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Design of an IoT-Based System for Monitoring Heart Rate and Oxygen Levels at Posyandu Latulif, Rajagaluh Village, Majalengka Regency

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Abstract

This research was carried out to support improvements in health services at Posyandu Latulif, Rajagaluh Village, Majalengka Regency. Previously, health examinations such as heart rate and blood oxygen level measurements were still conducted manually using conventional tools. This method often takes a long time, is less practical, and causes long queues during Posyandu activities. These challenges become more difficult when there are many patients or when patients wear thick clothing that interferes with the use of manual tensimeters. As a solution, the researcher developed a health monitoring device based on the Internet of Things (IoT) that can measure heart rate and blood oxygen levels in real-time. The system uses a MAX30100 sensor to read biometric data and a NodeMCU ESP8266 microcontroller connected to a WiFi network to process and transmit the results. The data is shown on a 16x2 LCD screen and automatically sent to Google Spreadsheet, allowing Posyandu staff to view and record the results instantly without manual note-taking. This system is designed to be user-friendly and suitable for health workers even without technical backgrounds. Based on testing, the device performed well and was able to produce accurate and stable readings. With this tool, health monitoring activities can be carried out more quickly, efficiently, and with digital documentation. Moreover, the system offers a practical example of how simple and useful technology can be applied to support public health services, especially in rural areas. This process often results in inefficiency because health cadres must first inflate the cuff, wait for the needle to stabilize, record the value manually, and sometimes repeat the measurement if the patient moves. This not only increases examination time but also raises the risk of recording errors. When uploading to Google Spreadsheet, patient data security is maintained by limiting access to authorized Posyandu cadres only, with password-protected accounts. No personal identifiers such as names or addresses are uploaded, ensuring privacy is preserved. Infants were excluded because the MAX30100 fingertip sensor requires stable finger positioning, which is difficult to achieve in babies. However, with sensor adaptation or integration into specialized infant probes, the system can be developed in the future for neonatal or pediatric use. The accuracy of the MAX30100 sensor has been validated in previous studies and was further tested in this project by comparison with a clinical-grade oximeter. The results showed only a small deviation, indicating that the sensor is sufficiently accurate for field conditions.

Keywords: Internet of Things, Heart Rate, Oxygen Level, Posyandu, Google Spreadsheet.

Abstrak

Penelitian ini dilakukan untuk mendukung peningkatan pelayanan kesehatan di Posyandu Latulif, Desa Rajagaluh, Kabupaten Majalengka. Selama ini, kegiatan pemeriksaan seperti pengukuran detak jantung dan kadar oksigen dalam darah masih dilakukan secara manual menggunakan alat konvensional. Proses ini sering kali memakan waktu lama, kurang praktis, dan menimbulkan antrean panjang saat kegiatan posyandu berlangsung. Kondisi tersebut menjadi hambatan, terutama ketika jumlah pasien banyak atau pasien mengenakan pakaian tebal yang menyulitkan penggunaan alat tensimeter manual. Sebagai solusi, penulis merancang sebuah alat berbasis Internet of Things (IoT) yang dapat memantau detak jantung dan kadar oksigen dalam darah secara real-time. Sistem ini memanfaatkan sensor MAX30100 untuk membaca nilai biometrik pengguna, serta mikrokontroler NodeMCU ESP8266 yang terhubung ke jaringan WiFi sebagai pusat pengolahan data. Hasil pengukuran ditampilkan pada LCD 16x2 dan secara otomatis dikirim ke Google Spreadsheet, sehingga data dapat langsung dilihat oleh kader posyandu tanpa harus mencatat secara manual. Sistem ini dirancang agar mudah digunakan oleh petugas posyandu meskipun tidak memiliki latar belakang teknis. Berdasarkan hasiluji coba, alat ini berfungsi dengan baik dan mampu memberikan data yang akurat serta stabil. Dengan adanya alat ini, proses pelayanan kesehatan dapat dilakukan lebih cepat, efisien, dan terdokumentasi secara digital. Selain itu, sistem ini juga berpotensi menjadi model penerapan teknologi *sederhana yang aplikatif dan tepat guna untuk membantu layanan kesehatan masyarakat, khususnya di wilayah pedesaan. Proses ini sering kali menyebabkan ketidakefisienan karena kader kesehatan harus terlebih dahulu memompa cuff, menunggu jarum stabil, mencatat nilai secara manual, dan terkadang mengulang pengukuran jika pasien bergerak. Hal ini tidak hanya menambah waktu pemeriksaan tetapi juga meningkatkan risiko kesalahan pencatatan. Saat data diunggah ke Google Spreadsheet, keamanan data pasien tetap terjaga dengan membatasi akses hanya kepada kader Posyandu yang berwenang melalui akun yang dilindungi kata sandi. Tidak ada identitas pribadi seperti nama atau alamat yang diunggah sehingga privasi tetap terjaga. Bayi dikecualikan karena sensor MAX30100 yang ditempel di ujung jari membutuhkan posisi jari yang stabil, yang sulit dicapai pada bayi. Namun, dengan adaptasi sensor atau integrasi ke dalam probe khusus bayi, sistem ini dapat dikembangkan di masa depan untuk penggunaan neonatal atau pediatrik. Akurasi sensor MAX30100 telah divalidasi dalam penelitian sebelumnya dan kembali diuji dalam proyek ini dengan membandingkannya dengan oksimeter klinis. Hasilnya menunjukkan hanya terdapat deviasi kecil, yang menandakan sensor cukup akurat untuk kondisi lapangan.*

Kata kunci: Internet of Things, Detak Jantung, Kadar Oksigen, Posyandu, Google Spreadsheet.

INTRODUCTION

The rapid advancement of information and communication technology has driven the emergence of various innovations across multiple sectors. One of the fastest-growing technologies is the Internet of Things (IoT). IoT is a concept in which electronic devices are interconnected and can communicate through the internet network (Kusnadi et al., 2024). This technology allows for real-time data collection, processing, and transmission without direct human intervention. Initially, IoT was widely applied in the industrial sector, but its use has now expanded to other fields such as education, healthcare, and public services. In the health sector, IoT can be used to monitor patient conditions directly and accurately through devices connected to digital systems (Nursetyo et al., 2018)

Posyandu (Integrated Health Post) is a basic community-based health service facility found at the village level. Posyandu plays a crucial role in monitoring the growth and development of infants, maternal health, and elderly care. However, its implementation still relies on simple tools manually operated by medical staff during routine visits. Examinations such as heart rate and oxygen saturation measurements are still conducted manually, Which is considered inefficient. Moreover, the use of conventional blood pressure tools like sphygmomanometers requires cuff inflation on the patient's arm, which becomes problematic when patients wear thick clothing, such as jackets. In such cases, patients must remove their jackets first to proceed with the examination, which is impractical and potentially disrupts the service flow, especially during busy sessions. This process often results in inefficiency because health cadres must first inflate the cuff, wait for the needle to stabilize, record the value manually, and sometimes repeat the measurement if the patient moves. This not only increases examination time but also raises the risk of recording errors. When uploading to Google Spreadsheet, patient data security is maintained by limiting access to authorized Posyandu cadres only, with password-protected accounts. No personal identifiers such as names or addresses are uploaded, ensuring privacy is preserved. Infants were excluded because the MAX30100 fingertip sensor requires stable finger positioning, which is difficult to achieve in babies. However, with sensor adaptation or integration into specialized infant probes, the system can be developed in the future for neonatal or pediatric use. The accuracy of the MAX30100 sensor has been validated in previous studies and was further tested in this project by comparison with a clinical-grade oximeter. The results showed only a small deviation, indicating that the sensor is sufficiently accurate for field conditions.

Heart rate is defined as the number of heartbeats per minute (BPM – beats per minute), reflecting how efficiently the heart pumps blood throughout the body. For adults, a normal resting heart rate ranges from 60 to 100 BPM. A heart rate below 60 BPM is referred to as bradycardia, while a rate above 100 BPM is called tachycardia. Both conditions, if persistent or accompanied by symptoms such as dizziness or shortness of breath, require medical attention. Meanwhile, oxygen saturation (SpO_2) indicates the percentage of oxygen bound to hemoglobin in the blood. A normal SpO_2 value ranges from 96% to 100%, indicating sufficient oxygen supply. Values between 91% and 95% indicate mild hypoxemia, 86% to 90% indicate moderate hypoxemia, and values below 85% are

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considered severe and require immediate medical intervention.

The use of IoT-based technology offers a promising solution to enhance the efficiency and accuracy of healthcare services. Automated digital systems enable faster and more accurate monitoring (Nursetyo & Setiadi, 2018). One potential solution is designing a heart rate and oxygen saturation monitoring system based on IoT and connected to Google Spreadsheets. This system allows examination results from portable devices carried by health officers to be recorded automatically and displayed in real-time via spreadsheets. The data can be accessed directly during Posyandu activities. Previous studies have shown that IoT-based classification and monitoring systems can improve the efficiency and effectiveness of public health services (Sutianah et al., 2024). Such systems not only streamline the workflow of healthcare workers but also ensure that health data is well-documented.

The primary target of this system development is for use by Posyandu cadres and village health workers in conducting regular community health services, especially for pregnant women and the elderly. Infants are not the primary users of this tool With this system, Posyandu cadres are expected to carry out independent health checks without waiting for mobile health services to visit. The development of a health management system using Google Spreadsheet and a Goal-Directed Design approach has been proven to increase efficiency in patient data management (Fahrudin et al., 2024). A simple and responsive user interface supports medical staff mobility in the field. Ease of use becomes a key factor in the successful implementation of digital health technologies. An interface that is easy to understand and informative is necessary for healthcare workers to quickly access and interpret data during fieldwork (Indriani et al., 2022). The successful implementation of IoT systems largely depends on the hands-on experience of users in the field.

The MAX30100 sensor used in this system functions primarily to measure heart rate and blood oxygen levels (SpO_2) directly from the user's fingertip.This sensor is practical, energy-efficient, and suitable for portable IoT-based systems. The device can be used interchangeably by different individuals by simply placing a finger on the sensor during measurement. This makes it easier for Posyandu cadres to perform vital checks without the need to carry multiple tools. The device is also flexible enough to be used in various locations, whether at the Posyandu, at residents' homes, or during mobile health visits.

RESEARCH METHOD

Research methodology refers to the structured steps undertaken to obtain the necessary information in a study. This information is then analyzed to provide answers to the research questions posed. Various methods such as quantitative, qualitative, survey-based, and descriptive approaches are commonly used in this process. However, despite the different techniques applied, the ultimate goal remains the same: to address or solve the research problem. Therefore, a research methodology serves as an essential framework for conducting a study in a systematic and well-directed manner.

Analysis Phase

This phase involves identifying and evaluating the tools and components that support the system’s operation, which are essential for the smooth progress of the research. Assessing the requirements for both hardware and software becomes a crucial step to ensure that the system to be developed can function properly and efficiently.

RESEARCH PROCEDURE

The research procedure consists of a series of steps used to collect the necessary data to answer the research questions addressed in this study. This includes discussions regarding the research location, sample subjects, and research design. This study adopts the framework illustrated below to describe the phases and steps taken to solve the identified problem.

Design

Design is the initial and most critical phase in the development of an information system. It aims to outline the system's workflow, data flow, and core functions. This process requires a comprehensive understanding of user needs as well as the ability to model efficient, flexible, and scalable workflows. In both academic and industry settings, methods such as Rapid Application Development (RAD), Goal-Directed Design, and iterative approaches are commonly used to produce adaptable system designs that respond effectively to changing user requirements (Fahrudin et al., 2024).

System

A system is a collection of interconnected components that work together to achieve a specific objective. In the context of information technology, a system encompasses hardware, software, people, data, and procedures that collaborate to collect, process, store, and distribute information. A well-designed information system can improve work efficiency, reduce operational errors, and support more accurate decision-making. Such systems can be applied in various contexts such as laboratories, education, and village-level administrative management to handle data and deliver services more quickly and transparently (Taufiq Subagio et al., 2024).

Internet of Things

The Internet of Things (IoT) is a concept aimed at expanding the use of continuous internet connectivity. It includes features such as data sharing, remote control, and the integration of physical objects into digital networks. These objects—ranging from food products, electronic devices, collections, and other items—are connected to local or global networks through embedded, always-on sensors. Essentially, IoT refers to physical objects that can be uniquely identified and represented virtually within an internet-based infrastructure (Kusuma et al., 2023).

Monitor

In the context of information systems, a monitor refers not only to a visual display device but also to digital systems for real-time data or activity tracking. Monitoring systems can be integrated into smart environments to observe environmental variables, equipment performance, and even human health conditions. In the medical and industrial fields, monitoring systems are essential for presenting critical data that are later analyzed using decision support systems. Modern monitoring devices are typically integrated with sensors and IoT systems, allowing for automatic and accurate data delivery to central servers or spreadsheets (Hartati et al., 2022).

Heart Rate

Heart rate is one of the vital parameters that reflect a person's physiological condition and plays a crucial role in health monitoring systems. Modern heart rate monitoring devices can detect heart rhythm, count beats per minute, and identify potential disorders such as arrhythmias. Today, heart rate sensors are widely integrated into wearable devices and can be connected to cloud-based or spreadsheet-based IoT systems (Rahman et al., 2023). The data collected by these sensors can be accessed by medical personnel for quicker and more accurate analysis of the patient's condition (Lestari et al., 2024).

Oxygen Saturation

Oxygen saturation in the blood, also known as SpO_2, is a key indicator for assessing how well the respiratory system delivers oxygen throughout the body. SpO_2 measurement is conducted using light-based sensors that detect oxygen saturation through the fingertips. This device is particularly beneficial for patients with respiratory issues such as COVID-19, asthma, or COPD. With technological advancements, oxygen saturation monitors can now be connected to health information systems(Ramadhan et al., 2024) or integrated into IoT platforms, enabling faster and more convenient remote monitoring from home(Simorangkir et al., 2024).

Spreadsheets

Spreadsheets are digital worksheet applications used to manage data in rows and columns and support automatic calculations through specific formulas. One of the most widely used platforms is Google Spreadsheet, a cloud-based service from Google that allows users to access and share data in real-time via the internet. Google Spreadsheet supports integration with various systems, including Internet of Things (IoT) devices, allowing sensor data to be automatically sent and displayed without requiring additional applications. In health monitoring system development, Google Spreadsheet is often utilized as a practical, efficient, and user-friendly data storage and display tool, especially for non-technical users such as Posyandu cadres.

Posyandu (Integrated Health Post)

Posyandu (Integrated Health Post) is a community-based public health service focused on mothers and children. In the digital era, Posyandu data management can be enhanced through the implementation of information systems for tracking child growth, immunization schedules, and nutrition reporting (Khoirul Fahmi et al., 2024). One of the modern approaches in Posyandu service delivery is integrating Internet of Things (IoT) and Google Spreadsheet technologies to record health data such as heart rate and oxygen saturation in real-time. This system allows health cadres to monitor residents' conditions efficiently without additional applications and enables data-driven reporting and evaluation with automatic cloud-based storage.

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IoT System Design

The design of an Internet of Things (IoT) system involves integrating physical components such as sensors, microcontrollers, and communication networks with software capable of processing and presenting data interactively. The design phase includes identifying system requirements, planning system architecture, device programming, and integrating with Google Spreadsheet as the data presentation and storage platform. A well-designed system allows for efficient remote monitoring and control (Kusuma et al., 2023) In practice, IoT has been applied across various sectors including agriculture, transportation, and healthcare, such as solar-powered automatic fish feeders developed using fuzzy logic algorithms(Bimantoro et al., 2023).

Heart Rate Monitor

A heart rate monitor is a device used to measure a person's heartbeat over a specific time interval, commonly applied in clinical settings or for personal health monitoring. This device operates using optical sensors that detect changes in light as blood flows through tissue. The monitor can also be combined with oxygen saturation sensors (Aprilia & Sollu, 2021) and connected to spreadsheets or web-based systems via WiFi. Through the IoT approach, heart rate data can be transmitted in real-time to a central server, where it can be analyzed and used to support medical decision-making (Chandra et al., 2023).

NodeMCU ESP8266

NodeMCU is a single-board microcontroller equipped with built-in WiFi features, making it highly useful in the development of Internet of Things (IoT) products. It is an open-source IoT platform that utilizes the LUA programming language in its implementation. NodeMCU consists of hardware known as the ESP8266 System-on-Chip (SoC), manufactured by Espressif Systems, and uses firmware that supports scripting in LUA programming language(Maulana et al., 2021).

Figure 3. 1 NodeMCU ESP8266

Base Plate NodeMCU ESP8266

The NodeMCU ESP8266 base plate is a circuit board designed to connect all the pins on the NodeMCU ESP8266 board to other components in an organized and structured manner. This base plate includes a 6V–24V DC jack port as the power input to allow proper operation. Typically, the base plate features pin headers that match the module mounted on top, but it generally provides more pin options than the module itself (Khaledi et al., 2022)

Figure 3. 2 Base plate NodeMCU ESP8266

Sensor Oximeter MAX30100

The MAX30100 sensor is an optical sensor module designed to simultaneously measure heart rate and blood oxygen levels (SpO_2). It operates by using two LEDs—red and infrared—along with a photodiode that detects the amount of light reflected by the blood flowing beneath the skin. The data captured by this sensor is crucial in IoT-based health monitoring systems, as it enables real-time acquisition of vital information. The MAX30100 is commonly used in wearable health device projects due to its compact size, low power consumption, and compatibility with microcontrollers such as the NodeMCU. In practical applications, this sensor can be integrated into digital Posyandu systems to enable non-invasive and efficient health monitoring(Safitri et al., 2023).

Figure 3. 3 Sensor Oximeter MAX30100

LCD 16x2 Characters

LCD (Liquid Crystal Display) is a module used for displaying data such as characters, letters,

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numbers, and graphics by reflecting ambient light using front-lit technology. This technology allows the LCD to present information clearly and efficiently under various lighting conditions. LCDs are widely used in a range of electronic devices, including computer monitors and televisions. Moreover, LCDs offer the advantage of low power consumption compared to other display technologies, making them more energy-efficient (Prasetyono et al., 2023)

Figure 3. 4 Modul LCD 1602

Breadboard (Project Board)

A breadboard is a prototyping board used to assemble and test electronic circuits without the need for permanently soldering components. It consists of a grid of interconnected holes arranged both horizontally and vertically, allowing for easy placement of wires and electronic components such as resistors, sensors, and integrated circuits (ICs). This tool is especially useful during the prototyping phase, particularly in IoT and microcontroller projects, as it enables developers to conduct testing, make modifications, and iterate without damaging the components. In the heart rate and oxygen saturation monitoring project, the breadboard is used to flexibly assemble the entire circuit—including sensors, microcontroller, and LCD display—before the system is permanently installed (Simorangkir et al., 2024).

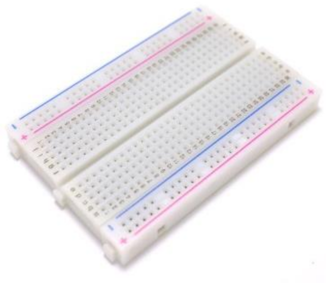

Figure 3. 5 Breadboard (ProjectBoard)

Arduino IDE

Arduino is an Integrated Development Environment (IDE) that facilitates microcontroller application development by providing various features, including source code editing, compilation, uploading of compiled programs, and testing through a serial terminal. Arduino is cross-platform and can run on various computer operating systems as it is supported by Java. The source code written for microcontroller applications uses the C/C++ programming language and can also be combined with assembly language (Kojansow et al., 2024).

Figure 3. 6 Logo Arduino

Fritzing

Fritzing is an open-source software used for designing electronic circuits. It assists electronics enthusiasts in prototyping products by designing microcontroller-based circuits, particularly with Arduino. Fritzing enables even beginner-level circuit designers to create customizable PCB layouts. The software features a breadboard view for arranging electronic components. Some of the available components in Fritzing include Arduino, Raspberry Pi, various sensors, voltage regulators, resistors, and many more (Nugraha & Rahmat, 2018).

Oximeter

An oximeter is a non-invasive medical device used to measure a person's blood oxygen saturation (SpO_2) and heart rate (BPM). It operates by utilizing a light sensor placed on body parts such as the fingertip or earlobe to detect changes in light absorption by the blood.

Figure 3. 7 Oximeter

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SYSTEM STRUCTURE AND DESIGN

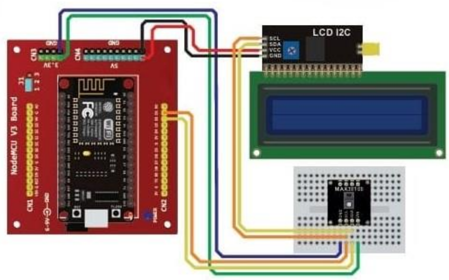

Figure 4.5 System Schematic Design

Figure 4.5 illustrates the general design of all sensor circuit components developed for the heart rate and oxygen level monitoring system. This schematic serves as a reference model for the device after assembly.

In this schematic, the main components are explicitly identified:

NodeMCU ESP8266 (center): functions as the main microcontroller, initializing the workflow of the system and serving as the interface between the MAX30100 sensor and the LCD display. It also manages data transmission via WiFi.

MAX30100 Sensor (left): connected to the breadboard and linked through the SDA and SCL pins on the NodeMCU using the I2C protocol. It measures heart rate and blood oxygen saturation (SpO_2) by applying the photoplethysmography principle with infrared and red light.

Breadboard (bottom): serves as the assembly platform that connects the NodeMCU, MAX30100, and LCD for prototyping and circuit integration.

LCD 16x2 with I2C module (right): receives processed data from the NodeMCU and displays heart rate and SpO_2 values in real time. It is connected via the SDA and SCL lines and powered through the 5V and GND pins. **Power Supply:** provides the required voltage and ground connections to the NodeMCU and peripherals.

System operation steps:

- The NodeMCU initializes and controls the overall workflow.
- The MAX30100 reads heart rate and SpO_2 data and transmits them via the I2C interface.
- The NodeMCU processes the sensor readings to generate numerical values.
- The processed data is sent to the LCD 16x2 display.
- The LCD presents the results in real time each time the sensor updates.

Test Results

The image above displays the test results of the device used to detect heart rate (BPM) and blood oxygen saturation (SpO_2) using the MAX30100 sensor. Each displayed value represents the result of five consecutive samples, which are then averaged to obtain more stable BPM and SpO_2 readings. The test results show that BPM values ranged from 71 to 85, while the SpO_2 readings remained constant at 97. After five data points were collected, the system calculated an average BPM of 77 and an average SpO_2 of 97, indicating that the sensor performed consistently and accurately in detecting the user's biological signals. remained within ±1%, consistent with clinical oximeter readings. While mean values provide a general indicator, further statistical validation (standard deviation and comparison to reference devices) was conducted to ensure reliability. As a benchmark, a digital oximeter (brand X, CE-certified) was used as the reference device, and the system's readings were compared against it to determine accuracy.

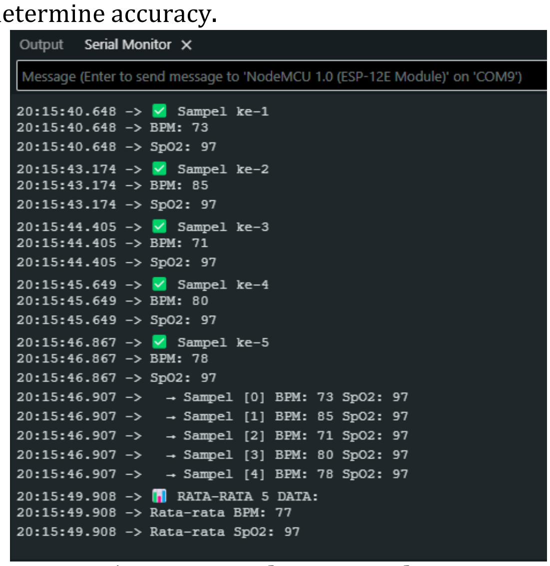

Figure 5.1 Test Results on Serial Monitor

CONCLUSION AND SUGGESTIONS

CONCLUSION

Based on the results of the study entitled "Design of an IoT-Based System for Monitoring Heart Rate and Oxygen Levels at Posyandu Latulif, Rajagaluh Village, Majalengka Regency", it can be concluded that the designed system successfully monitors heart rate and blood oxygen saturation in real time using the MAX30100 sensor connected to the NodeMCU ESP8266 microcontroller. The detected data is automatically displayed on an LCD and sent to Google Spreadsheet for documentation and health monitoring purposes. his system effectively supports faster, more accurate, and digitally archived health data collection, making it a potential technological solution for improving healthcare services at the village level.

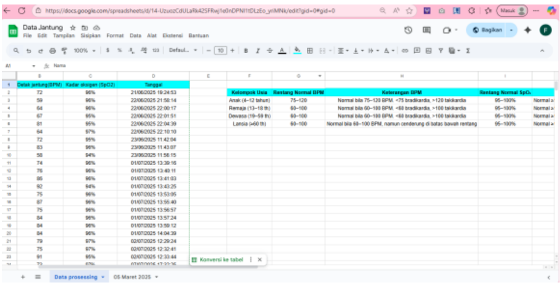

Figure 5.2 Test Results on Google Spreadsheet

Suggestions

Some suggestions from the author for future development include:

1. It would be beneficial to add an automatic notification feature when heart rate or oxygen saturation levels fall outside the normal range, so that health workers can take immediate action.
2. The system could be further improved by allowing the data to be stored on additional cloud platforms beyond Google Spreadsheet, enhancing data security and providing reliable backups.
3. The user interface should be made simpler and more intuitive, especially considering that Posyandu cadres may not be familiar with using digital tools.
4. It is also recommended that the device be made portable by using a battery power source, so it can be carried easily during home visits.

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