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IoT-Based Virtual Primary Clinic: Remote Patient Monitoring and Consultation System

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Abstract: *Using Internet of Things technology, the Virtual Primary Clinic project is a cutting-edge healthcare endeavor that enables remote patient monitoring and consultation. The project collects essential health metrics including body temperature, oxygen saturation, heartbeat, and ECG signals by integrating a variety of sensors, including NodeMCU ESP32, SpO2, DHT11, and AD8232 ECG. The information collected by these sensors is sent via API to a specially created website and an online platform called ThingSpeak. With features including patient registration, appointment scheduling, access to medical histories, and doctor-patient contact, the website acts as a comprehensive interface between patients and physicians. Patients can register on the website, provide their medical information, and get medications sent to them remotely based on their conditions. However, without having to see patients in person, doctors can examine patient data, diagnose ailments, and write prescriptions or offer medical advice.The Virtual Primary Clinic project intends to improve healthcare accessible, especially in remote or underserved locations, by enabling remote monitoring and consultation. In addition to providing healthcare providers with an effective platform for remote patient care, it gives patients the ability to take charge of their health. This project is a major step toward using cutting-edge IoT-based technologies to improve patient outcomes and democratize healthcare.*

Keywords: Remote healthcare, Remote Patient Monitoring, Healthcare Innovation, Consultation System, IoT (Internet of Things), Virtual Primary Clinic.

I. INTRODUCTION

Accessibility and affordability continue to be major obstacles in the Indian healthcare system, especially in rural or underdeveloped areas. The emergence of Internet of Things (IoT) technology offers a bright prospect to tackle these issues and transform the provision of primary healthcare services. In light of this, the Virtual Primary Clinic project stands out as a creative and timely solution that makes use of IoT technology to deliver remote patient monitoring and care.

In India, where access to medical services might occasionally be impeded by geographic constraints and the doctor-to-patient ratio is still relatively low, there is an urgent need for remote healthcare solutions. The latest numbers indicate that the paucity of over 2 million nurses and 600,000 doctors in India is exacerbating the already existent healthcare inequities. Furthermore, because fewer in-person medical consultations have occurred due to lockdowns and The COVID-19 pandemic has drawn attention to the importance of telehealth. In order to overcome these obstacles, the Virtual Primary Clinic project uses Internet of Things (IoT)-based sensors to remotely monitor vital health indicators like body temperature, heart rate, ECG, and SpO2. Utilizing NodeMCU ESP32, SpO2 sensor, DHT11 sensor, and AD8232 ECG sensor, among other technologies, the project provides a complete remote patient monitoring solution. The project's capabilities are further enhanced by the combination of the ThinkSpeak platform and Arduino IDE, which enables real-time data processing and display.

The project includes a web-based platform where patients may register, make appointments, and view their medical information in addition to its technical aspects. In a similar vein, physicians can register, authenticate themselves, and declare specializations, allowing patients and healthcare professionals to communicate easily.

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All things considered, the Virtual Primary Clinic project is a big step in the right direction toward solving India's healthcare problems, especially when it comes to remote patient care. This initiative has the potential to increase healthcare accessible, expand diagnostic capabilities, and ultimately save lives by utilizing the power of IoT technology.

II. LITERATURE REVIEW

1] Md. Ashiqur Rahman Emu and Wardah Saleh. "Heartbeat Sensor System for Remote Health Monitoring" in this paper author talks about a system for remotely monitoring a patient's heartbeat. The patient's heart rate is most likely determined by this system using a heartbeat sensor, which then sends the information to a distant location—possibly a clinic or hospital.

2] Björndell, Cajsa, and Åsa Premberg. "Physicians experiences of video consultation with patients at a public virtual primary care clinic: a qualitative interview study" in this paper, the author's objective is to explain what doctors saw when they saw new patients via video consultation in a publicly owned online primary care facility. Semi-structured individual interviews provided the data for this qualitative study, which was then analyzed using systematic text condensation.

3] Alshehri, M. A., L. K. Alsulaiman, et al. "Patients Satisfaction on Virtual Clinic in Primary Health Care Centers in Prince Sultan Military Medical City, 2020-2021: A Qualitative Study" in this paper, the author conducted thirty-six participants who specifically attended the virtual clinic at Prince Sultan Military Hospital in year 2020 were chosen for a semi-structured phone interview. The interviews were then transcribed and subjected to thematic analysis. Of these, 20 participants were male (55.5%), 16 were female (44.4%), 6 were older than or equal to 60 (16.6%), and 30 individuals were younger than or equal to 60 (83.3%).

4] Hull, S. A., V. Rajabzadeh, N. Thomas, et al. "Improving coding and primary care management for patients with chronic kidney disease: an observational controlled study in East London" in this paper, the author describes a cutting-edge community kidney service run by four regional clinical commissioning groups (CCGs) in east London and the renal department of Barts Health NHS Trust. A service delivery improvement impact study used quantitative data from a virtual CKD clinic and primary care electronic health records (EHRs) from 166 participating practices. Data from health professionals' surveys and interviews were utilized to investigate changes to working procedures.

5] Lu, Amy D., Elise Gunzburger, et al. "Impact of Longitudinal Virtual Primary Care on Diabetes Quality of Care" in this paper, the author's objective is to compare the treatment of diabetes before and after a long-term virtual primary care program is put into place. The design includes a propensity score-matched cohort study with analysis of differences. Diabetes patients treated in VA primary care clinics as part of the Virtual Integrated Multisite Patient Aligned Care Teams (V-IMPACT) program between January 2018 and December 2019.

6] Patrick Harnett, Matthew Jones, and others. " A virtual clinic to improve long-term outcomes in chronic kidney disease". The virtual CKD clinic (VC), which the author introduces in this research, is a novel monitoring system implemented at their institution. The VC is an online results review people with chronic kidney disease. They discovered that the VC was a useful surveillance tool. There was no need for emergency dialysis for any of the VC patients, indicating strong supervision. Patients with CKD who were released to primary care had comparable survival rates.

7] N. A. Abanemai, G. Alyobi, et al. "Patient Satisfaction with Virtual Care Compared to Clinic Visit among Diabetic Patients in Primary Care" in this study, the author assessed the degree of patient satisfaction among primary care diabetes patients receiving virtual care as opposed to in-person appointments. In the family and community department of Prince Sultan Military Medical City (PSMMC), Riyadh, Saudi Arabia, a primary health care centre hosted a cross-sectional study. In order to gauge patient satisfaction with virtual care as opposed to in-person visits, a set of 23 multiple-choice question was created for the questionnaire. The patient satisfaction with primary virtual care questionnaire's Cronbach's alpha was 0.856, indicating good reliability.

8] Benjamin Wall, Aidan Dunnill, Patrick Daly, et al. "Is Virtual Clinic the Way Forward: Patient Satisfaction Comparing Phone Clinic vs. Conventional Clinic" in order to create a call list of patients, the author of this research used a procedure that involved gathering a list of patients who Atten the outpatient orthopaedic telephone clinic at

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Rockingham General Hospital between March 23 and May 30. This list was then filter through a randomised generator. Patients were phoned and asked to verbally consent to taking part in a phone-based satisfaction survey.

9] Georgina Jones, Victoria Brennan and others. "Evaluating the impact of a 'virtual clinic'on patient experience, personal and provider costs of care in urinary incontinence: a randomised controlled trial" in this study, the author evaluates the effect of using a "virtual clinic" on patient experience and costs in the treatment of female urinary incontinence. Women over 18 years of age referred to the urogynecology department were randomly assigned to one of two clinics: (1) Standard Clinic or (2) Virtual Clinic. Before the meeting, both groups completed an interactive, web-based, validated patient-reported outcome (ePAQ-Pelvic Floor). This was followed by either a telephone consultation (Virtual clinic) or a personal consultation. The primary outcome was the mean "short-term outcome scale" of the Patient Experience Questionnaire (PEQ). The remaining measures of PEQ (communication, emotions and barriers), the Customer Satisfaction Questionnaire (CSQ), Short Form 12 (SF-12) and individual, social and NHS costs were examples of secondary outcome measures.

10] Richard H. Glazier, Michael E. et al." Do Incentive Payments Reward The Wrong Providers? A Study Of Primary Care Reform In Ontario, Canada" ,the purpose of this article was to examine how office-based and virtual primary care evolved in the early months of the pandemic in Ontario, Canada, and for which patients and physicians. This population-based study compared comprehensive composite billing data on physicians from January 1 to July 28, 2020, with the same time in 2019. During the study period, they identified Ontario residents who had at least one office visit or virtual visit (by phone or video). Adjusting for patient and provider characteristics, they compared trends in total physician visits, office visits, and virtual visits before COVID 19 to trends after pandemic-related public health interventions that changed care. Interrupted time series analysis was used for comparisons.

11] Damon Ramsey, John Ward, Michael Krausz, et al. "From Telehealth to an Interactive Virtual Clinic" , the author of this research proposed E-health for mental health clinics, based on enhancing web-based technology. They said that in order to increase accessibility and service quality, essential components of a virtual clinic should expand on the usage of mobile devices, video conferencing, mobile health (M-health), and patient communication in an integrated way. These features should be linked with other online technologies.

III. METHODOLOGY

The Virtual Primary Clinic project's approach consists of multiple crucial phases that are intended to accomplish efficient remote patient monitoring and healthcare administration. It starts with a detailed requirements analysis that takes into account the needs of stakeholders as well as technical requirements. Subsequently, appropriate hardware and software components are chosen according to compatibility and accuracy. After that, system architecture and design are created with user interfaces and communication protocols in mind to guarantee scalability and seamless integration. To make sure the system is reliable and useful, a prototype is created and put through a thorough testing process. In order to iteratively enhance and optimize the system, user feedback is requested.

Before a technology is put through pilot testing in actual healthcare settings, it is carefully assessed against predefined standards to establish its effect on remote patient care. This systematic approach guarantees comprehensiveness in the development and implementation of IoT-based solutions, facilitating the recognition and resolving of challenges while satisfying the needs of patients and healthcare providers in equal measure. These technologies seek to improve clinical decision-making, expedite workflows, and enable patients to actively participate in their care by methodically resolving interoperability, security, and regulatory issues. Ultimately, this should improve patient outcomes and healthcare delivery. Constant feedback loops guarantee flexibility and response to changing requirements, solidifying the system's efficacy and significance in the ever-changing context of remote patient care.

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IV. BLOCK DIAGRAM

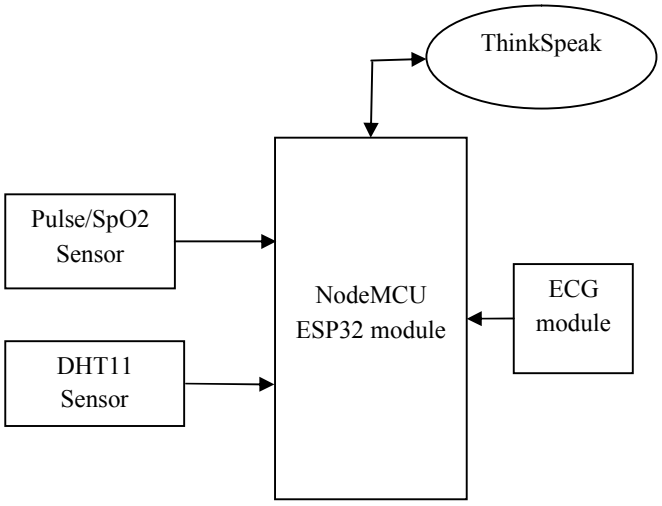

Fig.1. Block Diagram of Virtual Primary Clinic

V. DESCRIPTION

The microcontroller in the circuit diagram, the NodeMCU ESP32 module, is responsible for managing the operation of the Virtual Primary Clinic system. The SPO2 sensor, DHT11 sensor, and ECG sensor are the input devices that are attached to the NodeMCU ESP32 module. Vital health factors like body temperature, electrocardiogram (ECG) measurements, and blood oxygen saturation (SpO2) are recorded by these sensors. The data gathered from these sensors is processed by the NodeMCU ESP32 module, enabling real-time patient health state monitoring. With this configuration, various sensors can be seamlessly integrated into the Virtual Primary Clinic system, providing extensive remote patient monitoring capabilities.

VI. CIRCUIT DIAGRAM

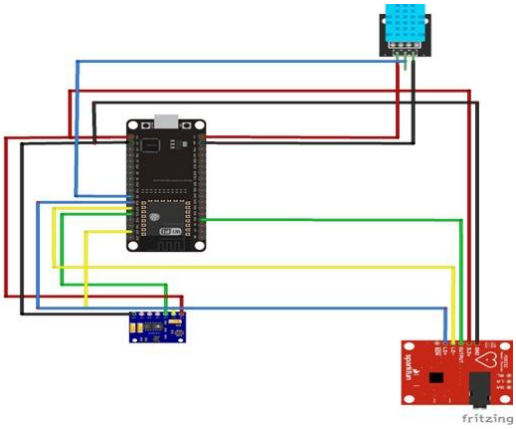

Fig. 2. Circuit Diagram of Virtual Primary Clinic

VII. WORKING

The paper title is “VIRTUAL PRIMARY CLINIC”. The Virtual Primary Clinic project's approach consists of multiple crucial phases that are intended to accomplish efficient remote patient monitoring and healthcare administration. It starts with a detailed requirements analysis that takes into account the needs of stakeholders as well as technical requirements. Subsequently, appropriate hardware and software components are chosen according to compatibility and

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accuracy. After that, system architecture and design are created with user interfaces and communication protocols in mind to guarantee scalability and seamless integration. To make sure the system is reliable and useful, a prototype is created and put through a thorough testing process. In order to iteratively enhance and optimize the system, user feedback is requested. In order to determine the system's effect on remote patient care, it is lastly evaluated based on predetermined standards and put into pilot testing in actual environments. This methodology guarantees a methodical approach to the creation and execution of the IoT-based solution, tackling obstacles and providing a solution that satisfies the requirements of healthcare providers as well as patients.

VIII. FLOWCHART

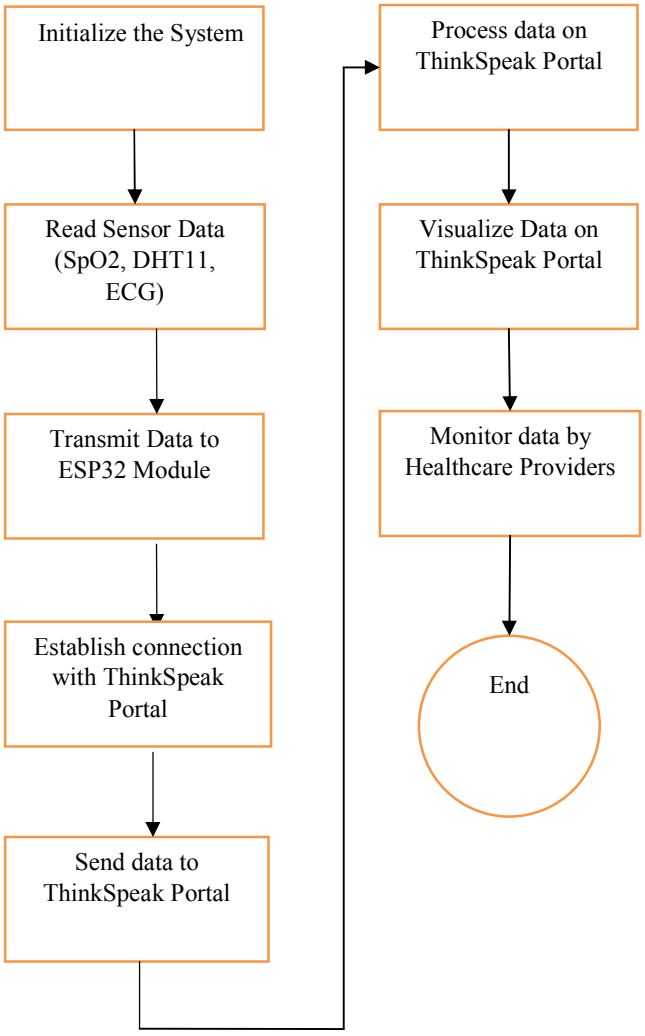

Fig 3.Flow Chart of Virtual Primary Clinic

IX. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

- NodeMCU ESP32 module
- SPO2 sensor
- DHT11 sensor
- ECG sensor

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SOFTWARE REQUIREMENT

- Arduino IDE
- Proteus
- ThingSpeak Application

These are the components and sensors that this project is using.

More sensors can be added to the system in accordance with the user's demand to examine other health-related parameters.

X. EXPERIMENTAL SETUP

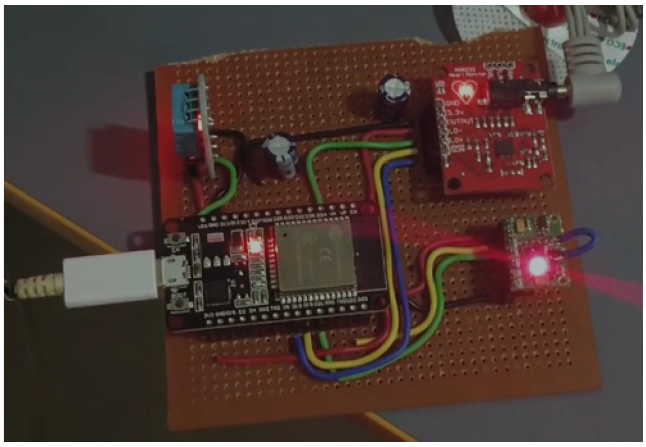

Fig. 4. Shows The Experimental Setup of The System

XI. RESULT

Promising outcomes were obtained from the deployment of the Virtual basic Clinic IoT system, which greatly improved the effectiveness and accessibility of basic healthcare delivery. Vital indicators, including body temperature, pulse rate, oxygen saturation, and ECG data, were continuously monitored by healthcare experts to provide them with real-time insights into the health status of their patients. The ThingSpeak portal's seamless data transfer and visualisation made proactive interventions possible, enabling quick responses to unusual readings and potential health problems. The common consensus is that a person's typical body temperature is 37°C or 98.6°F. A "normal" body temperature is defined as falling between 97°F (36.1°C) to 99°F (37.2°C), according to some study. A fever exceeding 100.4°F (38°C) is typically a sign of an infection or illness. An acceptable oxygen saturation level is between 96% to 99%, while an ideal heart rate is between 50 to 90 beats per minute (bpm). Even when they're in good health,some persons with lung diseases may have decreased oxygen levels.

In addition to improving patient outcomes, this increased monitoring and intervention enabled healthcare providers to provide individualized care that was catered to each patient's specific needs.

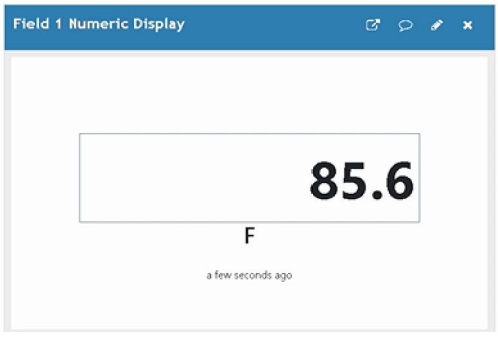

Fig.5. Shows The Temperature Output is 85.6 Fahrenheit.

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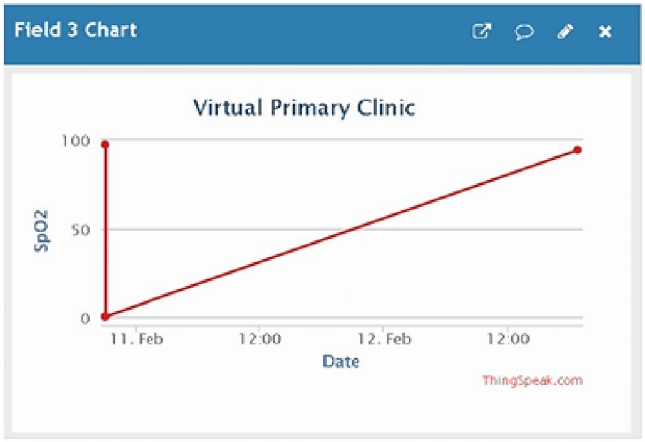

Fig. 6. Shows The SpO2 Output Graph

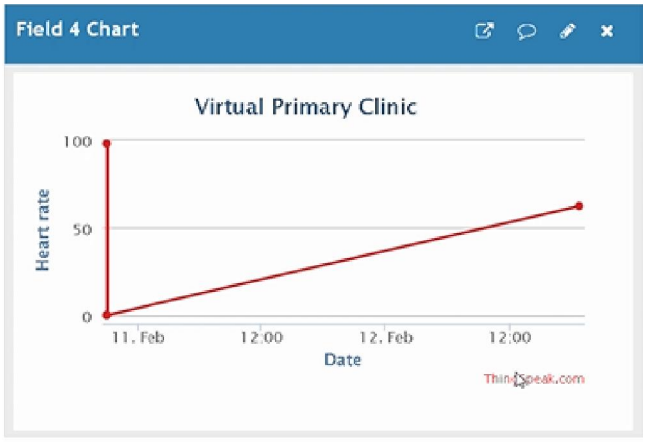

Fig.7. Shows The Heart Rate Graph According To Date

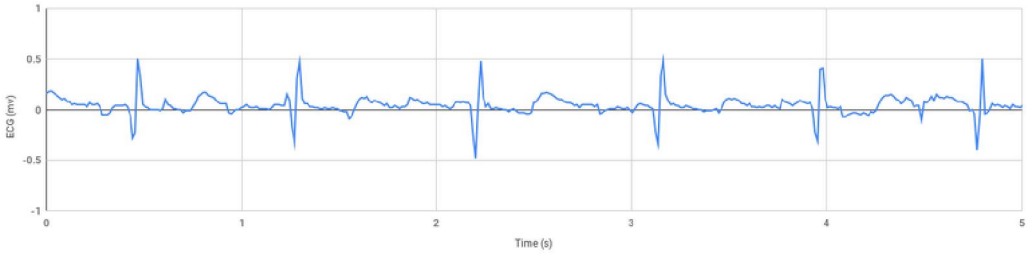

Fig.8. Shows The ECG Graph of Pulse Rate.

Overall, the project's successful implementation demonstrates the transformative potential of IoT technology in revolutionising primary healthcare delivery, fostering a future where quality healthcare is more accessible and effective than ever before.

XII. CONCLUSION

With its all-inclusive solution to close the communication gap between patients and healthcare providers, the Virtual Primary Clinic IoT system is a major advancement in healthcare technology. Real-time vital sign monitoring is made possible by this system's integration of sophisticated IoT modules and sensors, as well as its smooth data transmission to the cloud via the ThingSpeak site. This allows for proactive and customized care delivery.By empowering healthcare professionals with timely access to patient data, it enhances diagnostic capabilities, enables early detection of health issues, and facilitates informed decision-making. Furthermore, the system's ability to operate remotely fosters

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accessibility to healthcare services, particularly in underserved or remote areas. As technology continues to evolve, the Virtual Primary Clinic IoT system stands as a testament to the potential of innovation in revolutionising primary healthcare delivery, promising a future where quality healthcare is accessible to all, regardless of geographical barriers or resource constraints.

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