Smart System for Early Diagnosis of Gastroesophageal Reflux Disease (GERD)

Rika Rokhana[1], Agrippina Waya Rahmaning Gusti[1*], and Rizki Umar Salim[1]

[1]Department of Electrical Engineering, Politeknik Elektronika Negeri Surabaya, Surabaya, Indonesia

[*]Email: agrippina@pens.ac.id

Received on 25-09-2025 | Revised on 17-11-2025 | Accepted on 17-12-2025

Abstract—**Gastroesophageal Reflux Disease (GERD) occurs when gastric contents reflux into the esophagus, yet early diagnosis remains limited due to the lack of accessible screening tools. This limitation contributes to reduced public awareness and delays in seeking appropriate medical evaluation. To address this problem, this study aims to develop an intelligent system capable of supporting early GERD diagnosis. The proposed system evaluates stomach acid levels through saliva pH measurement and incorporates symptom assessment using the GERD-Q questionnaire, which is widely adopted by internist physicians as a clinical screening instrument. Additional variables—including lifestyle factors, age, height, and weight—are integrated into a logistic regression model to estimate the probability of GERD. The pH sensor demonstrates an accuracy of approximately 99,25%. Future studies will focus on validating the sensor data against patient medical records and comparing the system's diagnostic performance with standard clinical examinations conducted by healthcare professionals**.

Keywords: Gastroesophageal Reflux Disease, Internet of Things, Non-invasive, pH sensor

I. INTRODUCTION

Gerd is prevalent worldwide, with varying rates across regions. In North America, it affects 18,1%–27,85% of the population, while in Europe, the prevalence ranges from 8,8%–25,9%. East Asia reports lower rates, between 2,5% and 7,8%, and Australia stands at 11,6%. However, Indonesia has a higher prevalence at 27,4%, surpassing even East Asia [1]. GERD is characterized by the reflux of gastric contents into the esophagus, leading to bothersome symptoms and potential complications [2]. These symptoms commonly include heartburn (a burning sensation in the chest) and regurgitation (stomach contents rising to the mouth), often accompanied by bloating, nausea, chronic cough, hoarseness, dental cavities, and nighttime asthma. The rise in GERD cases in Indonesia is attributed to unhealthy lifestyles. Despite incomplete epidemiological data in the country, healthcare professionals emphasize the importance of promptly seeking treatment upon experiencing GERD symptoms. This may involve consulting the nearest health facility for proper diagnosis and management.

Diagnosis of GERD can be made based on empirical therapy, the use of endoscopy, ambulatory reflux monitoring, and esophageal manometry. In diagnosing GERD, the doctor will examine the classic symptoms based on the results of the history taking and questionnaire filling and the results of proton pump inhibitor (PPI) therapy tests. In addition, the classic symptoms of GERD can also be assessed using the Gastroesophageal Reflux Disease Questionnaire (GERD-Q). Furthermore, the doctor will confirm the suspicion of GERD through several follow-up examinations, such as esophageal and gastric endoscopy. Endoscopy is a medical procedure that uses an instrument called an endoscope to examine the digestive tract, especially the esophagus, stomach, and upper part of the small intestine. This process allows the doctor to directly see the state of the esophagus and stomach [2].

Although endoscopy is the best method for diagnosis, it also has the disadvantage of being an invasive procedure, as it involves inserting instruments into the patient's body. Some people may feel uncomfortable or anxious during this procedure. Additionally, the cost of endoscopy is relatively high compared to other diagnostic methods. The cost of endoscopy includes the cost of equipment, anesthesia, and the honorarium of the doctor performing the procedure. This makes endoscopy a less affordable option for some individuals, especially if they have no health insurance or limited insurance coverage.

An early diagnosis tool for detecting stomach acid using a pH sensor has been previously studied by Karolin et al. in 2021. In this study, the measurement of gastric acid in the saliva of cancer patients was carried out, which is expected to help in confirming the diagnosis and supporting treatment related to cancer [3]. In 2022, similar research was also conducted by Taufan and Dwiki. Their GERD Acid Detector (GACOR) tool also aimed to measure stomach acid levels through pH measurements in salivary fluid [4]. However, these previous studies still had shortcomings, as the prototype made was not portable and had not been directly integrated into a website to facilitate medical personnel in inputting the medical records of GERD patient examinations.

Based on this background, this research aims to create a Smart System for Early Diagnosis of Acid Reflux Disease (GERD) Non-invasively through Saliva pH Monitoring and GERD-Q Questionnaire, based on the Internet of Things. The system will work by measuring the pH of stomach acid through saliva. It will combine the results of salivary pH monitoring and the GERD-Q questionnaire filled out by the patient to produce an early detection decision on whether the patient has GERD or not, through logistic regression calculations. Additionally, this system will be made portable and integrated into a website, allowing the examinations carried out using this system to be recorded on the website, making it easier for doctors to track the examination status of GERD patients.

II. METHOD

A. System Design

The system design stage includes the process of designing hardware, mechanical programming of the tool to be made. In this stage, the design of the working system of the tool to be made is carried out. There are several components used such as sensors, actuators, voltage sources, and microcontrollers (Figure 1).

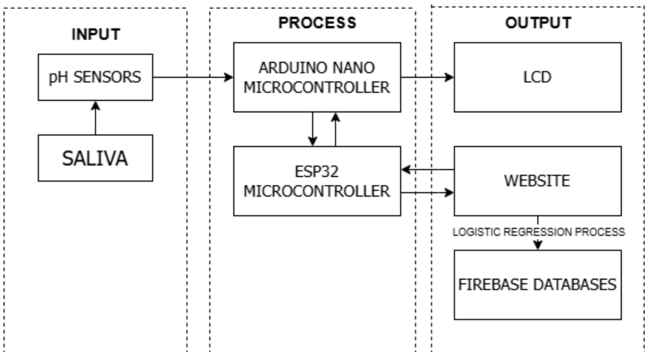

Figure 1. Block Diagram of the GERD Early Diagnosis System

The Figure 1 above illustrates the components including sensors, actuators, voltage sources, and microcontrollers for non-invasive pH monitoring and IoT integration.

B. Hardware Mechanical Design

This mechanical packaging system aims to enhance its aesthetic appeal by carefully determining the dimensions and sizes of each part. These adjustments prioritize user comfort and flexibility. The system's portability and lightweight design are key features of this research. To accommodate saliva samples, a beaker glass is utilized. A sensor is inserted into the beaker to measure the acidity level of the saliva (Figure 2).

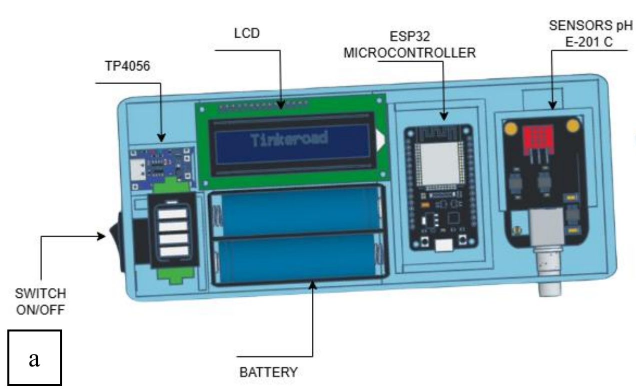

Figure 2. (a) Mechanical design of the portable GERD diagnostic device with ergonomic features for user comfort; (b) Detailed mechanical system incorporating a beaker glass for saliva samples and sensor insertion for pH measurement (units in cm)

C. IoT System Design

The existence of IoT in this system takes the form of a website for processing data from sensors and questionnaire assessments. This website also serves to display the results of patient examination procedures and medical record data.

D. Website System Design

This website system utilizes the Vue.js framework for its design and Firebase for data storage. The system is designed for monitoring purposes by both doctors and patients. Doctors can access all registered patient data, while patients can use the website to monitor their test results. The initial design includes a login page and a registration page. Data stored on the website can be viewed in the Firebase database. Both doctors and patients need to register an account to access the website. The activity diagram for the IoT-based website system, showing user roles (doctors and patients), login/registration processes, and data access functionalities is provided in Figure 3.

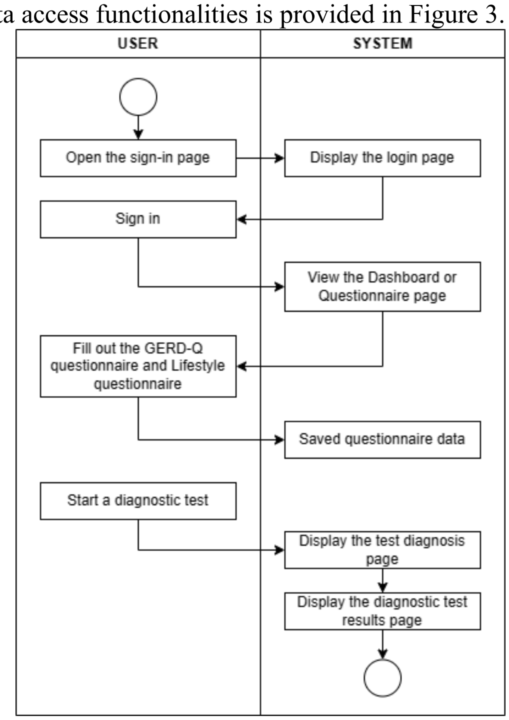

Figure 3. Activity Diagram for the IoT-Based Website System

E. Flowchart System

At this stage of the system flowchart, the process initiates with a "Start" point. A program typically consists of a "setup" function and a "loop" function. The "setup" function initializes variables, such as the pH level and establishes a Wi-Fi connection. The "loop" function, often implemented as while (1) for continuous operation, includes a core process flow. The program starts by requesting information from a questionnaire, including the user's name and other relevant parameters. Upon receiving this information, the program prompts for a sample to be taken. Following the sample request, the program proceeds to a pH sampling condition. It then presents a question to the user, asking if the sampling was successful. The corresponding response is displayed on the OLED screen. The program subsequently asks again if the sampling is appropriate. If the user confirms the appropriateness with a "Y", the data is uploaded to a designated website, allowing access to the processed results by both doctors and patients. If the user indicates inappropriateness with an "N", the program returns to the while (1) loop and repeats the sampling process until a "Y" confirmation is received. The system flowchart is illustrated in Figure 4 below.

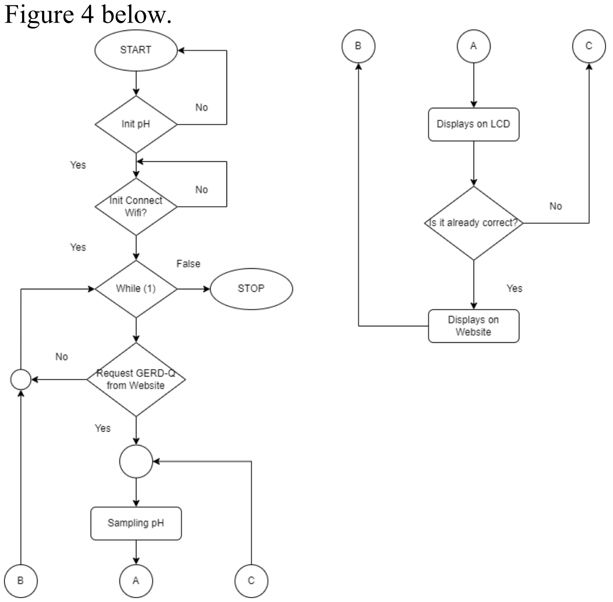

Figure 4. Flowchart of the system operation, detailing the loop for questionnaire input, pH sampling, user confirmation, and data upload to the website.

F. Design of Logistic Regression Method

At this stage, logistic regression is applied to determine the results of the data collection. This analysis was conducted after obtaining the values from each experiment's sensor data retrieval and GERD-Q questionnaire completion.

This tool requires processing data from every procedure performed to determine the likelihood of subjects achieving high GERD-Q scores, considering the influence on salivary fluid measurement results. Data collected using JupyterLab Portable is used to calculate the class probabilities using (1) below:

$$Y = \frac{exp^{\beta 0+\beta 1\ X1+\ \beta 2\ X2+\ldots+\ \beta 7\ X7}}{1+\ exp^{\beta 0+\beta 1\ X1+\ \beta 2\ X2+\ldots+\ \beta 7\ X7}} \qquad (1)$$

Equation (1) is the general form of the logit function in logistic regression, where Y is the probability of occurrence of the dependent variable. β1, β2,..., β7 are regression coefficients. X1, X2, ... X7 are independent variables. Here are the details for X1 to X7: X1 = pH value, X2 = Age, X3 = Gender, X4 = Body Height, X5 = Weight Loss, X6 = Gerd-Q values, X7 = Lifestyle value.

This formula predicts the probability of a patient developing GERD based on the values of the specified variables. The value of Y ranges from 0 to 1, where 0 indicates the patient is not at risk of developing GERD, and 1 signifies a high risk. The regression coefficients, β1, β2, ..., β7, represent the influence of each variable on the probability of GERD development. A positive β value signifies that as the variable's value increases, the probability of developing GERD also increases. Conversely, a lower variable value corresponds to a lower probability of GERD development.

The calculation results using equation (1) provide a conclusion regarding the likelihood of GERD in patients, where a predictive value of the new coefficient greater than 0,5 indicates that the patient is potentially affected by GERD, while a predictive value of 0,5 or below suggests that the patient is not likely to develop GERD. The threshold of 0,5 for classifying patients as having GERD or being healthy in the logistic regression method is determined by fitting the logistic regression model. This threshold value represents the probability predicted by the model for a patient having GERD.

G. Sensor Calibration

E-201C pH sensor calibration is the process of adjusting the sensor reading to match the actual pH value of the measured solution. Calibration should be performed periodically to ensure accurate pH measurement results. The E-201C pH sensor utilizes two pH standard solutions for calibration: a pH 4 solution and a pH 7 solution to ensure accurate voltage-to-pH conversion. A pH 4 solution represents an acidic solution, while a pH 7 solution represents a neutral solution. The flowchart for E-201C pH sensor calibration can be seen in Figure 5.

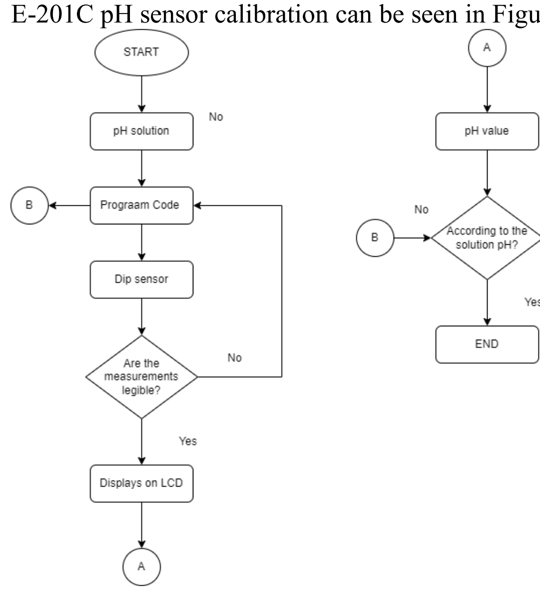

Figure 5. Flowchart for E-201C pH sensor calibration

H. Sensor Sterilization

After using the sensor and retrieving the data, the following sterilization procedure should be followed: first, rinse the sensor with clean water, then soak it in a 70% ethanol solution for 15 minutes. After soaking, remove the sensor and rinse it thoroughly with clean water, and finally dry it with a clean cloth. This sterilization process using 70% ethanol effectively kills bacteria and viruses on the sensor surface, and 70% ethanol was chosen because it is effective against microorganisms without damaging the sensor.

I. Data Acquisition and Sensor Sensitivity

To ensure variability, the dataset was gathered from ten willing participants (five males and five females ages 19 to 53) representing diverse age groups and lifestyle backgrounds. The calibrated E-201C pH sensor was placed into a beaker containing saliva samples to measure salivary pH non-invasively. After completing the lifestyle survey and GERD-Q questionnaire, participants underwent anthropometric measurements, including weight and height. The data acquisition process involved rinsing the mouth with water, collecting five to ten milliliters of saliva into a beaker and recording the pH values using a sensor connected to an Arduino microcontroller for ADC conversion and OLED display output. The recorded data were then uploaded to the IoT-based website for storage in Firebase, and the procedure was repeated to ensure accuracy.

Calculated as the difference between sensor readings and reference pH meter values, the sensitivity of the pH sensor is defined as the smallest detectable change in pH. The sensor demonstrated high sensitivity during calibration tests, with a minimum error of 0,03 pH units (e.g., a sensor reading of 4,03 compared to a reference value of 4,00 for a pH 4 buffer), enabling accurate detection of subtle acidity variations relevant to GERD assessment. Based on salivary pH thresholds, this sensitivity ensures that the system can distinguish between healthy individuals and those potentially affected by GERD.

III. RESULT AND DISCUSSION

A. System Calibration Result

The calibration process is carried out to project the amount of analog voltage from the pH sensor in order to obtain the pH value of the measured liquid. Figure 6 shows the results of liquid measurements using pH 4 buffer and a pH sensor. The Figure 6 below shows analog voltage (V) on x-axis and pH value on y-axis, with high similarity indicating calibration accuracy.

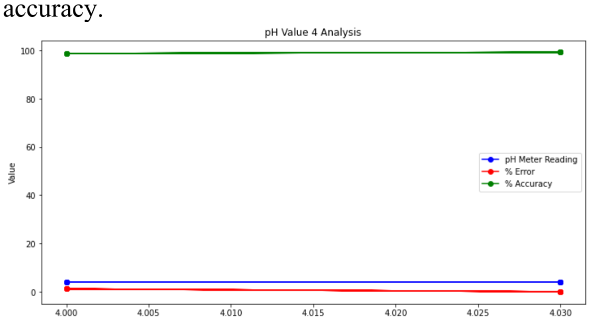

Figure 6. Comparison of sensor readings and test graphs for pH 4 buffer solution

The calibration process is performed to project the amount of analog voltage from the pH sensor and subsequently obtain the pH value of the measured liquid. Figure 7 presents the results of liquid measurements using pH 7 buffer and the pH sensor. Based on Figure 7, the measurement results of the pH sensor demonstrate a reasonably good similarity.

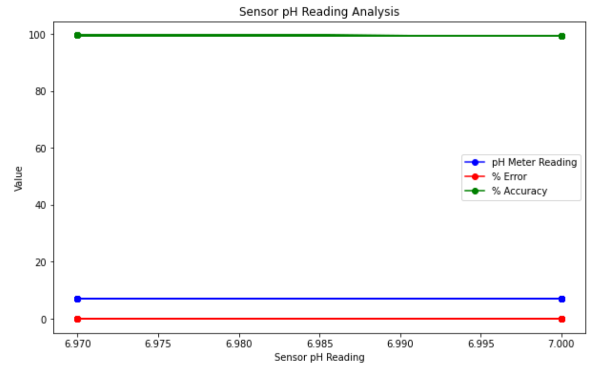

Figure 7. Comparison of sensor readings and test graphs for pH 7 buffer solution

Figure 7 above shows analog voltage (V) on x-axis and pH value on y-axis, demonstrating reliable neutral pH measurement. In this test, a comparison was made between the value taken by the sensor and the value taken by the pH meter. The results showed that the accuracy value of the pH sensor reached around 99,25%, indicating that the pH sensor gives results very close to a known reference value (actual pH). The sensitivity of the sensor in this case was also good, as the difference between the sensor value and the reference value was very small (0,03), suggesting that the pH sensor has good sensitivity to pH changes.

The calculation of the percentage of measurement result error can be seen in equation (2) below:

$$Error = \frac{|\,reference - measuring\ instrument\,|}{reference} x\ 100\% \qquad (2)$$

B. Sample Data Retrieval

Sample data were collected, with 10 samples divided into 5 male and 5 female samples, ranging in age from 19 to 53 years, and exhibiting a variety of age and lifestyle patterns. This was a specific result of a logistic regression calculation performed using JupyterLab software. The analysis used salivary pH, age, weight, height, GERD-Q score, and lifestyle score to interpret the early diagnosis of GERD.

C. Data Collection of Salivary PH, BMI of subjects, and Questionnaires

In this first data collection, the acidity of the subjects' saliva was measured, and the results of questionnaires and BMI from the subjects were collected. These findings are presented in TABLE I.

D. Logistic Regression Testing from Sample Data

This test is a specific result of the calculation using logistic regression. It uses the values of salivary pH, age, weight, height, GERD-Q, and lifestyle. The following are the results of data validation for the logistic regression calculations in TABLE II.

For the implementation of data calculation using logistic regression to determine whether each subject has potential GERD or not, each data can be entered using (1).

Here is an example of the implementation of the calculation as follows:

$$Y = \frac{exp(16{,}62)+(-1{,}60\ x\ 5{,}74)+(0{,}04\ x\ 27)+(0{,}29\ x\ 1)+(-0{,}15\ x\ 163)+(0{,}19\ x\ 63)+(0{,}53\ x\ 4)+(0{,}28\ x\ 4)}{(1+Exp\ (16{,}62)+(-1{,}60\ x\ 5{,}74)+(0{,}04\ x\ 27)+(0{,}29\ x\ 1)+(-0{,}15\ x\ 163)+(0{,}19\ x\ 63)+(0{,}53\ x\ 4)+(0{,}28\ x\ 4)}$$

$$= 0{,}992$$

Based on the data in the table above, it can be seen that in men, the salivary pH ranges from 4,16 to 7,41, with a lower average pH in those diagnosed with potential GERD. In women, the salivary pH ranged from 4,66 to 7,55, with women who had a lower salivary pH tending to be diagnosed with potential GERD more often. Overall, individuals with lower salivary pH and higher GERDQ scores showed a significant correlation with potential GERD diagnoses in both genders. The output values in these logistic regression calculations to determine the condition of each data were also higher in potentially GERD individuals. However, age, height, weight, and lifestyle did not show a consistent pattern linking them to potential GERD directly.

Methods for diagnosing gastroesophageal reflux disease (GERD) are classified into two types: invasive and non-invasive. Existing invasive techniques, such as pH-metry, pH impedance measurement, esophageal manometry, Bravo pH measurement, and Multichannel Intraluminal Impedance (MII), are used to diagnose GERD. However, there is only one non-invasive technique, which is based on changes in saliva volume, used to diagnose GERD. Invasive monitoring methods for the diagnosis of GERD all involve the use of invasive devices inserted through the nose or esophagus to measure various parameters such as pH, impedance, and motility. While these methods are effective in detecting reflux and provide important diagnostic information, they also have limitations, such as patient discomfort and the inability to detect non-acidic reflux in some cases [5-12]. Mucosal Impedance Testing is a recent technique that offers real-time diagnosis without long-term monitoring, but further research is needed to determine its effectiveness in predicting response to treatment [13].

In an effort to non-invasively diagnose gastroesophageal reflux disease (GERD), the measurement of pepsin levels in saliva has been proposed as a promising method [14-16]. This is because pepsin is contained in the reflux fluid that mixes with saliva. Although suitable for the diagnosis of GERD and extraesophageal reflux cases, this method has limitations, such as a lack of protocol standardization, differences in reference values, and only giving positive results in about 45-50% of GERD patients. The current data is not strong enough to conclude the effectiveness of this method of measuring pepsin levels in saliva [13].

Research on monitoring the diagnosis of Gastroesophageal reflux disease (GERD) early with this non-invasive method has been conducted before. The research uses a pH sensor to measure the pH value or acidity. The results of the sensor readings are processed using an Arduino Uno microcontroller and converted into digital data (ADC), which is then displayed on the LCD screen. This research does not specifically explain the level of accuracy, but when tested on several acidic liquid samples, this tool can detect pH values well [3]. The next study used a technique to measure the impedance of the gastrointestinal tract using two pairs of electrodes attached to the patient's chest skin. Two electrodes were positioned on the front and back areas of the torso from the neck to the abdomen to measure esophageal impedance. The resistive/capacitive activity that commonly occurs in human tissue is quite influential for the results of monitoring the diagnosis of GERD [13]. Then the research utilizes the certainty-factor method to handle the uncertainty in diagnosing this GERD condition based on symptoms using the application system. In this study, no samples were tested, so the accuracy of the system is highly dependent on the quality and breadth of expert knowledge integrated into the system [17].

To overcome the shortcomings of non-invasive methods, the GERD-Q is used as one of the standardized protocols utilized by Internal Medicine Doctors in diagnosing GERD. The GERD-Q was developed as a symptom-based diagnosis and management tool, with the aim of improving the accuracy of GERD diagnosis without the need for initial referral to a specialist or endoscopy. This study showed that the GERD-Q has a sensitivity of 65% and a specificity of 71% in diagnosing GERD, which is equivalent to the accuracy achieved by gastroenterologists [18]. Sensitivity refers to the ability of the test to identify patients who actually have the disease (true positive rate), while specificity measures the ability of the test to identify patients who do not have the disease (true negative rate). Additionally, the GERD-Q also helps to provide a more personalized approach in the evaluation and management of GERD symptoms. By identifying and managing GERD based on patient-reported symptoms, the GERD-Q is able to improve the accuracy of diagnosis and treatment compared to traditional methods that rely on subjective judgment or empirical trials of Proton Pump Inhibitor (PPI) therapy [19].

The accuracy value of the pH sensor reaches about 99,25%, indicating that the results provided by the pH sensor are very close to the known pH reference value (actual pH). The difference between the pH sensor value and the reference value is only 0,025, indicating that the pH sensor has good sensitivity to pH changes. This level of accuracy is important in the context of GERD diagnosis and management, where the detection of small changes in esophageal pH can contribute significantly to the proper assessment of the patient's condition. The use of pH sensors with this high level of accuracy can improve the reliability of GERD diagnosis and management, ensuring that patients receive appropriate treatment based on accurate and reliable data.

However, this study has some shortcomings. The pH sensor accuracy results have not been compared with more complete medical record data. In addition, the system has not been tested directly with a doctor's examination method, which is the gold standard in GERD diagnosis. Future research is expected to include a comparison between pH sensor data and medical records as well as an evaluation of this system compared to clinical examinations by doctors. This will provide a more complete picture of the effectiveness and practical application of the pH sensor in a clinical context. Future research can also explore further development of this sensor technology to improve its accuracy and reliability in various patient conditions.

IV. CONCLUSION

GERD can be diagnosed early by invasive and non-invasive methods. This research has created a Smart System for Early Diagnosis of Acid Reflux Disease (GERD) Non-invasively through Saliva pH Monitoring and a GERD-Q Questionnaire based on the Internet of Things. The results of the saliva pH, GERD-Q, lifestyle questionnaire, age, height, and weight were calculated using the logistic regression method. The accuracy of the pH sensor reaches about 99,25%, which indicates that the results provided by the pH sensor are very close to the known pH reference value (actual pH). However, there are some limitations to this study. The pH sensor accuracy results have not been compared with more complete medical record data; therefore, future research is expected to include a comparison between pH sensor data and medical records, as well as an evaluation of this system compared to clinical examinations by doctors. The sensor technology could be developed further to improve its accuracy and reliability in various patient conditions. Additionally, future research should expand the sample size to include a larger and more diverse population, ensuring that statistical analyses, such as the logistic regression model, yield more accurate, unbiased, and representative results for broader applicability in clinical settings.

REFERENCES

[1] L. P. Suherman, R. Ramdani, V. Septiani, W. Indrayani, A. N. Islamiyah, and P. K. Hasyim, "Pola Penggunaan Obat Pada Pasien Gastroesophageal Reflux Disease (GERD) di Salah Satu Rumah Sakit di Bandung," *Pharmacoscript*, vol. 4, no. 2, p. 208, Aug. 2021.

[2] N. Vakil, "Developments in Gastroesophageal Reflux Disease over the Last 40 Years," *Digestive Diseases*, vol. 42, no. 2, pp. 127–136, Sep. 2023, doi: 10.1159/000533901.

[3] K. Adhisty *et al.*, "Pendeteksi Asam Lambung dengan Menggunakan Sistem Sensor pH," *Artikel Penelitian Jurnal Keperawatan Sriwijaya*, vol. 8, no. 2, 2021.

[4] T. Maulana Putera and D. A. Murad, "GACOR (Gastric Acid Detector): Inovasi Alat Pengukur Tingkat Asam Lambung," 2022.

[5] S. Chae and J. E. Richter, "Wireless 24, 48, and 96 Hour or Impedance or Oropharyngeal Prolonged pH Monitoring: Which Test, When, and Why for GERD?," *Curr Gastroenterol Rep*, vol. 20, no. 11, Nov. 2018, doi: 10.1007/S11894-018-0659-0.

[6] D. Ang *et al.*, "Diagnosis of gastroesophageal reflux: an update on current and emerging modalities," *Ann N Y Acad Sci*, vol. 1481, no. 1, pp. 154–169, Nov. 2020, doi: 10.1111/NYAS.14369.

[7] M. Frazzoni, N. de Bortoli, L. Frazzoni, S. Tolone, V. Savarino, and E. Savarino, "Impedance-pH Monitoring for Diagnosis of Reflux Disease: New Perspectives," *Dig Dis Sci*, vol. 62, no. 8, pp. 1881–1889, Aug. 2017, doi: 10.1007/S10620-017-4625-8.

[8] R. D. Naik, L. Evers, and M. F. Vaezi, "Advances in the Diagnosis and Treatment of GERD: New Tricks for an Old Disease," *Curr Treat Options Gastroenterol*, vol. 17, no. 1, pp. 1–17, Mar. 2019, doi: 10.1007/S11938-019-00213-W.

[9] F. Ates *et al.*, "Mucosal impedance discriminates GERD from non-GERD conditions," *Gastroenterology*, vol. 148, no. 2, pp. 334–343, Feb. 2015, doi: 10.1053/J.GASTRO.2014.10.010.

[10] E. Saritas Yuksel *et al.*, "Use of direct, endoscopic-guided measurements of mucosal impedance in diagnosis of gastroesophageal reflux disease," *Clin Gastroenterol Hepatol*, vol. 10, no. 10, pp. 1110–1116, Oct. 2012, doi: 10.1016/J.CGH.2012.05.018.

[11] D. A. Katzka *et al.*, "Endoscopic Mucosal Impedance Measurements Correlate with Eosinophilia and Dilation of Intercellular Spaces in Patients with Eosinophilic Esophagitis," *Clin Gastroenterol Hepatol*, vol. 13, no. 7, pp. 1242-1248.e1, Jul. 2015, doi: 10.1016/J.CGH.2014.12.032.

[12] M. F. Vaezi, D. Katzka, and F. Zerbib, "Extraesophageal Symptoms and Diseases Attributed to GERD: Where is the Pendulum Swinging Now?," *Clin Gastroenterol Hepatol*, vol. 16, no. 7, pp. 1018–1029, Jul. 2018, doi: 10.1016/J.CGH.2018.02.001.

[13] M. Laracca, G. Miele, L. Podestà, and S. Sangiovanni, "A Non-Invasive Technique for Long-Term Monitoring of Gastroesophageal Reflux—A Pilot Study," *Sensors 2023, Vol. 23, Page 9459*, vol. 23, no. 23, p. 9459, Nov. 2023, doi: 10.3390/S23239459.

[14] Y. J. Wang *et al.*, "Salivary Pepsin as an Intrinsic Marker for Diagnosis of Sub-types of Gastroesophageal Reflux Disease and Gastroesophageal Reflux Disease-related Disorders," *J Neurogastroenterol Motil*, vol. 26, no. 1, pp. 74–84, 2020, doi: 10.5056/JNM19032.

[15] R. Yadlapati *et al.*, "Abilities of Oropharyngeal pH Tests and Salivary Pepsin Analysis to Discriminate Between Asymptomatic Volunteers and Subjects with Symptoms of Laryngeal Irritation," *Clin Gastroenterol Hepatol*, vol. 14, no. 4, pp. 535-542.e2, Apr. 2016, doi: 10.1016/J.CGH.2015.11.017.

[16] E. Ocak, G. Kubat, and İ. Yorulmaz, "Immunoserologic Pepsin Detection in The Saliva as a Non-Invasive Rapid Diagnostic Test for Laryngopharyngeal Reflux," *Balkan Med J*, vol. 32, no. 1, p. 46, 2015, doi: 10.5152/BALKANMEDJ.2015.15824.

[17] D. S. Kariza, A. Jamaludin, and A. Perimajaya, "Expert System Diagnosing Gastroesophageal Reflux Disease (GERD) Using Certainty-Factor Method," *Jurnal Mantik*, vol. 6, no. 3, pp. 2685–4236, 2022.

[18] R. Jones *et al.*, "Development of the GerdQ, a tool for the diagnosis and management of gastro-oesophageal reflux disease in primary care," *Aliment Pharmacol Ther*, vol. 30, no. 10, pp. 1030–1038, Nov. 2009, doi: 10.1111/J.1365-2036.2009.04142.X.

[19] R. Yadlapati *et al.*, "AGA Clinical Practice Update on the Personalized Approach to the Evaluation and Management of GERD: Expert Review," *Clin Gastroenterol Hepatol*, vol. 20, no. 5, pp. 984-994.e1, May 2022, doi: 10.1016/J.CGH.2022.01.025.

ATTACHMENTS

TABLE I
SAMPLE DATA CAPTURE

	pH Saliva	Age (y.o)	Height (cm)	Weight (kg)	GERD-Q	Life style
Men	5,74	27	163	63	4	4
	7,41	44	165	60	6	2
	6,18	20	175	65	7	4
	6,24	38	165	63	6	1
	5,41	46	168	61	10	1
	pH Saliva	**Age (y.o)**	**Height (cm)**	**Weight (kg)**	**GERD-Q**	**Life style**
Women	5,12	25	155	55	12	4
	7,21	53	162	57	7	3
	6,14	32	152	53	3	1
	6,17	35	156	50	6	1
	5,41	22	155	55	9	3

TABLE II
LOGISTIC REGRESSION TESTING

	pH Saliva	Age (years old)	Height (cm)	Weight (kg)	GERDQ	Lifestyle	Output	Interpretation
Men	5,74	27	163	63	4	4	0.992	Potential GERD
	7,41	44	165	60	6	2	0.040	No GERD Potential
	6,18	20	175	65	7	4	0.143	No GERD Potential
	6,24	38	165	63	6	1	0.218	No GERD Potential
	5,41	46	168	61	10	1	0.844	Potential GERD
	pH Saliva	**Age (years old)**	**Height (cm)**	**Weight (kg)**	**GERDQ**	**Lifestyle**	**Output**	**Interpretation**
Women	7,21	53	162	57	7	3	0.488	No GERD Potential
	6,14	32	152	53	3	1	0.440	No GERD Potential
	6,17	35	156	50	6	1	0.444	No GERD Potential
	5,41	22	155	55	9	3	0.820	Potential GERD
	5,12	25	155	55	12	4	0.776	Potential GERD