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Development IoT-based Infant Monitoring System for Preventing Sudden Infant Death Syndrome (SIDS) with Abnormal Condition Notifications and Lost Data Analysis

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ABSTRACT Sudden infant death syndrome or SIDS is the sudden death of a healthy baby under 1 year of age that occurs without any symptoms. It can be triggered by various factors, ranging from the baby's sleeping position to the baby's physical condition that has not reached a certain stage of development. Checking the baby's body temperature and heart rate is a very important element to monitor the baby's condition. In addition, checking body temperature and heart rate can also prevent febrile seizures that can cause epilepsy. Therefore, a tool is needed that can monitor the body temperature and heart rate of babies in real time and with an efficient mechanism. The purpose of this research is to conduct real-time monitoring with vital parameters of Respiration Rate using Piezo Electric sensor and heart rate monitoring using MAX30100 sensor. This research method is the design of a respiration and heart rate monitoring tool using piezoelectric sensors and ESP 32. The measurement results show that the largest difference value with the comparison tool is 28.74% and the smallest is 0.00%. suggestions and recommendations in this study on the right sensor placement so that effective results are obtained and the output results can be accessed via the website by doctors and other health workers and the existence of telegram notifications if conditions are abnormal so as to prevent SIDS..

INDEX TERMS SIDS,Apnea, Heart Rate, IoT

I. INTRODUCTION

One of the sensors that is widely used for newborns has a high risk of death. This is because newborns have difficulty adapting to life outside the womb which is a result of the immaturity of the body's organ systems. Suddeninfant death syndrome (SIDS) is death in healthy newborns, death usually occurs during sleep. Based on data from around the world, SIDS has the highest mortality rate among all causes of infant death during sleep. This value varies between 0.5 and 2 per thousand infants in some data between 1990 and 2015[1][2][3][4]. Although not yet known, SIDS (Sudden Infant Death Syndrome) is associated with abnormalities in the infant's brain that controls breathing upon awakening from sleep[5][6][7][8]. Sleep apnea is an abnormal sleep condition that occurs when breathing stops actively and repeatedly without realizing it and disrupts the breathing cycle during sleep. This disorder can cause a lack of oxygen intake to the brain and other body organs so that it can cause death in infants with SIDS[9][10][11]. Diagnosis of sleep apnea is a challenge in the medical world, besides the cost of expensive equipment, the limitations of existing tools, the diagnosis is quite complicated to be carried out personally by ordinary people in their respective homes, especially when applied to infants. Heart rate is also a vital sign that must always be monitored to determine the health condition of the baby, especially to prevent the occurrence of SIDS in infants[12][13][14]. Based on this, continuous monitoring of apnea and baby's heart rate is important. In this study, a monitoring tool for apnea and baby's heart rate will be designed to prevent Sudden Infant Death Syndrome (SIDS) which is equipped with a notification or notification to health workers when the baby has abnormal conditions[15][16][17].

The purpose of this research is to conduct real-time monitoring with vital parameters of Respiration Rate using Piezo Electric sensor and heart rate monitoring using MAX30100 sensor. The results of some of these studies are expected to facilitate researchers in designing apnea and heart rate monitoring tools using Piezoelectric sensors, and Internet of Things-based GY-MAX 30100 sensors with email notifications when apnea and heart rate abnormalities occur in infants and can facilitate officers in monitoring apnea and heart rate in infants in real time. Furthermore, data loss analysis will be carried out when abnormal conditions occur in the baby's condition . It is hoped that with this research, it can help health facilities in knowing the condition of apnea and heart rate of babies effectively and efficiently [18][19][20]. Therefore, researchers will make apnea and heart monitoring with abnormal notifications based on the internet of things[21][22].

II. METHODS

Data transfer requires a data processing unit. This unit must be programmable taking into account several criteria such as portability, effectiveness and compatibility [23]. Internet of things (IoT) includes autonomous devices that are proficient in censorship and data processing[24]. The use of IoT continues to increase, Gartner (2014) estimates that IoT will reach 26 billion units by 2020[25]. In general, the data transmission design is divided into 2, namely the transmitter which contains a circuit that processes sensor readings and sends it to the receiver. And a receiver that functions as a receiver and data processor to be displayed to users or stored in a database [26][27].

The interface model for viewing data that has been transferred using HTTP can be seen in FIGURE 1.

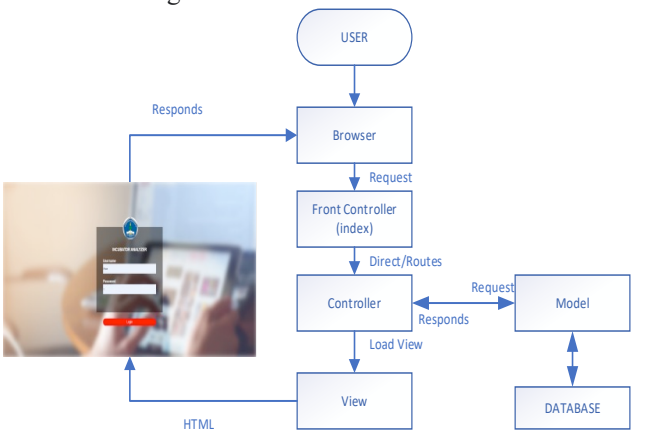

FIGURE 1. The diagram block of the system

FIGURE 1 explains that once the data is received by the server, it is stored in the database. Then, the user can access the menu through the browser. The browser will display the display according to the user's request. There are several important stages in developing a data monitoring application, the first of which is

1. Planning stage The system development strategy at this stage includes planning interface procedures, completion on request and communication between devices.[28]
2. Design Stage. Where the flow and user needs are adjusted.
3. Coding Stage. Coding must have a good structure so that it is easier to trace if an error occurs The testing stage is carried out to test whether the software is functioning properly and immediately make corrections to errors found during testing
4. The final stage is the delivery of the programme to the user.

III. RESULT

The purpose of this research is to conduct real-time monitoring with vital parameters Respiration Rate using Piezo Electric sensor and heart rate monitoring using MAX30100 sensor. In this case, MAX30100 temperature sensor to detect Heart Rate and Piezoelectric to detect Respiraton Rate. Data collection was performed on simulated adult subjects because the design of the sensor and module was made for use by adult and infant patients. In **TABLE 1** and **TABLE 2** there are data collection of RR and HR values in patient A (Male age 22 years), **TABLE 3** and **TABLE 4** are patient B (Male age 21 years), data collection was carried out 20 times for each patient.

TABLE 1
Measurement of RR of Patient A

No	Time (second)	RR (breaths per minute)
1	18:20:14	15
2	18:20:18	15
3	18:20:22	15
4	18:20:26	14
5	18:20:30	14
6	18:20:35	14
7	18:20:39	14
8	18:20:43	14
9	18:20:48	14
10	18:20:52	14
11	18:20:56	14
12	18:21:01	14
13	18:21:05	13
14	18:21:10	13
15	18:21:14	13
16	18:21:18	12
17	18:21:23	12
18	18:21:27	12

19	18:21:31	14
20	18:21:35	14

The measured data will then be displayed on the website to make it easier for users to monitor the patient's condition, if needed data with more analysis can be downloaded in excel form as shown in **FIGURE 2**

No	Time	RR
1	18:20:14	15
2	18:20:18	15
3	18:20:22	15
4	18:20:26	14
5	18:20:30	14
6	18:20:35	14
7	18:20:39	14
8	18:20:43	14
9	18:20:48	14
10	18:20:52	14

FIGURE 2. Data Display On Website (Patient A)

TABLE 2
Comparison of Measurement Error HR between Modul with Tool (Fingertip Oxymetri) Patient A

Measurement	Heart Rate (pulse per minute)	Oxymetri (pulse per minute)	Error Percentage
1	79	88	10.23%
2	92	88	4.55%
3	89	88	1.14%
4	88	88	0.00%
5	86	88	2.27%
6	87	88	1.14%
7	82	89	7.87%
8	88	89	1.12%
9	88	89	1.12%
10	87	89	2.25%
11	86	91	5.49%
12	86	91	5.49%
13	86	91	5.49%
14	86	91	5.49%
15	87	91	4.40%
16	87	91	4.40%
17	85	91	6.59%
18	86	90	4.44%
19	86	90	4.44%
20	87	90	3.33%

In **FIGURE 2** and **TABLE 2** based on the results of comparisons using fingetipoxymetri there are differences or differences in the measurement results. The biggest difference value is 10.23% HR value and the smallest value is 0.00% HR value.

Respiration measurement is done by tapping the movement of the abdomen or abdomen during the inspiratory and expiratory phases. And for Heart Rate with finger sensor[9].

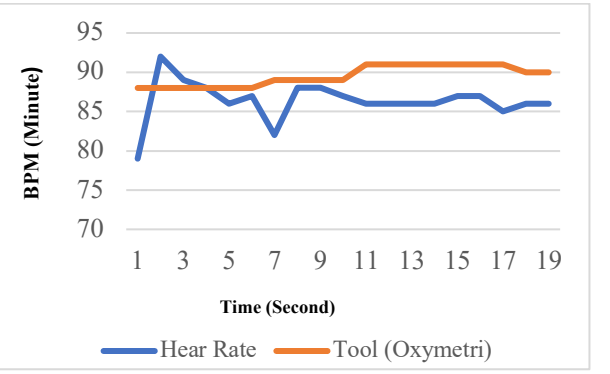

FIGURE 3. Chart of Comparison HR Modul with Tool (Fingertip Oxymetri) of Patient A

TABLE 3
Measurement of RR of Patient B

No	Time (second)	RR (breaths per minute)
1	19:45:30	17
2	19:45:35	17
4	19:45:43	18
5	19:45:48	18
6	19:45:52	14
7	19:45:56	14
8	19:46:01	14
9	19:46:05	13
10	19:46:10	13

11	19:46:14	17
12	19:46:18	17
13	19:46:23	17
14	19:46:27	14
15	19:46:31	14
16	19:46:35	14
17	19:46:40	14
18	19:46:44	14
19	19:46:48	14
20	19:46:58	13

TABLE 4
Comparison of Measurement Error HR between Modul with Tool (Fingertip Oxymetri) Patient B

Measurement	HR (pulse per minute)	Oxymetri (pulse per minute)	Error Percentage
1	88	86	2.33%
2	81	86	5.81%
3	80	86	6.98%
4	86	86	0.00%
5	62	86	27.91%
6	83	86	3.49%
7	82	86	4.65%
8	85	86	1.16%
9	86	86	0.00%
10	62	86	27.91%
11	82	86	4.65%
12	63	86	26.74%
13	92	87	5.75%
14	81	87	6.90%
15	86	87	1.15%
16	86	87	1.15%
17	62	87	28.74%
s18	87	86	1.16%
19	81	86	5.81%
20	63	86	26.74%

1	20:01:28	13
2	20:01:33	26
3	20:01:38	26
4	20:01:45	18
5	20:01:49	34
6	20:01:55	27
7	20:02:02	27
8	20:02:08	62
9	20:02:15	29
10	20:02:21	28
11	20:02:27	28

FIGURE 4. Data of RR Abnormal Display on Website

1	19:45:30	17
2	19:45:35	17
3	19:45:39	18
4	19:45:43	18
5	19:45:48	18
6	19:45:52	14
7	19:45:56	14
8	19:46:01	14
9	19:46:05	13
10	19:46:10	13

FIGURE 5. Data Display On Website (Patient B)

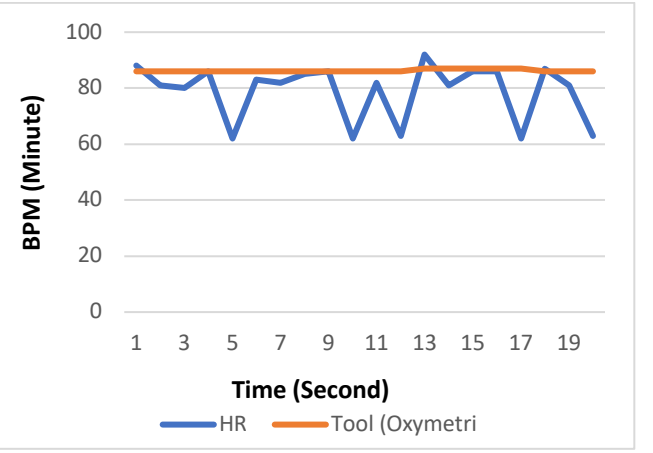

FIGURE 6. Chart of Comparison HR Modul with Tool (Fingertip Oxymetri) of Patient B

In FIGURE 6 and TABLE 4 Patient B based on the results of comparison using fingertip oximetry there are differences or differences in measurement results. The value of the largest difference is 28.74% of HR values and the smallest obtained is 0.00% HR values. This difference value is obtained because there are still external factors that affect the measurement results, such as the location of the sensor at the time of measurement, and the respondent's breathing is not always stable.

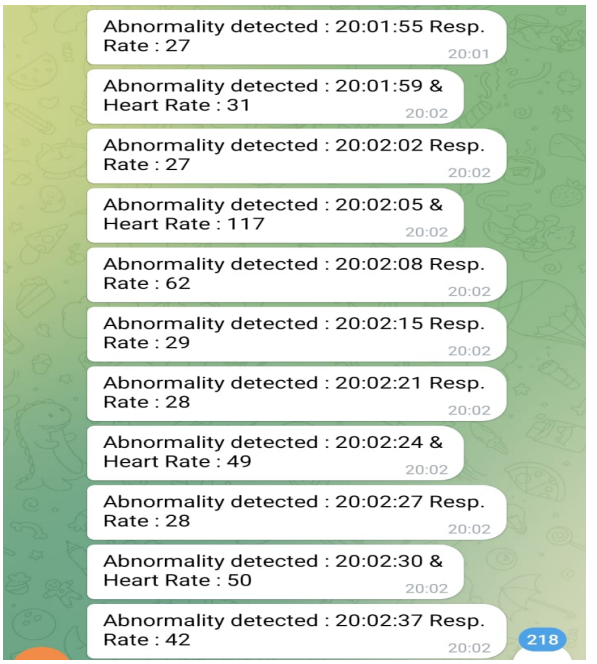

FIGURE 7. Notification of HR Abnormal and RR Abnormal Display on Telegram

FIGURES 7 show RR and HR data with abnormal counts with reference to normal and abnormal data. Adult respiratory rate 12 – 20 is abnormal less than 12 and more than 20. In adult heart rate is 60-100 BPM, so the abnormal value is less than 60 and over 100.

So that the notification value appears on the telegram when the patient's RR and HR values exceed the normal range, there is data loss between the data display on the website and the notification that appears due to excessive patient movement or the sensor is not suitable (too tight or too far apart).

I V. DISCUSSION

Understanding the signs of an infant emergency is very important. Some infants can have signs of an emergency that indicate a very serious problem and the infant can die within minutes if not treated immediately. One of the signs of an emergency is abnormal heartbeat and breathing in infants*[8]*[29]. The purpose of this research is to conduct real-time monitoring with vital parameters of Respiration Rate using Piezo Electric sensor and heart rate monitoring using MAX30100 sensor.

In 2014, Sanjay Kumar conducted research on the diagnosis of heart rate and Sp/02 saturation levels based on IoT with an oxygen level measuring sensor and a pulse measuring sensor (MAX30100) that provides accurate readings with BLYNK or Thinkspeak mobile applications [12]. Furthermore, by Ulil Albhi Ramadhani, at all (2021) about monitoring breathing signals in real time using piezoelectrics and ESP32 microcontrollers as signal processors which are then sent to android devices using a Bluetooth network.[30] In many cases, nurses cannot provide information to all doctors in a timely manner so that patients cannot immediately get the right treatment *[14]* as well as research on respiration rates *[15]*. In 2020, Muhammad Fuad Nurillah conducted research on internet of things-based apnea monitoring. The test results in this study are that the device can transmit data properly and without data loss with a distance of 5 metres in one room and 10 metres in a different room [10]. In 2021, Martin Clinton Tosima Manullang conducted research on the implementation of a respiration rate counter on a polysomnography system. Apart from the high cost of equipment, the limitations of existing tools, diagnosis is quite complicated to be carried out personally by ordinary people in their respective homes. Based on the measurements taken, the accuracy achieved is above 93% [11]. Based on analysis of the measurement data obtained, the respiration rate and heart rate of patients A and patient B that have been carried out will then be analyzed based on the set points that are said to be normal when RR is 16-20 per minute and HR is 70-80 per minute. Furthermore, if the RR and HR values are detected outside the range, a telegram notification will appear in the range of these conditions. In these measurements there is an analysis of data loss because the sensor is not suitable (too tight or too far apart) and also program overloading.

V. CONCLUSION

Based on the results of module development and literature studies, tool testing and data collection, it can be concluded that an apnea and heart rate monitoring tool with notification of abnormal conditions to prevent sudden infant death syndrome is based on IoT with a sensor accuracy value of 28.74%. and the data obtained can be analyzed, namely data loss occurs, this is because reading the Arduino program works in a loop from the top line to the bottom line. And on the data transmission program. Arduino will send data to IoT and not take measurements. So that there is loss of measurement data due to program delays caused by signals or limitations of the IoT platform. In the future, it is necessary to develop a more efficient sensor (belt) modification tool to minimize baby movement and replace the microcontroller with the principle of multitasking program reading so that it continues to read (measure) data without being interrupted by the internet.

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