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Innovation Article

# Design and development of electronic stethoscope for auscultation

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## A B S T R A C T

**Background:** Currently, several companies offer Bluetooth-based electronic stethoscopes. However, the stethoscopes are pretty overpriced. In this case, we need a stethoscope innovation with a more affordable price that carries the same function and improves ear sensitivity during auscultation of heart and lung sounds.

**Technic:** This stethoscope is equipped with a condenser mic that functions as a sound catcher on the stethoscope membrane. The analog data of the condenser mic is regulated by the potential of the pre-amp mic amplifier; then, analog data is forwarded using Bluetooth 5.0 A2DP BT600 USB Wireless Audio Transmitter and received by Bluetooth receiver using earphones.

**Conclusion**: A electronic stethoscope has been successfully developed, which can function adequately to detect, increase heart, lung, bowel sounds, and prenatal sounds.

## INTRODUCTION

In the development of biomedical technology, many studies have been made to help paramedics work, one of which is to diagnose diseases. Heart and lung disease are dangerous diseases. In determining and diagnosing the disease, medical personnel will use auscultation techniques, such as a stethoscope.[1]

The results of the analysis of heart and lung sounds using auscultation techniques depend on the ability of medical personnel.[2] Problems that arise from auscultation of the heart and lungs occupy a low frequency of around 20-2000 Hz, environmental noise, differences in human ear sensitivity, and relatively similar sound patterns that require experience and good listening skills.[3–5] In such cases, misdiagnosis can occur if the auscultation procedure is not correctly performed.[6]

An electronic stethoscope in sound analysis can be one solution to the above problems. The advantage of an electronic stethoscope is that it increases the amplification between 56.679 Hz – 88.646 Hz. This proves that electronic stethoscopes are more sensitive than conventional stethoscopes.[7,8]

Research on electronic stethoscopes has been carried out, one of them a "real-time smart digital stethoscope system" uses an Arduino microcontroller and several analog circuits and is displayed on a TFT screen.[9] The difference with previous research is that the stethoscope is designed to be simpler, easier to use, and connects directly to headphones, earphones, and speakers. The purpose of this research is to make a Bluetooth electronic stethoscope that is more power-efficient, more ergonomically priced and to test the amplification of the resulting sound, and compare the sound with a conventional stethoscope.

## TECHNIC

The electronic stethoscope is an innovation of earphone-based stethoscope connected via Bluetooth to increase ear sensitivity during auscultation of heart and lung sounds in performing physical examinations, checking patient blood pressure, abdominal disorders, and prenatally, has a length of 9 cm, width 5 cm, height 4 cm (Figure 1). This system is equipped with a condenser mic that functions as a sound catcher on the stethoscope membrane. The pre-amp mic amplifier regulates the analog data of the condenser mic. Analog data is sent using Bluetooth 5.0 A2DP BT600 USB Wireless Audio Transmitter and received by-

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**Figure 1.** Design of the Electronic Stethoscope

**Figure 2.** Application of the Electronic Stethoscope to the Patient

the Bluetooth receiver using earphones. Using a stethoscope is easy, namely bringing the instrument closer to the patient and preparing the client; by adjusting the position in a comfortable position, the examiner puts the earphones into both ears and presses the button on the stethoscope (Figure 2).

## DISCUSSION

We have designed, manufactured, and collaborated with an electrical engineering study program to create an earphone-based wireless electronic stethoscope. Conducted a test of health experts, health technology experts, tested on patients carried out by 15 medical personnel at the Cikadu Watukumpul Health Center. The variable that is assessed is the accuracy of the sound produced. We also examined sound comparison with a conventional stethoscope conducted at the Muhammadiyah Hospital of Mardhotillah Randudongkal. The results of this study have passed the health expert test with the parameters of the shape, quality, and function of the tool included in the excellent category. Medical technology expert tests for ergonomic size, attractive appearance, relatively affordable prices, quality, and easy use are outstanding.

The trial results found that 81.95% of medical personnel state that earphone-based wireless electronic stethoscopes can improve heart, lung, bowel, and prenatal sounds. The sound auscultation results are amplified by the Pre-mix circuit entering the filter circuit to filter the required sound frequency.[10] The quality indicator of the tool proves that the stethoscope is more energy-efficient and can be used for more than one hour during the inspection. The use of headphones on a stethoscope increases the comfort of medical personnel when performing auscultation techniques.

The comparison of abnormal heart and lung sounds with a conventional stethoscope to the patient showed that the inter-rater reliability coefficient (Kappa) was 0.375. Cohen kappa scores with a score of 21-40 are interpreted in the appropriate agreement category, which means that they can both listen to the sounds of the heart and lungs without changing the sound character and improving auscultation sounds. The existence of an analog circuit in this system improving the produced sound resulting in a distinct and precise sound.[10]

The results of this study support previous research that designed a real-time intelligent digital stethoscope. The heart sound will be transmitted to the condenser mic, converting the sound into electricity which will be amplified through the Pre-Amp circuit with an adjusted gain value. The output of the Pre-Amp enters the filter circuit to filter the required sound frequency. It is strengthened again with a series of gains that have been adjusted, from the incoming filter to the Bluetooth Transmitter, which will then be forwarded to the Bluetooth headset. The signal enters the microcontroller to be processed, then displayed through the speaker and TFT. Prabowo proves that its accuracy is suitable for monitoring heart signals in real-time and is portable with a touchscreen display.[10]

## CONCLUSIONS AND RECOMMENDATION

An electronic stethoscope based on earphones has been successfully developed, functioning adequately to detect and determine heart, lung, bowel, and prenatal sounds. In order to minimize misdiagnosis, an electronic stethoscope such as an earphone-based wireless electronic stethoscope should be used. The recommendation for further research is to improve the appearance and the size.

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