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DEVELOPMENT OF A BLUETOOTH-BASED WIRELESS STETHOSCOPE WITH MUSIC FEATURES TO REDUCE TODDLER ANXIETY

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Abstract

Auscultation examinations in toddlers are often hampered by psychological responses such as fear, anxiety, and rejection of the stethoscope, making it difficult to guide the child and resulting in a less than optimal diagnosis process. This study aims to develop a child-friendly Bluetooth-based electronic stethoscope with additional music features as audio distractions to improve comfort and reduce anxiety in toddlers during medical examinations. The research method uses a research and development approach that includes electronic system design, prototype creation, audio testing, and device performance evaluation. The prototype was designed with a microphone signal amplifier system integrated with a Bluetooth module for wireless transmission to a headset and music player module. The test results showed that the use of this stethoscope was able to create a calmer examination atmosphere, marked by reduced resistance and excessive movement in toddlers during auscultation. The music feature proved to be a positive distraction that increased the child's comfort and cooperation. In addition, physiological sounds such as heartbeat and breathing remain clearly audible through the wireless connection without latency interference. This innovation has the potential to be a child-friendly auscultation solution that improves the comfort of infant patients and the effectiveness of medical examinations

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Keywords: Child Patient Comfort, Toddler Comfort in Auscultation Examination, Toddler Anxiety in Medical Examination, Electronic Stethoscope, Toddler Anxiety

INTRODUCTION

Toddler health is an important indicator in determining the quality of a country's health [1]. To achieve good health quality for a nation, comprehensive attention is needed to the growth and development of toddlers through optimal, continuous, and child-centered health services. Physical examination is an important part of health services, one of which is the Auscultation stage. Routine medical examinations by conducting auscultation using a stethoscope are an integral part in detecting health disorders. In a Theory of Acceptance in Public Health Communication, namely a theory that aims at the process of how a health message can be received, interpreted, and understood by the audience [2]. In this case, the audience is toddlers who require special forms of communication and interaction so that toddler patients understand and comprehend that health examinations are good and enjoyable. However, the use of stethoscopes on toddlers often presents its own challenges for both children and medical personnel. Many children feel afraid or anxious during medical examinations, especially when the stethoscope is placed on their body, which can make it difficult for medical personnel to perform accurate examinations [3]. The process of auscultation examinations on toddlers also often encounters obstacles when children show fear, anxiety, or resistance when the stethoscope is attached to the body. This emotional state makes it difficult to direct toddlers, making the diagnostic process ineffective. This condition makes children less cooperative, increases anxiety, and can ultimately hinder the examination process and reduce the accuracy of medical results [4].

The fear or anxiety felt by toddlers regarding medical equipment can interfere with the examination process and worsen the child's experience with the medical world. One way to reduce this fear is to create a more pleasant and friendly atmosphere for children. Music has a positive impact on children's emotions and psychology, which can help them feel more comfortable and relaxed during medical examinations [5]. Ease of access to examinations using a stethoscope is highly desirable. Conventional stethoscopes have limitations due to the hanging tube [4], making it difficult for medical personnel to examine because they must always be close to the toddler. The combination of psychological and technical issues results in examinations often taking longer, being less optimal, and potentially reducing the level of accuracy of early detection of health conditions in toddlers. The inspiration for developing this innovation came from real phenomena in pediatric health examination rooms, where medical personnel needed a tool that could provide a more calming examination atmosphere, while remaining reliable in capturing physiological body sounds. The intellectual challenge that then emerged was how to design a medical examination device that was not only technically functional, but also psychologically responsive to the characteristics of toddlers. As technology advances, innovations in medical devices have begun to integrate wireless connectivity such as Bluetooth, which allows for more comfortable sound transmission to receiving devices such as headphones [6].

Bluetooth-based wireless electronic stethoscope innovation has previously existed. A wireless electronic stethoscope based on earphones has been successfully created that can function well to detect and amplify heart sounds, lung sounds, bowel sounds, and prenatal [7]. However, this innovation has not yet addressed the problem of toddler anxiety during the auscultation examination process . Based on this challenge, a prototype was developed, namely "Development of a Bluetooth-Based Wireless Stethoscope with Music Features to Reduce Toddler Anxiety". The distracting music playback feature was added as a positive stimulus to reduce anxiety, creating a more comfortable and cooperative examination atmosphere. Research and commercial products related to digital auscultation have shown significant progress in aspects of amplification, noise cancellation, recording and signal analytical capabilities [8]. Medical personnel can increase children's comfort by using music interventions [9].

The development of a child-friendly stethoscope with music features is the right choice to reduce fear in children, improve the medical experience, and enhance the quality of health examinations in toddlers. Listening to music can affect psychological, physical, spiritual, cognitive, and social aspects [10]. Music can function as a positive distraction that makes children calmer, so that the examination process can proceed more smoothly [11]. Studies on auditory distraction techniques in pediatric procedures show that music is consistently able to reduce anxiety in pediatric patients during medical procedures [12]. The scientific answer why the development with music features is the answer to this problem. In music therapy, stimuli are received by the body through the auditory system. This process can influence moods to be more positive, improve children's emotional responses, and provide a calming effect so that stress levels can be reduced [13]. Physiologically, music can stimulate brain function by diverting the process of analyzing the sounds heard. Musical stimuli are received through the cochlear nerve and transmitted to the central nervous system, which then activates the parasympathetic nervous system. This activation influences the pituitary gland to release beta-endorphins as hormones that trigger feelings of happiness, while also reducing cortisol levels that play a role in the emergence of anxiety. As a result, individuals become more relaxed, feel safe, and anxiety levels can be reduced [14].

As technology advances, innovations in the field of medical devices have begun to integrate wireless connectivity such as Bluetooth, which allows for more practical sound transmission to receiving devices such as headphones [6]. In recent years, the development of electronic-based medical device technology has progressed rapidly, particularly in the development of digital stethoscopes and smart auscultation devices. Various research and developments have been carried out to create more accurate, portable, and easy-to-use tools for both medical personnel and the general public [15]. Research on heart measuring devices was carried out using a microcontroller integrated with Bluetooth [16]. In this study, it produced a heartbeat that could be heard remotely by health workers. In this electronic stethoscope, the amplifier functions as a receiver of sound signals from the stethoscope and makes it a sound that will be connected to the listener's ear [17]. In addition, research has practical applications in the field of technology [18]. Technology currently plays a major role in human activities and plays a role in supporting personal activities, one of which is the information system. [19]. Everyone has the right to receive balanced and responsible information and education about health [20]. By utilizing technological advances and an understanding of child psychology, this tool is expected to provide more effective and efficient solutions in the world of pediatric medicine.

METHOD

The electronic stethoscope development project was implemented in stages and systematically, starting with data collection and ending with final product evaluation. The following are the detailed implementation stages, as shown in Figure 3.1.

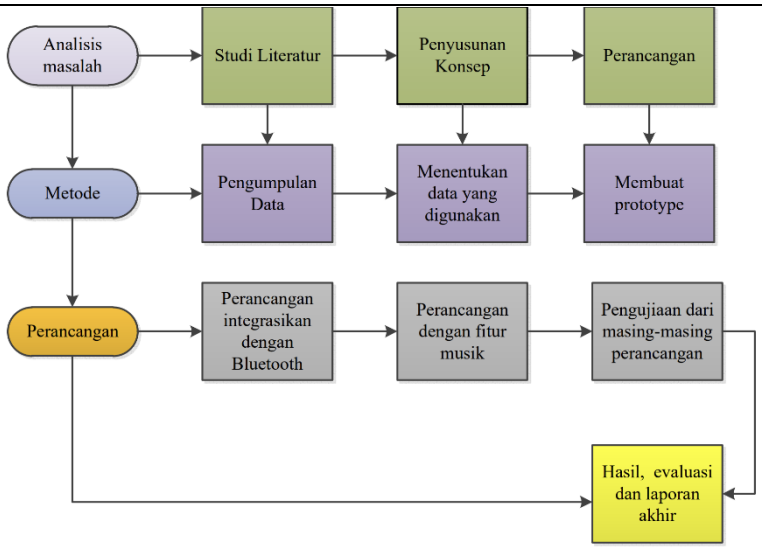

Figure 1.1 Stages of Activity Implementation

This stage began with the observation that conventional stethoscopes often have limitations in hearing body sounds, especially in crowded places. In addition, many young medical personnel require modern and practical medical equipment. From this condition emerged the idea to design a Bluetooth-based electronic stethoscope that can transmit detected sounds to headphones wirelessly, while also having an additional feature in the form of relaxation music so that users can study in a calm atmosphere. At this stage, discussions were held with the supervising lecturer and a search for references about previous electronic stethoscopes. The reference results were used as the basis for creating an initial system design and determining the components to be used. After the idea was formulated, a technical design was made with a system consisting of: 1. a microphone used to capture the patient's body sounds from the stethoscope 2. an amplifier circuit to amplify the sound signal. 3. a Bluetooth module to transmit sound to wireless headphones. 5. a lithium battery and charging module as a power source. 5. an Arduino Nano programmed to play music.

The addition of music sounds is done with a controller process to control music playback. The microcontroller will access the music files stored on the SD card, then the DF player mp3 module, then the mp3 file will be coded into a digital audio signal and then the audio signal is converted into an analog signal and output through the speaker. Music that can be heard by toddler patients is cartoon music, children such as "my balloons have five", "brother meatball seller", and so on. In addition, cartoon characters for the cover of the stethoscope design machine with music features are also added, this is done so that the examination is fun for toddlers. With the music feature it will still not interfere with the function of the stethoscope as a transmitter of audio data to the ears of health workers. because in this design concept, the music feature is added as a distraction during the examination of toddler patients. It's just that for sending audio signals to the ears of health workers via Bluetooth. Health workers will turn off the music when the patient is examined and turn on the music if the patient has not been examined. Turning off the music during the patient examination is done so that the health workers who examine can focus more on listening to the patient's body sounds. Circuit schematic on PCB layout using EasyEDA software. Once the circuit is operational, a PCB is fabricated and components such as the amplifier and Bluetooth module are installed. The circuit is then housed in a small, 3D-printed case for a sleek and ergonomic look. This stage includes programming the Arduino using the Arduino IDE. The program is created to run the logic of the music feature by sliding the on/off switch so that it can play music. Testing is carried out to ensure the device works as designed. Testing includes: Testing the microphone's sensitivity to body sounds. Testing the stability of Bluetooth transmission to ensure clear sound without interruption. Testing battery life with 6 hours of use for the stethoscope and 1 hour for the music player.

Figure 1.2 Prototype Results

This prototype was then realized in the form of a functional tool with the main electronic components, namely an electret microphone, an amplifier circuit, a Bluetooth transmitter module, an Arduino, a small MP3 music player module, a rechargeable battery and controlled via an on-off switch. This prototype is also equipped with music features and removable decorations or costumes. So, when the music is turned off, there is still a fun way for toddlers by presenting cute toy shapes and bright colors. The following is a realization with a decorative design in Figure 1.3. The following tool functions to detect the patient's body sounds, and transmits the results wirelessly to a Bluetooth headset. How this tool system works can be seen in Figure 1.4.

Figure 1.3 Interactive Decorations and Removable Costumes

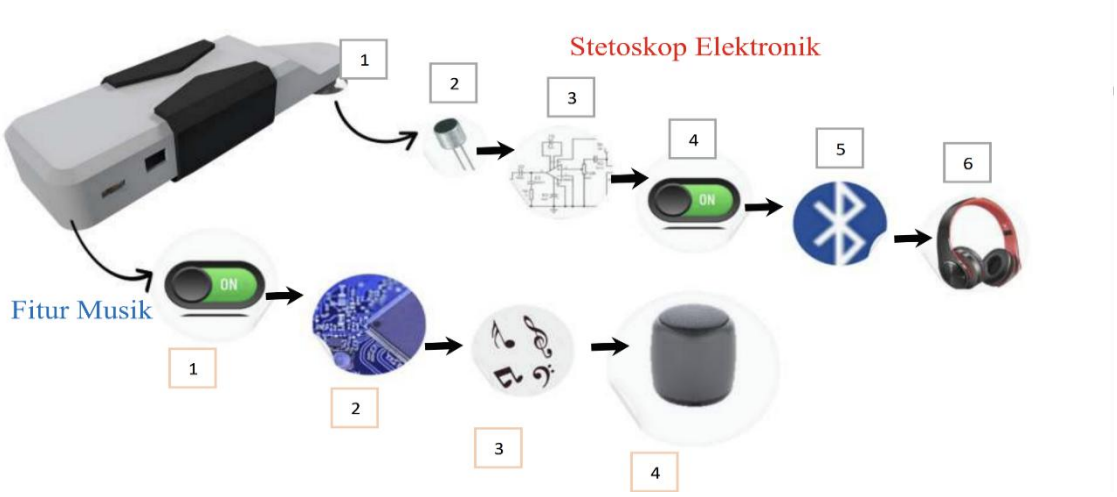

Figure 1.4 How Systems and Tools Work

Based on Figure 1.4, the system's operation consists of two main parts: an electronic stethoscope and a music feature system. On an electronic stethoscope, the user activates the device by pressing the switch to the ON position. The stethoscope's chestpiece then captures sounds from the patient's body, which are then received by the microphone. The analog sound signal is converted into an electrical signal and amplified using an audio amplifier circuit. After the amplification process, the signal is sent wirelessly via a Bluetooth module and received by a Bluetooth headset, allowing the user to hear the patient's heart or breathing sounds more clearly. Furthermore, this system is also equipped with a music feature. The music feature is activated by pressing a special switch, and the microcontroller then runs the programming logic to operate the music module. The music module will play songs according to the microcontroller's commands, and the resulting sound is output through the speaker.

RESULTS AND DISCUSSION

Table 1.1 Electronic Stethoscope Testing Data Results

No.	Test Conditions	Output Voltage	Frequency	Information
1.	Mic+amplifier circuit (quiet room)	5-9V	-	When the microphone has not been given signal input, it looks small, just environmental noise.
2.	Amplifier circuit and stethoscope (attached to the chest area of the heart)	5-9V	1-2Hz	a wave appears that is different from the usual noise, indicating the capture of body sound vibrations (heartbeat/respiration)
3.	The results are heard when transmitted with Bluetooth and headphones.	5-9V	1-2Hz	although the sound of the body is still a bit faint.

The electronic stethoscope has two USB ports: one for charging the battery for the amplifier circuit and the microphone, and one for Bluetooth. The specifications of the Bluetooth stethoscope are shown in Tables 1.2 and 1.3.

Table 1.2 Amplifier and Microphone Circuit Specifications

Information	Specification
Battery Capacity	500 mah
Charging Voltage	DC 5V/500 mA
Charging Time	2-3 Hours
Usage Time	+- 1 Hour

Table 1.3 Amplifier and Microphone Circuit Specifications

Information	Specification
Battery Capacity	200mah
Charging Voltage	DC 5V/500 mA
Charging Time	2 hours
Usage Time	5 Hours (Transmitter Mode)
Dimensions	44 x 444 x 12 mm
Heavy	18g
Operation Range	10m (Without Obstructing Objects)

Some of the main advantages of this prototype compared to conventional stethoscopes and other electronic stethoscopes can be seen in table 1.4 .

Table 1. 4 Product Advantages

No.	Aspect	Product excellence
1.	Innovation	Combines auscultation, electronic and musical distraction functions (medical, electronic and psychological) in one device.
2.	Patient Comfort	Helps provide comfort to toddlers so that the examination is more cooperative
3.	Technology	Using bluetooth connectivity for wireless sound transmission
4.	Portability	Compact, ergonomic and easy to carry design
5.	Efficiency	Without the use of additional devices such as mobile phones or tablets.

Product Benefit Predictions provide tangible benefits for medical personnel and pediatric patients in hospital and clinic settings. With its integrated distraction music feature, this device can help reduce anxiety and fear in toddlers during examinations, making them more cooperative and allowing for faster and more accurate examinations. For medical personnel, this device helps optimize the auscultation process without the need for connecting cables, increasing comfort and freedom of movement. Furthermore, the prototype has the potential to support child-friendly healthcare services and focus on patient psychological comfort. In addition to functioning as a digital auscultation tool, the music feature is also designed to adapt to the toddler's mood and physiological condition. The music played is random and can be selected according to the child's condition. This prototype has the potential to generate positive impacts, both academically and practically.

Potential outcomes that can be achieved include: 1.1 Scientific potential 1. The development of this prototype can be the basis for further research in the field of wireless technology-based medical devices. 2. The prototype has the potential to be submitted as Intellectual Property Rights (IPR) in the form of a simple medical device design. 1.2 Social Potential 1. This tool can help medical students and medical personnel in the learning process and initial patient examinations. 2. It can be used as a medium for public health education, especially regarding the importance of early heart and lung examinations. 3. Publication on social media has the potential to increase public literacy regarding innovations in affordable and portable medical devices. 1.3 Economic Potential 1. Estimated production costs (Rp. 850,000 per unit), so this tool can be mass-produced at a standard price. 2. The tool can be marketed to educational institutions (campuses, health schools, and medical training) and the health community. 3. If further developed, this product can be an entrepreneurial opportunity for students in the field of health technology. 1.4 Sustainability Potential This prototype can be developed into a more professional version with additional features, such as voice data recording and integration with smartphone applications. The product has the potential to be included in technology innovation competitions, business incubation applications, or advanced research programs.

Figure 1.5 Interaction between Toddler and Doctor in the Health Examination Process

CONCLUSION

This prototype has been successfully realized as a Bluetooth-based electronic stethoscope equipped with a distraction music player feature. Test results show that auscultation sounds are heard clearly over a wireless connection without disturbing latency. The built-in music feature has been proven to help create a calmer atmosphere

for toddlers during the examination process, making the auscultation process more comfortable and efficient for both toddler patients and medical personnel. This device has the potential to be a child-friendly solution for medical personnel in the auscultation process.

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