Original Article

An IoT based health monitoring system for cancer treatment

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Background: Novel anti-cancer therapies have helped improve prospects of treating patients with various cancer malignancies, therefore, increasing the chance of survival for many cancer patients. One of the major risks for anti-cancer therapies, notable is the increased risk to develop systemic hypertension. High blood pressure also known as hypertension is the pressure of blood pushing against the walls of the arteries. High blood pressure may cause heart related complications and failure of vital human body organs like kidney and many others if not detected early and during the anti-cancer treatment therapies. An internet of things (IoT) based system for monitoring and observing of systemic hypertension before and after cancer treatment has been developed in this work to minimize the chances of treatment-induced hypertension by providing regular readings of critical blood pressure parameters like pulse rate, temperature and blood pressure.

Methods: In this paper, an IoT based device using sensors to detect pulse rate, temperature and blood pressure using the LM35 temperature sensor, blood pressure and pulse rate sensors to detect and decode these values and send to the web server for notification and recommend action was analyzed, modeled, designed and implemented. The IoT device was tested to determine its efficiency.

Results: Accurate readings of Blood Pressure, pulse rate and temperature readings were obtained and transmitted through an IoT protocol. The values were processed according to expected treatment actions and recommended by the IoT Based Health Monitoring System for Cancer Treatment application server.

Conclusions: Using IoT and sensors provides a convenient and easy access to monitoring and detection of incident diseases like blood pressure in patients receiving cancer treatment on a real-time bases. This approach provides a better analysis and detection of blood pressure development in cancer patients receiving treatment and has better accuracy compared to using traditional face to face or physical meetings with the patient.

Keywords: Blood pressure; cancer treatment; database; health monitoring system; internet of things (IoT)

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Introduction

Cancer is a universal and serious illness that is contributing too many deaths globally according to a report by the World Health Organization (1). Heart disease is one of the leading illness that has caused severe body disability thorough stroke and other related heart diseases. In some types of cancer, the heart disease has been observed as the chief cause for the demise of the dreaded disease (2) and hypertension condition in patients with cancer is most likely to cause cardiac disease and leading to immediate death if not monitored and if not treated. According to (3) the treatment of cancer today employs an amalgamation of chemotherapy, radiotherapy and surgery as means to mitigate and alleviate cancer spreading and cross infection.

Some anticancer therapies produce severe increase in blood pressure (4), resulting in worsening of pre-existing heart conditions and lead to severe hypertension related impediments in severe cases.

Since hypertension supersedes other comorbidity conditions in cancer patients, these patients ought to be observed diligently throughout their chemotherapy and post treatment for the development of hypertension (5). The developed IoT based health monitoring system will monitor blood pressure (BP) of the patient before and after cancer treatment. The measured values are displayed on a liquid crystal display (LCD) and subsequently uploaded to an internet-based database. The internet-based database of the project provides remote monitoring of patients, opening up the advantage of patient BP data being accessed by any authorized doctor in the hospital or any other remote location. If patient BP measurements rise above certain predetermined thresholds, automated recommendations are sent to the doctor/caretaker to prevent the consequences of treatment-induced hypertension and other cardiovascular complications.

Literature review

In global, the study in this field is quite wide-ranging and numerous studies have been performed by different researchers for dealing with cancer using IoT based smart devices and sensor networks (6-9). Mohammed *et al.* (10) reviewed several cancer treatments that have been related with the improvement of hypertension and existing approaches for blood pressure management for each drug class used. During treatment, they would discuss treatment plan for each patient by profiling the BP, state the monitoring objectives for each patient with cancer, develop assessment plans, and create a treatment plan for regulating and controlling the BP using oncology. Fraeman *et al.* (11) determined the prevalence of new-onset hypertension in adults with cancer by using the Varian Medical Oncology outpatient database. Occurrence rates of new-onset hypertension amongst adults with cancer and that were persistent and severe were noted. A treatment plan for cancer that involved exposure and non-exposure to chemotherapy was developed for these patients. These results derived was used to elucidate that exposing patients to chemotherapy seemed to be related with a high-risk incidence of causing hypertension amongst the cancer patients, noted that there is a lack of information and knowledge on the causes of hypertension in patients who have cancer with respect to cardiac risk reduction. Cohen *et al.* (12) proposed the use of home BP monitoring method for observing and monitoring of hypertension for patients with cancer. The rational was to constantly inform the medical personnel so that they will correlate the hypertension condition and the treatment the patient is receiving. Meijers and de Boer (13), informed that cancer patients undergoing chemotherapy need cardiovascular observing, together with efficient measurement of BP. The authors of (14) mentioned that early diagnosis and sufficient treatment of hypertension for cancer patients can improve the chances of better treatment of cancer to the patient by avoiding damage to vital organs of the body due to hypertension.

This study proposes to develop a system that could be used to constantly take readings of hypertension amongst the patients with cancer at home or wherever using the IoT technology and deliver to the respective medical personnel attending to the patient regularly and timely.

Methods

Currently, there very few approaches used to conduct hypertension monitoring and reporting and most of them are manual or semi-automated and do not use contemporary technologies like internet of things (IoT). This research study therefore proposed to model and develop an IoT Based Health Monitoring System for people living with cancer and also under treatment. This study conducted a desktop review of other IoT systems for monitoring other events and occurrences. Based on the techniques and technologies used, this study designed a model for monitoring hypertension for cancer patients who might be located anywhere and the data would be remitted to their medical personnel. This study based on the diagram given below noted that there is for sensor readers for hypertension, sensors for pulse reading and ultimately sensors for temperature. The data collected would sent to data conditioning unit, next to Wi-Fi transmission unit and over the public network then to web server which receive the results for storage and access. Hence, there is a need for tailored treatment plan for patients undergoing cancer treatment. This system also provides treatment guidelines to doctor/caretaker concerning the management of hypertension in cardio-oncology. These particulars are stowed in the webserver which can be easily retrieved by the hospital patients and physicians. The study was conducted in accordance with the Declaration of Helsinki

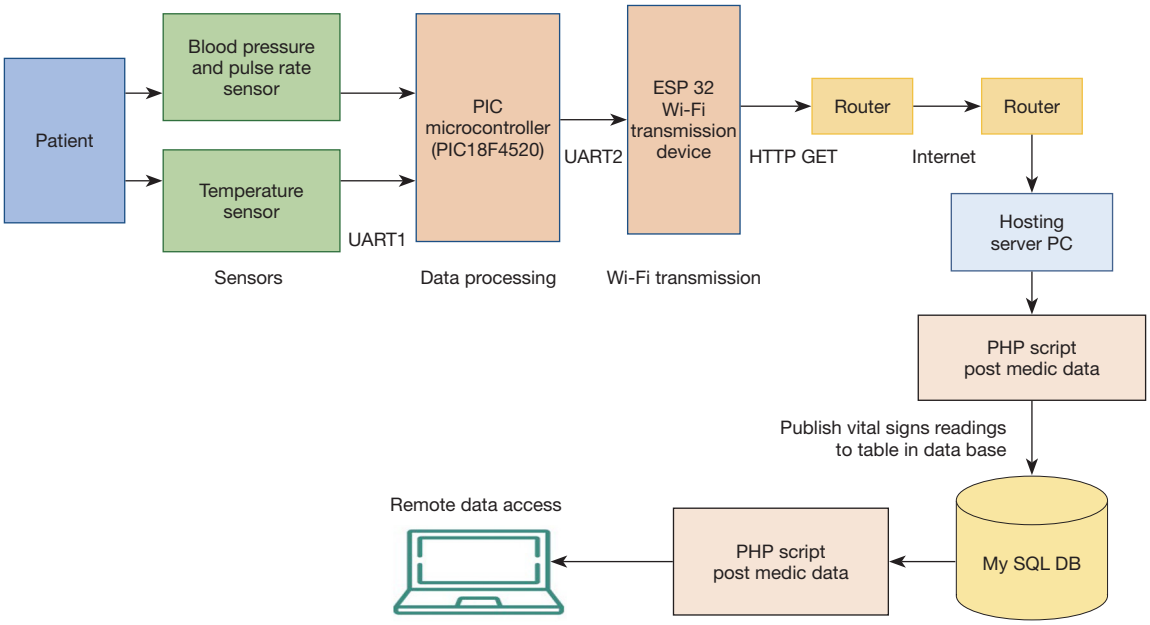

Figure 1 Block diagram of the developed system. PIC, peripheral interface controller; UART, universal asynchronous receiver-transmitter; PC, personal computer; PHP, hypertext preprocessor; SQL, structured query language; DB, database.

(as revised in 2013).

Block diagram

Figure 1 shows block diagram of overall system configuration. In this system configuration, the first device in the system chain comprised of sensors to detect the vital signs. The sensor outputs were processed by a PIC Microcontroller (Peripheral Interface Controller - PIC18F4520) and transferred to the WIFI transmission device (ESP32 or ESP8266) via serial (UART) communications. The data is posted to the internet as a Hypertext Transfer Protocol (HTTP) post via a local WIFI router. On the receive end (Database End), the database is accessed via a webserver such as XAMPP MySQL (Structured Query Language) powered Webserver that is installed within an internet connected personal computer (PC). MySQL database management system is employed in this project to enable addition, accessing and processing of the vital signs data sent by the vital signs device.

Vital signs acquisition, web transmission and database storage

(I) Vital Signs are transferred from PIC18F MCU to ESP32 MCU via UART.
(II) ESP32 integrated the data to HTTP/HTTPS GET request and sent the request to the web server (cPanel/PHPMYADMIN).
(III) The webserver runs a Hypertext Preprocessor (PHP) script that handles the request from the ESP32.
(IV) The PHP script extracted the Vital Signs data from the HTTP request, the data was processed and then interacted with PHPMYADMIN database to insert the data into the data table.
(V) The data table received the vitals parameters (Temperature, Pulse, Blood Pressure, Recommendation, the patient name, timestamp) and inserted them into their respective columns on the data table.
(VI) PHP script processed the result and returns only the necessary result to the ESP32 via HTTP response.

Vital signs acquisition

An LM35DZ analogue temperature sensor is used to read the temperature from the patient. BP and pulse rate are detected by a BP Measurement device manufactured by Sun rom Electronics in India.

UART, or Universal Asynchronous Receiver-Transmitter, is one of the device used to facilitate serial data transmission.

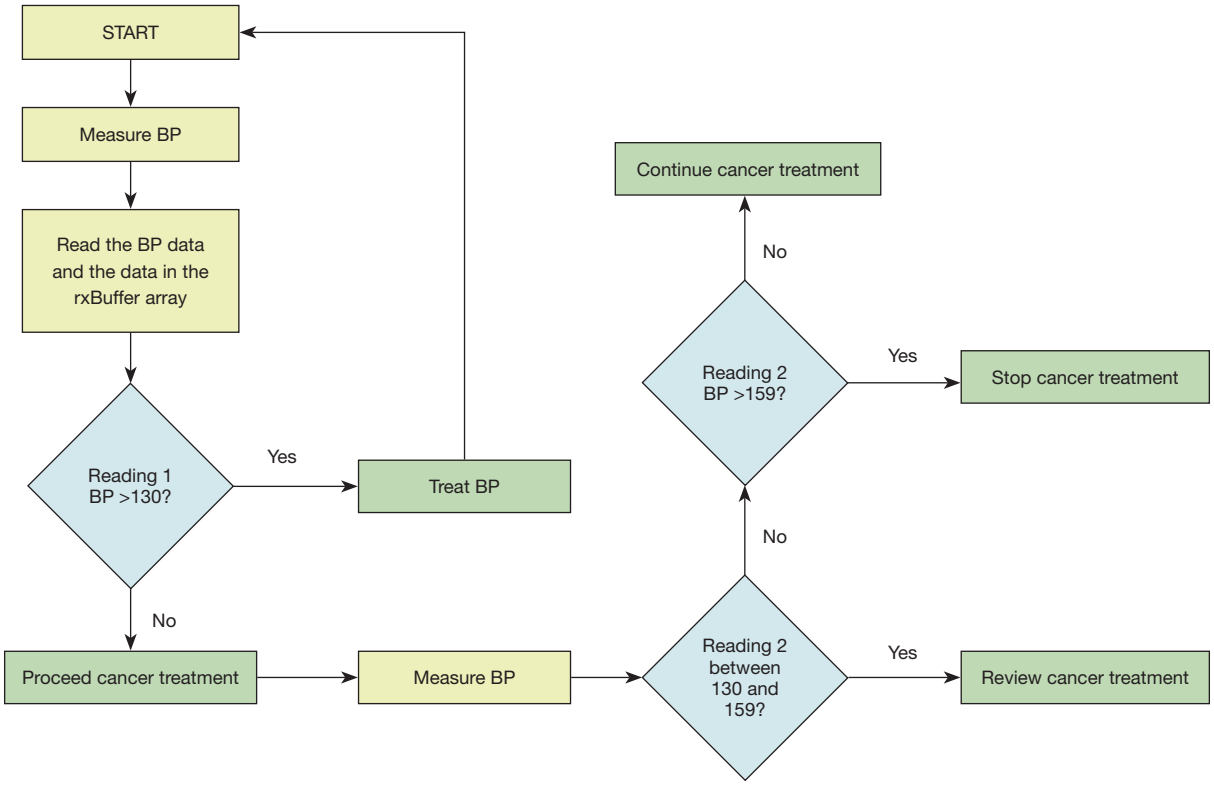

Figure 2 Flowchart for cancer routine algorithm. BP, blood pressure; EEPROM, electrically erasable programmable read only memory.

Communication between the two microcontrollers, PIC18F4520 and ESP32 is via UART Communications.

Cancer routine algorithm

The project is configured to monitor a cancer patient's BP before, during and after cancer drug treatment. It follows an algorithm as shown in *Figure 2*, that tests the BP values received to give recommendations to the local or remote doctor/caregiver. Before a cancer patient is treated, the device is used to read the patient's BP. If the BP does not exceed 130/90 mmHg before cancer treatment, then the device will recommend that treatment can be proceeded. If, however the pressure exceeds this level, the device will give a recommendation that the patient should be treated to reduce the BP before treatment commences. If treatment commences, a second reading is taken some time after treatment. The device determines whether the BP has increased compared to the first reading by how much. If the second reading BP is between 130/x and 159/y mmHg, the device recommends that the treatment should be reviewed by the doctor. The review might entail a reduction of the treatment dosage or a change of medication for example. If the BP exceeds 160/x mmHg, the device recommends a halt to treatment altogether. This algorithm is based on current guidelines and expert recommendations from (15) on how to practically approach blood pressure monitoring and treatment.

ESP8266/ESP32 Wi-Fi Transceivers

The ESP8266 Wi-Fi Module is a self-reliant System on Chip (SoC) with integrated Transmission Control Protocol/ Internet Protocol (TCP/IP) protocol stack that can provide any microcontroller access to Wi-Fi networks.

Web Server

The main aim of the web server is to store, process and transport web pages to the consumers. This intercommunication is finished using (HTTP). In this project, The *Apache HTTP Server* is utilized. PHP is a server-side scripting language that is embedded in HTML and integrated with MySQL. It is used in this database.

In order to remotely store data in a web database, the application MySQL was implemented to achieve this objective.

Results

In the developed system, the blood pressure measurements are acquired by connecting sensors on the patient's body which are interfaced to micro controllers. These values are processed by micro controller and transmitted to the database through a Wi-Fi module. These data can be perceived on the webpage using the computer or the mobile. *Figure 3* shows overall system hardware design and configuration. Sensors are connected via 3 pin External Line Return (XLR) connectors configured to provide both 5V DC supply to the sensors via pins 1/3 and pin 2 used as data output to the system. The power supply consists of a 220V mains to 12V direct current (DC) adapter.

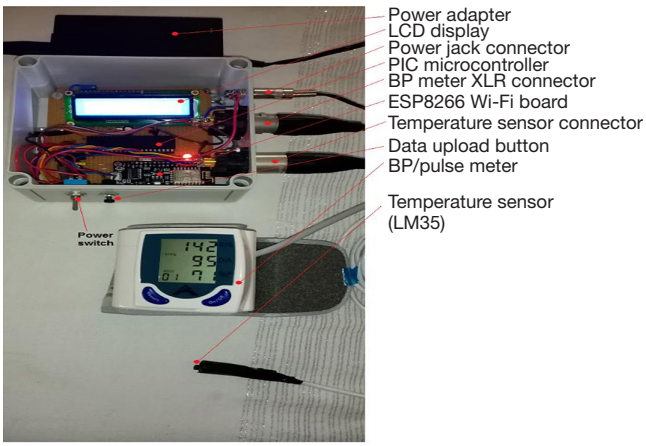

Figure 3 Hardware connection setup. LCD, liquid crystal display; PIC, peripheral interface controller; BP, blood pressure; XLR, external line return.

Discussion

Figure 4 shows the sample test cases of blood pressure measurement taken from patients before and after cancer treatment. *Figure 5* shows these recommendations are also sent to the doctor's website/caretaker database. If the blood pressure does not exceed 130/90 mmHg before cancer treatment then the device will recommend that treatment can proceed. If blood pressure exceeds 130/90 mmHg then the device will give a recommendation that the patient should be treated to reduce the blood pressure before treatment commences.

Conclusions

The use of IoT and mobile technology has ushered the creation of technologies that could be easily used to create bio technology. The application of bio technology to conduct very critical and importance biological parameters

(a) BP value <130/90 mmHg. Recommendation is OK

(B) BP value >130/90 mmHg

(c) BP value >130/90 mmHg.
Recommendation is to review the treatment

(d) BP value >130/90 mmHg. Recommendation is to treat BP

(e) After cancer treatment. BP value >130/90 mmHg

(f) BP value >160/90 mmHg.
Recommendation is to stop the cancer treatment

Figure 4 LCD showing BP values before and after cancer treatment. BP, blood pressure; LCD, liquid crystal display.

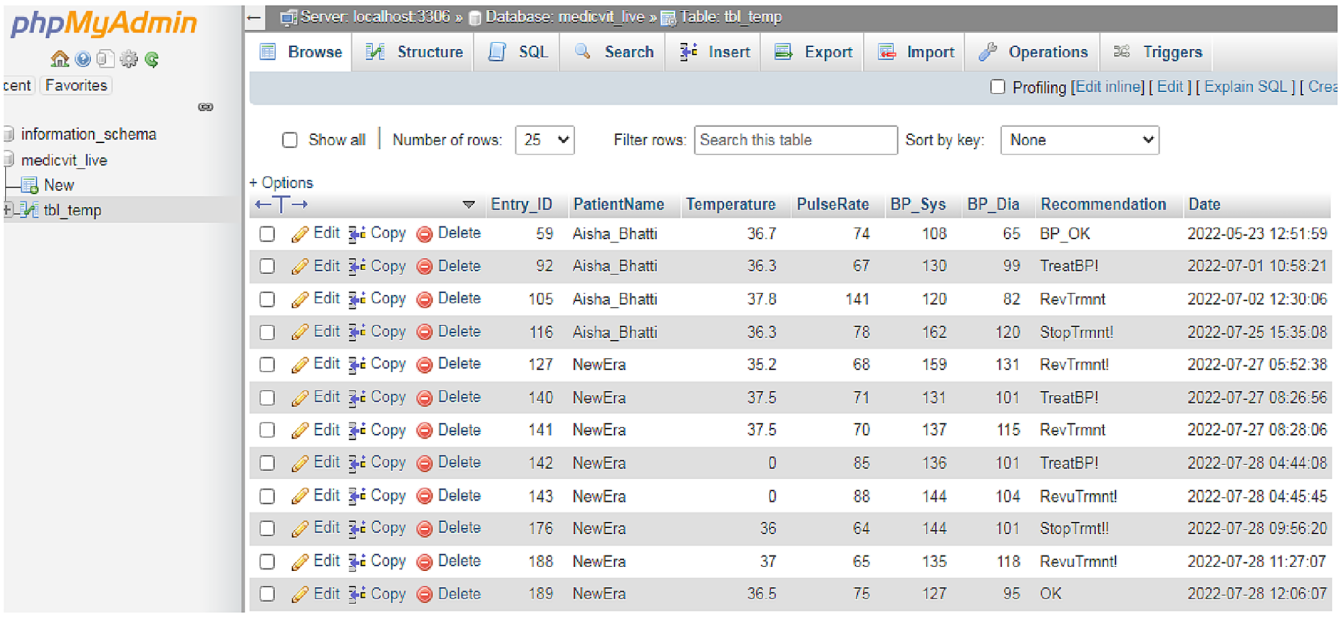

Figure 5 Doctor/caretaker website showing results of temperature, pulse rate, blood pressure before and after cancer treatment.

is a huge step towards controlling some issues that have been a problem for human beings. For instance, constant monitoring of BP, temperature and pulse rate for patience living with cancer is now possible without necessary having to make unnecessary trip to the doctor. The accumulation of such data would serve a purpose with regards to creating trends and patterns of hypertension conditions in patients being treated for cancer and changes in the anticancer therapies which has significantly improved. Therefore the developed system is essential in the medical field to treat the hypertension in cancer treatment patients in preventing cardiovascular events. This developed system is efficient for the cancer treatment patients to provide a guidance about the treatment suggestions with low time consumption. The system shall be further investigated on real-time basis to establish its efficiency.

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Footnote

Data Sharing Statement: Available at https://ht.amegroups.com/article/view/10.21037/ht-22-13/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://ht.amegroups.com/article/view/10.21037/ht-22-13/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

References

1. Rehman O, Farrukh Z, Al-Busaidi A, et al. IoT powered cancer observation system. ACM International Conference Proceeding Series 2020:313-8.

2. Essa H, Dobson R, Wright D, et al. Hypertension management in cardio-oncology. J Hum Hypertens 2020;34:673-81.
3. Souza VB, Silva EN, Ribeiro ML, et al. Hypertension in patients with cancer. Arq Bras Cardiol 2015;104:246-52.
4. Kidoguchi S, Sugano N, Tokudome G, et al. New Concept of Onco-Hypertension and Future Perspectives. Hypertension 2021;77:16-27.
5. Buzby S. (2023). Close BP monitoring important before, during and after cancer therapy. Available online: https://www.healio.com/news/cardiology/20230119/close-bp-monitoring-important-before-during-and-after-cancer-therapy
6. Onasanya A, Elshakankiri M. Smart integrated IoT healthcare system for cancer care. Wireless Networks 2021;27:4297-312.
7. Mourtzis D, Angelopoulos J, Panopoulos N, et al. A Smart IoT Platform for Oncology Patient Diagnosis based on AI: Towards the Human Digital Twin. Procedia CIRP 2021;104:1686-91.
8. Ahammed S, Hassan N, Cheragee SH, et al. An IoT-based Real-Time Remote Health Monitoring System. International Journal of Recent Engineering Science 2021;8:23-9.
9. Sriram A, Sekhar Reddy G, Anand Babu GL, et al. A Smart Solution for Cancer Patient Monitoring Based on Internet of Medical Things Using Machine Learning Approach. Evid Based Complement Alternat Med 2022;2022:2056807.
10. Mohammed T, Singh M, Tiu JG, et al. Etiology and management of hypertension in patients with cancer. Cardiooncology 2021;7:14.
11. Fraeman KH, Nordstrom BL, Luo W, et al. Incidence of new-onset hypertension in cancer patients: a retrospective cohort study. Int J Hypertens 2013;2013:379252.
12. Cohen JB, Geara AS, Hogan JJ, et al. Hypertension in Cancer Patients and Survivors: Epidemiology, Diagnosis, and Management. JACC CardioOncol 2019;1:238-51.
13. Meijers WC, de Boer RA. Common risk factors for heart failure and cancer. Cardiovasc Res 2019;115:844-53.
14. Souza VB, Silva EN, Ribeiro ML, et al. Hypertension in patients with cancer. Arq Bras Cardiol 2015;104:246-52.
15. Ruf R, Yarandi N, Ortiz-Melo DI, et al. Onco-hypertension: Overview of hypertension with anti-cancer agents. Journal of Onco-Nephrology 2021;5:57-69.

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