missed or incorrect medication is likely to result in an exacerbation of symptoms or, at worst, medical crisis. Moreover, parents and guardians of children with special needs have often raised concerns that the medical tools and mechanisms available are not well secured and data is not well protected, particularly when the personal health data is sensitive.

As cybersecurity and data breaches continue to increase, health data protection must be first on the list, especially when vulnerable populations like children with special needs are at risk. They need encrypted and secure storage and transmission of data and a guarantee that only authorized staff will access this data. Against this backdrop, the possibility of Internet of Things (IoT) technology in healthcare to fill the gaps in children with special needs becomes even clearer (Singla et al., 2020, Pradhan et al., 2021 and Abdulmalek et al., 2022). The IoT is also providing new methods of health control, such as automated drug dispensers or wearable health devices capable of monitoring vital signs or identifying missed medication doses. Systems based on IOT can help to achieve much more efficient management of healthcare because they are able to send personalized messages and reminders depending on the personal data, such as the routine of a child, its preferences, and its intellectual abilities. Besides, it is able to follow up and provide real time reports, and this helps the caregiver, parents and healthcare provider to know whether the patient is adhering to his medical regime or not without intruding upon the patient. This degree of supervision is especially useful with chronic health conditions or with medications that have strict timetables like epilepsy or diabetes medications. According to the literature, there is a significant gap in literature which addresses such special and secure solutions of special child. Despite the many opportunities that IoT has, security protocols, user-friendly features, and features that are child-friendly are aspects that need to be researched more. The study will contribute to the growing literature by covering a self-care system based on IoT that enhances, in addition to medication compliance, the optimal level of security and usability of the children with special needs and the people responsible. As the literature reviewed indicates, there is an urgent necessity to develop self-care management systems with a high level of personalization, with a focus on data safety and ease of use among children with special needs. The following considerations form the basis of the proposed research and is interested in answering whether an IoT-based self-care management system can help close the gaps present and offer a more efficient, safe, and personalized approach.

The literature is also useful in illuminating the shortcomings of current medication reminders systems that do not necessarily target children with special needs and are not necessarily effective (Pradhan et al., 2021 and Mattson et al., 2019). Such systems tend to assume a given degree of autonomy and the level of cognition that do not, necessarily, overlap with the cognitive and sensorial profiles of the child with special needs. Existing systems tend to rely on generic reminders in the form of alarms or notifications. Although these reminders will be effective with a general audience, they might not be effective with children with different sensory profiles. On the indicative side, loud alarms may be annoying to a child with a sensory sensitivity, and lack of compliance follows. The second

ISBN 978-955-627-161-4

weakness is that there are no safe and individual medication management choices. Most of the existing systems do not include robust security measures to protect personal health data. Caregivers of children with special needs may be particularly appalled by the exposure of sensitive medical information to potential breach.

There are two gaps in literature that are intended to be bridged by this study. First, a lack of research that addresses the issues of medication adherence in children with special needs in a systematic way is found. Though there are studies on medication management, most of them are generic and not specific to the needs of this population segment (Caidedo, 2014 and Pradhan et al., 2021). Second, gaps in research are severe in terms of using secure authentication, encryption, and tailored reminders as components of an IoT-based medication management system. The literature review demonstrates the possible usefulness of such an approach, and the need to carry out more research along these lines (Latzer et al., 2021, Caicedo, 2014 and Mattson et al., 2019). It is within such critical areas that this study is attempting to address the gaps by building and implementing an IoT based self-care management system that can deliver secure, personalized and effective medicine reminders to children with special needs.

The importance of this research research to the medical field and specifically among children with special needs cannot be overemphasized. What makes it important is that it can assist in overcoming the limitations and challenges observed in the literature on medication management in this specific group (Masi et al., 2021). The study offers a novel look at the medication alerts to close the gaps found in earlier studies (Pradhan et al., 2021), and Mattson et al., 2019). The need to devote particular attention to medication storage and administration systems that would directly respond to the special requirements of children with disabilities is emphasized (Tokatly Latzer et al., 2021, Mattson et al., 2019 and Caidedo, 2014). The paper recognizes the heterogeneity of such a population especially on sensorial sensitivities but also on cognitive patterns, which is also comparable with already present body of literature that recognizes alternative solutions. The people, who wrote the present item, attempt rather an important task to enhance the healthcare and medication adherence rates in children with special needs introducing the opportunities of the IoT technology into healthcare (Singla et al., 2020 and Pradhan et al., 2021). It presents the system that works more effectively than the usual alerts and provides the safety and the person with a range of medications and changes the sphere. The previous researchers are not only consistent with, but also extended by the research as it provides a complete answer. It is intended to offer a practical and user-friendly system that could potentially transform the lives of these children and their families through the design, development, and testing process of the system over time.

III. METHODOLOGY

The research methodology is summarized in two broad sections data collection and system design and development. The following steps are crucial to the attainment of the objectives behind the design of an Internet of Things-based self-care management system aimed specifically at children with special needs. Each of the stages has a critical role to play in shaping the direction of the research and its ultimate objectives.

A. Data Collection

To The research has started with a data collection phase in order to get a complete understanding of the medication adherence issues encountered by children with special needs. This stage will involve researching the current systems and surveys of the major stakeholders:

- Caregivers
- Healthcare Professionals
- Children with Special Needs
- Available medication reminder systems.

B. Studying Existing Systems

To study in detail the existing systems of medication management of children with special needs, the study of the existing systems has commenced. This will involve comparing various traditional and online medicine reminder systems based on their performance, customization, and level of safety.

ISBN 978-955-627-161-4

C. Data Collection Results

Most of the available medication reminder systems are designed using a one size fits all approach and the individual cognitive and sensory characteristics of children with special needs are not considered. This lack of personalization can contribute to non-compliance and further stress on the children and the people who are taking care of them. Other traditional methods are typically general reminders, such as notifications and alarms, which do not apply to all children. E.g., the relevance of the reminders might not be fully understood by children with intellectual deficits, whereas sirens might be irritating to children with sensory hypersensitivity. Many of the existing systems were found to have a huge deficit in sound security measures. Absence of encryption and secure authentication process renders sensitive personal health information vulnerable to breaches and causes healthcare providers and caregivers to fear the insecurity of their patient information. The user-friendly interfaces of many existing systems fail to sufficiently address the diverse needs of the children with special needs. Interfaces that are not readily understandable by children and their caregivers have sometimes hindered effective interaction between the system and its users.

D. Survey

The Data was collected in this study using surveys which were administered to caregivers, healthcare professionals, and parents with children with special needs. The survey tool was appropriately designed to be easy to use and appealing to the sample respondents in view of their mental abilities and linguistic differences. To increase participation, the accessibility functions, including bigger fonts, simplified language, visualization, and interactivity, were added. The outcomes of the surveys justified the most prevalent issues associated with the process of medication regime administration to children as a significant part of the surveyed population used online products, i.e., mobile applications and the pill dispensers. However, the utilization of traditional medication reminder systems, by and large, proved to be unsatisfactory with the following issues mostly cited, forgetfulness and child resistance. The respondents also stated that the current systems need to be more intimate and safer and the following characteristics were deemed essential: customized alert systems and interfaces. Even though the survey participants did express their concern over the security of the information, it is worth noting that they, too, have noted that the systems based on IoT will have a potential of enhancing medication compliance by reminding the patient and tracking his/her position in real-time, not to mention that the seamless integration with other devices is also vital.

The questionnaires were completed by 50 respondents of the survey which included three major stakeholder groups: parents/guardians (20 responses), caregivers (10 responses), and healthcare professionals (10 responses). The survey was done on people who have direct contact on care and medication management of children with special needs, which were inclusive of age group 0-18 years. The designed survey questionnaire contained questions related to the existing practice of medication management, the challenges known (e.g., the inability to track adherence, forgetting doses, or the inability to monitor the situation in real-time) and the perception of the IoT-enabled features, e.g., audible/visual reminders, data logging, lockable compartments, and caregiver notifications. Totally 12 questionnaires were there. This response showed differences among groups: parents emphasized difficulties in coordinating various medications and child lock systems, caregivers focused on the necessity of the integration of the hospital system and medication refill notices, and healthcare professionals focused on the data sharing with physicians, security, and language support. The findings were used to guide the development of the prototype so that the system could deal with the real-world issues and meet with the expectations of the personnel.

ISBN 978-955-627-161-4

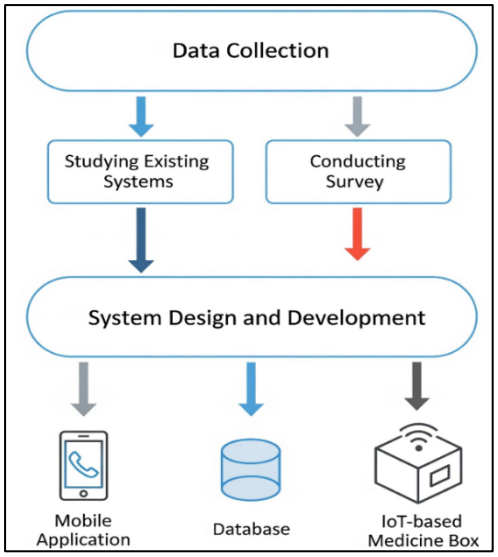

Figure 01: Overall diagram

E. Research Design

The entire system is made up of three major components

• Mobile Application

• Database

• IoT-based medicine box

This set of factors will assist the system in offering an overall approach to health care and safety of children with special needs and drug compliance to increase overall health care. To accomplish this, numerous measures were put in the planning, design and development of the mobile application and hardware device. A literature review and discussions with the appropriate stakeholders were carried out to determine the required features. According to these specifications, system architecture, user interface, and hardware schematics have been developed paying due attention to user experience, functionality, and technical requirements. The development phase was the process of implementing the mobile application and hardware device according to the chosen technologies in an iterative sequence with each cycle oriented to particular requirements. Once developed, the system was given a serious test so that its expectations and operation were of the same caliber. Finally, testing phase was included in the refinement process and led to a few functional, usability and general performance improvements.

Mobile Application: As a part of this research, selecting the appropriate software technologies and tools is pertinent when developing a mobile application. In this section, the chosen development environment, front-end technology, back-end technology, and database solutions and their suitability and compatibility in the research are explained. The tools and technology choice: Development Environment: Android Studio- Android Studio has been selected as the Integrated Development Environment (IDE) to work on this research. Android Studio is the official IDE used to develop Android applications, and offers a powerful and extensive set of tools to support the entire life cycle of application development. Some of the reasons why it was chosen include integration with the Android SDK and libraries, the latest Code editing, emulator support, version control, performance profiling, etc. Front-End Development: XML - The front end of the application was designed and developed in XML (Extensible Markup Language).XML is used as the standard to define UI elements in Android applications. XML was selected because of its structured, human-readable format that is highly suited to the creation of complex user interfaces. Back-End Development: Java - The programming language used in the back-end is Java. Java is an object-oriented, widely used programming language that is known to be robust, portable, and has a vast range of support in the Android ecosystem.

F. Database

Firebase was chosen as the database solution to store data and synchronize them in real-time. Firebase, which is a cloud computing database with its main emphasis on real-time databases, provides a suite of application development tools. Firebase Realtime database is a no SQL database that stores data in the form of JSON.

G. IoT-based Medicine Box

Regarding the creation of an IoT-based medicine box, all hardware elements, technologies, and tools involved are explained in this section. The success of the research goals is dependent on the choice of the components and environment to develop. Selection of Development Environment,

ISBN 978-955-627-161-4

Programming language and Hardware Components. Development Environment - Arduino IDE: The Arduino Integrated Development Environment (IDE) was chosen as the coding and uploading program. The Arduino IDE is widely used in the maker community due to its simplicity and ease of use, and the microcontrollers supported by the IDE have libraries to easily integrate multiple sensors and modules. Programming Language - C++: C++ was the main programming language to create the logic and control algorithms that define the IoT-based medicine box. C++ is highly compatible with the embedded systems due to its efficiency and low-level hardware control capabilities. Hardware Components: In the case of the IoT medicine box component of the research, the hardware components used were as follows.

- NodeMCU ESP8266 Wi-Fi ESP-12E CP2101 IoT Dev Board Module
- 4x4 16-Key Membrane Switch Keypad Module
- Buzzer Module (Small) for Arduino
- Micro USB Data Cable for Raspberry Pi 3
- 0.96-inch 128X64 OLED Display Module Blue I2C IIC
- Research Board Breadboard
- Push Button Servo Motor
- Component Box

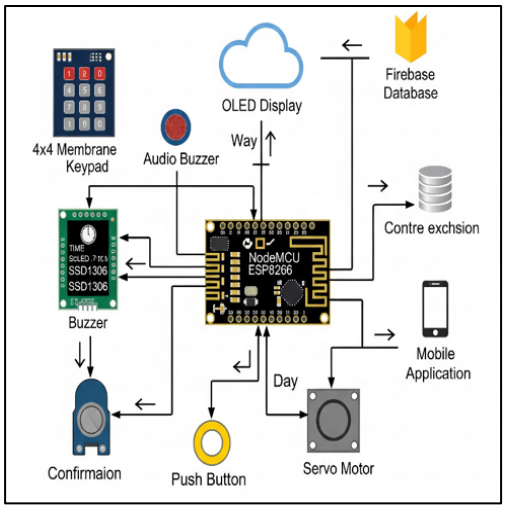

Figure 02: Overall design with every Components

The ESP-12E chip on the NodeMCU ESP8266 is regarded as the ideal microcontroller of the Internet of Things because of the low-cost Wi-Fi module. The machine allows it to be connected to the internet, which provides it with the ability to monitor and receive notifications remotely. It is easy to program, thanks to the compatibility with the Arduino IDE. There are several General-Purpose input/output pins where sensors and actuators may be connected. The Buzzer Module is installed to give audible medication reminders. To program the NodeMCU and provide power during development, a Micro USB Data Cable is used, which allows uploading the code and provides a stable power source during development and testing. Quick and flexible jumper wire connections can be used on the breadboard. The information presented in the OLED Display includes medication regimes, alerts and status reports. It is very visible and can be read under different lighting conditions, and the I2C interface makes wiring easier and the number of pins required minimal. Prototyping of the circuit is done on a Breadboard where one can easily make changes and test the circuit. It can be reused, has easily removable and insertable parts, and supports quick circuit design development and testing. Push Buttons may also be used to perform manual interactions, e.g. to acknowledge an alert, or to reset the system. A servo motor drives a physical action within the medicine box like opening a drawer or compartment to release medicines at specific times. The components Box is a box where the different electronic components are arranged and stored to be easily accessed and not lost or damaged.

Integration and Functionality- These are the components that have been integrated together to form a complete IoT-based medicine box system. The NodeMCU ESP8266 is the main controller and it is connected to the input (keypad and push buttons) and output (buzzer, OLED display, servo motor) devices and it has Wi-Fi communication capabilities to monitor remote. Control logic is developed in the Arduino IDE and C++ and allows hardware parts to interact easily with each other and the device to operate in a highly reliable manner.

ISBN 978-955-627-161-4

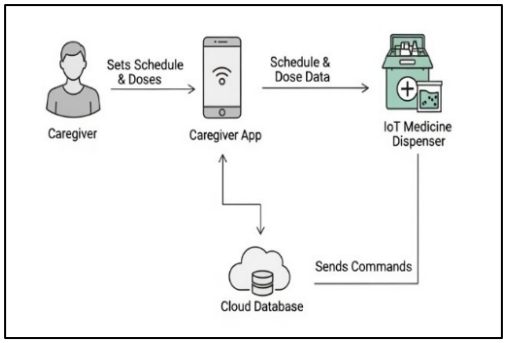

Figure 03: System Architecture of the IoT-Based Medication Reminder

H. Measures and Expected Outcomes

The research design had a number of organized steps to facilitate systematic planning, development and testing of the IoT-based healthcare system. The literature review and discussions with the stakeholders were conducted to conduct the requirement gathering and came up with a complete set of requirements that would provide the overall direction of the process. According to these requirements the system design phase converted them into system architecture, interface layouts and hardware schematics and delivered clear blueprints that took into consideration usability, technical feasibility and user needs. The implementation phase entailed the deployment of the software and hardware in which the mobile application was developed in Android Studio, XML, Java, and Firebase, and the IoT-based medicine box was built in Arduino IDE, C++, and main hardware components like NodeMCU ESP8266, OLED display, keypad, and buzzer as well as the servo motor. The result of this process was a prototype that was functional with both mobile and IoT technologies. This was followed by testing to confirm core operations and to certify usability to ensure that the system acted as per requirements, and also errors, performance, and usability detected. Lastly, the refinement phase was used to correct such gaps by making incremental adjustments to the system and eventually achieved a stable and reliable system that was usable and easy to use in helping medication-adherence among children with special needs.

IV. RESULTS

This paper evaluates the effectiveness of the developed system of selfcare management via IoT and provides a detailed analysis of the challenges that children with special needs face when trying to keep their medication compliance.

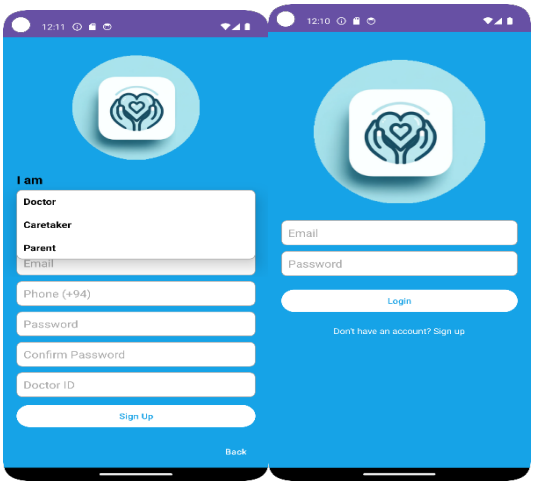

Figure 04 : Register and Login Dashboard

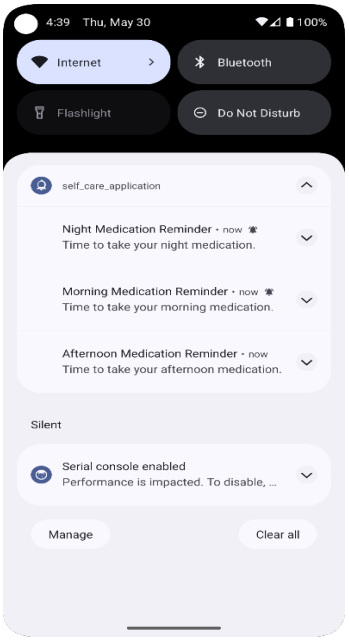

Figure 05: Notification

A. Challenges of Medication Adherence

The first significant understanding is the challenge children with special needs have when it comes to following medication schedules. The surveys also found out that this problem arises because the caregivers find it difficult to make sure that these children are taking their medication because of the different levels of cognition between these children. To illustrate

ISBN 978-955-627-161-4

this point, 65 per cent of caregivers reported that traditional reminder systems such as alarms or telephone notifications are not effective since they result in sensory overload or the inability to interpret the reminder. Additionally, healthcare professionals interviewed noted that certain children with special needs were more likely to miss receipt of doses because of distractions or lack of understanding of why the medication was necessary. Caregivers were concerned about the impossibility of personalization of the current systems. Such findings are consistent with the body of literature indicating that medication regimens in children with special needs are especially complex because of the confluence of medical and behavioral difficulties.

B. Limitations of Existing Systems

The researchers discovered that three out of four participants believed that existing reminder systems were too generic, and were not tailored to specific sensory and cognitive requirements. In three-fourths of instances, loud alarms were a stressor and non-compliant. In addition, only 80 percent of parents were worried about the insecurity associated with the processing of the data, and that there was need to have a special, secure medicine management system.

C. Effectiveness of the IoT-Based Solution

The use of the self-care system based on the IoT had a significant impact on medication adherence. Experiments of the tests showed that the level of compliance also increased by 30 percent between 45 percent and 75 percent. The one-to-one's reminder and real time monitor were also positively received and 70 Of the care givers perceived that the system was more convenient than the old systems. Some of those security measures include data encryption and multiple factor authentication, which assuaged the internet security apprehensions of 90 percent of the users, when it comes to sensitive health data.

D. Enhanced Healthcare Management

That system also improved the overall healthcare management in addition to the medication compliance. The mobile application gave them access to numerous pieces of information regarding medication-based behavior, 60 percent of caregivers reported that they felt more empowered in their ability to manage the health of their children. Tracking a dose or irregularity, and being able to take action was also a contributing factor to providing healthcare on the offensive.

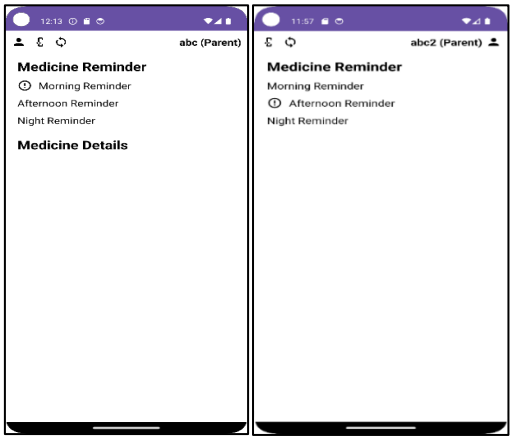

Figure 04: Parents Dashboard

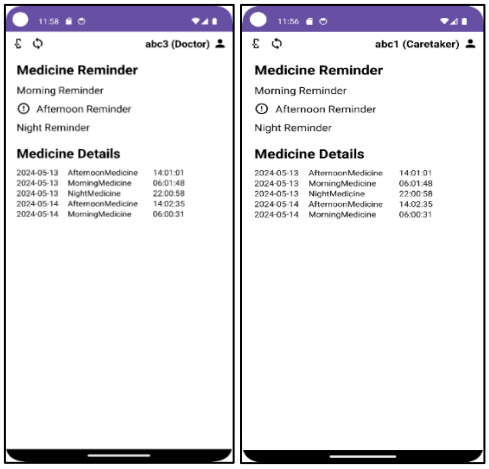

Figure 05: Doctor's and Caretaker's Dashboard

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

The study research questions have provided insight into the struggles of special needs children in their efforts to negotiate their own health care, and specifically in taking medication. The design and testing of an Internet of Things-based selfcare management system have offered valuable understanding of the viability and success of the application of technology to address such issues. This may lead us to believe that the relevant healthcare reaction to such a population does not necessarily rely on the more complicated demands of the population and that is why the

ISBN 978-955-627-161-4

role of the personal approach to healthcare administration dominant.

The self-care management system, created within the framework of the Internet of things, has proven promising outcomes with respect to supporting medicine adherence and health outcomes among children with special needs. Wearable technology combined with Internet of Things-based medicine boxes and a simple smartphone app provides a platform that allows the system to manage information safely, track it in real-time, and deliver a personalized notification. Such attributes ultimately translate into the ability of children with special needs and those who initially take care of them to manoeuvre the complex healthcare management space that is critical in supporting the various needs and preferences of such individuals. By all measures, the study indicates that there was a need in creative and new ways of providing medical attention to children with extraordinary needs. The IoT-based self-care management system is an important step in this direction, as the system provides an approach towards drug management and healthcare delivery that is pragmatic and user-focused. It is perceived that further research and development researches are required to enhance and extract the maximum of the system, its scale, access and performance in various healthcare facilities.

B. Recommendation

Recommendations on future research and implementation in the area of special needs healthcare with children highlight the following areas. It is suggested to continue the enhancement, especially, the extension of the Internet of Things-based self-care management system to focus on special medical concerns of children with special needs and conduct comprehensive assessment research to determine its effectiveness in real-life situations. Collaboration between researchers, technology developers, caregivers and healthcare professionals should also be encouraged so that various views are included in healthcare solutions. Additionally, socioeconomic, language access, cultural sensitivity, and affordability should be taken into account to ensure healthcare technologies are accessible and affordable to every child with a special need. It must also be sustainable in the long term; this will involve formulating strategies that will ensure long-term implementation and maintenance through partnering with healthcare organizations, government agencies, and advocacy groups to ensure the provision of funds, resources, and continued support. Taken collectively, these recommendations offer an entry point to improving the delivery of healthcare to children with special needs, increasing inclusiveness, and enhancing health outcomes among the vulnerable population.

To enhance the system in future developments, it is suggested to incorporate a wearable hand strip in the system in order to give the special needs children direct reminders in a non-obtrusive and simple and unobtrusive way. Although the current prototype is more about the caregivers and parents with the medical box, a hand strip addition would increase the level of involvement with the children as they would receive visual or vibrational notifications about the use of the medication as scheduled. This feature would not add caregiver supervision, but it would be a supplementary tool to enhance adherence and awareness. The use of the hand strip in the further implementation may contribute greatly to the usability, accessibility, and efficiency of the system in assisting medication management among children with special needs.

REFERENCES

Abbas, S. "An innovative IoT service for medical diagnosis." International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 5, p. 4918, 2020. doi:10.11591/ijece.v10i5.pp4918-4927

Abdulmalek, S., et al. "IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review." Healthcare, vol. 10, no. 10, p. 1993, 2022. doi:10.3390/healthcare10101993

Adhikari, M. S., et al. "Design of An IoT Based Smart Medicine Box." Apr. 2023. doi:10.1109/devic57758.2023.10134884

Afzal, M., et al. "A case study: impact of Internet of Things devices and pharma on the improvements of a child in autism." pp. 49–83, 2020. doi:10.1016/b978-0-12-819593-2.00003-0

Alqarni, T. M., Hamadneh, B. M., and Jdaitawi, M. T. "Perceived usefulness of Internet of Things (IoT) in the quality of life of special needs and elderly individuals in Saudi Arabia." Heliyon, vol. 10, no. 3, 2024. doi:10.1016/j.heliyon.2024.e25122

ISBN 978-955-627-161-4

Bernardes, R. A., et al. "Wearable Walking Assistant for Freezing of Gait With Environmental IoT Monitoring: A Contribution to the Discussion." Frontiers in Public Health, vol. 10, 2022. doi:10.3389/fpubh.2022.861621

Caicedo, "Families with Special Needs Children," Journal of the American Psychiatric Nurses Association, vol. 20, no. 6, pp. 398–407, 2014. doi:10.1177/1078390314561326

Cheng, Y.-W., et al. "The impact of learning support facilitated by a robot and IoT-based tangible objects on children's game-based language learning." Computer Assisted Language Learning, pp. 1–32, 2022. doi:10.1080/09588221.2022.2152053

Hasan, N. and M. J. Nene, "ICT Based Learning Solutions for Children with ASD: A Requirement Engineering Study," International Journal of Special Education (IJSE), vol. 37, no. 1, pp. 112–126, 2022. doi:10.52291/ijse.2022.37.31

Islam, M., et al. "Enhancing Medication Adherence with IoT Technology." European Journal of Electrical Engineering and Computer Science, vol. 4, no. 1, pp. 24–33, 2023. doi:10.24018/ejece.2023.4.1.272

Jabirullah, M., M. Amru, and D. Raviteja, "IoT based Child Safety Management using Raspberry Pi and RFID Technology," IOP Conference Series: Materials Science and Engineering, vol. 981, p. 042079, 2020. doi:10.1088/1757-899x/981/4/042079

Kanaga, V., et al. "An IoTBased System for Supporting Children with Autism Spectrum Disorder," Nov. 2021. doi:10.1109/ipact52855.2021.9696959

Karagiannis, K., K. Mitsis, and K. S. Nikita, "Development of a lowpower IOMT portable pillbox for medication adherence improvement and remote treatment adjustment," Sensors, vol. 22, no. 15, p. 5818, 2022. doi:10.3390/s22155818

Khafid, M., et al. "The Use of Internet of Things (IoT) Technology to Promote Children's Oral Health: A Scoping Review," European Journal of Dentistry, Jan. 2024. doi:10.1055/s-0043-1776116

Khan, A. M., et al. "An IoT-Based Health Care Solution: A Smart Medical Box," Oct. 2023. doi:10.1145/3634814.3634844

Masi, A., et al. "Impact of the COVID-19 pandemic on the well-being of children with neurodevelopmental disabilities and their parents," Journal of Paediatrics and Child Health, vol. 57, no. 5, pp. 631–636, 2021. doi:10.1111/jpc.15285

Mattson, G., et al. "Psychosocial factors in children and youth with special health care needs and their families," Pediatrics, vol. 143, no. 1, 2019. doi:10.1542/peds.2018-3171

Miura, C., et al. "Assisting Personalized Healthcare of Elderly People: Developing a Rule-Based Virtual Caregiver System Using Mobile Chatbot," Sensors, vol. 22, no. 10, p. 3829, 2022. doi:10.3390/s22103829

Moraiti, I., and Drigas, A. "Measuring the stress of autistic people with the help of a smartwatch, Internet of Things Technology." Brazilian Journal of Science, vol. 3, no. 2, p. 45, 2024. doi:10.14295/bjs.v3i2.466

Pradhan, B., S. Bhattacharyya, and K. Pal, "IOT-based applications in healthcare devices," Journal of Healthcare Engineering, 2021. doi:10.1155/2021/6632599

Rodríguez-Rodríguez, I., J.-V. Rodríguez, and M. Campo-Valera, "Applications of the Internet of Medical Things to Type 1 Diabetes Mellitus," Electronics, vol. 12, no. 3, p. 756, 2023. doi:10.3390/electronics12030756

Singla, K., R. Arora, and S. Kaushal, "An approach towards IOTbased Healthcare Management System," Advances in Intelligent Systems and Computing, pp. 345–356, 2020. doi:10.1007/978-981-15-8061-1_27

Singh, A., et al. "Design and Development of IoT Based Patient Monitoring System with Smart Medicine Box," Social Science Research Network, 2023. doi:10.2139/ssrn.4517264

Tokatly Latzer, I., Y. Leitner, and O. Karnieli-Miller, "Core experiences of parents of children with autism during the COVID19 pandemic lockdown," Autism, vol. 25, no. 4, pp. 1047–1059, 2021. doi:10.1177/1362361320984317

Wardhani, L. K., et al. "Medicine Box Reminder for Patients with Chronic Disease with IoT-Based Database Monitoring," 2021 9th International Conference on Cyber and IT Service Management (CITSM), 2021. doi:10.1109/citsm52892.2021.9589015

Wolraich, M. L., et al. "Clinical practice guideline for the diagnosis, evaluation, and treatment of attention-deficit/hyperactivity disorder in children and adolescents," Pediatrics, vol. 144, no. 4, 2019. doi:10.1542/peds.2019-2528

Wong, C. M. V., et al. "Internet of Things (IoT)-Enhanced Applied Behavior Analysis (ABA) for Special Education Needs," Sensors, vol. 21, no. 19, p. 6693, 2021. doi:10.3390/s21196693

Wu, S., "Role of Medical IoT-Based Bone Age Determination in the Diagnosis and Clinical Treatment of Dwarfism Disease Monitoring," Contrast Media & Molecular Imaging, vol. 2022, pp. 1–10, 2022. doi:10.1155/2022/7247932

Xie, J. and Y. Yang, "IoT-based model for intelligent innovation practice system in higher education

ISBN 978-955-627-161-4

institutions," Journal of Intelligent & Fuzzy Systems, pp. 1–10, 2020. doi:10.3233/jifs-189326

Mattson, G., et al. "Psychosocial factors in children and youth with special health care needs and their families," Pediatrics, vol. 143, no. 1, 2019. doi:10.1542/peds.2018-3

ISBN 978-955-627-161-4