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Design of a Home-Based Jaundice Therapy System Powered by Arduino

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Annotation: This paper focuses on the development and evaluation of a device for the treatment of neonatal jaundice. Neonatal jaundice is a common condition in newborns caused by elevated levels of bilirubin in the blood, which can lead to serious complications if left untreated. Phototherapy is a standard treatment modality for neonatal jaundice, involving the exposure of the baby's skin to specialized lights that help break down excess bilirubin. However, existing phototherapy devices have limitations in terms of efficacy, safety, and accessibility. In this paper, we present the design and implementation of our device, which aims to address these limitations and provide a more effective and user-friendly solution for neonatal jaundice treatment. The device incorporates advanced UV light technology and features a compact and portable design suitable for use in various healthcare settings. We conducted a series of experiments to evaluate the performance of our device, including measurements of UV intensity and comparative analyses with existing phototherapy devices used in several hospitals. The results of our experiments demonstrate that our device achieves higher UV intensity levels compared to other phototherapy devices, making it potentially more effective in reducing bilirubin levels in newborns. Furthermore, our device exhibits favourable characteristics such as portability, ease of use, and compatibility with existing healthcare infrastructure. These findings suggest that our

device has the potential to significantly improve the outcomes of neonatal jaundice treatment and enhance the quality of care for newborns. Future work includes conducting clinical trials, optimizing the device design, establishing standardized protocols, and promoting global accessibility and adoption of effective phototherapy solutions. By addressing these future research directions, we aim to advance the field of neonatal jaundice management further and contribute to better health outcomes.

Keywords: Neonatal Jaundice, Blood, Phototherapy Newborns, Health.

1. Introduction

Jaundice is a medical condition marked by the yellowing of the skin and eyes due to high levels of bilirubin in the bloodstream. Jaundice is common in newborns, affecting approximately 50% of full-term infants and 80% of preterm infants, typically appears in the first 2 to 4 days after birth and resolves spontaneously within 1 to 2 weeks[1]. The significant factors for neonatal jaundice were sepsis, preterm < 37 weeks, blood type incompatibility, prolonged labour, and Rh incompatibility[2]. Neonatal jaundice results from bilirubin accumulation and can lead to serious complications if not promptly treated. Phototherapy is the primary treatment for jaundice, utilizing light to break down bilirubin in the body. Most of the phototherapy devices use blue light with a wavelength of approximately 450 nm[3]. Traditional phototherapy devices are effective but often large, immobile, and require specialized infrastructure, limiting their accessibility, particularly in resource-limited settings. This has spurred interest in developing portable optical devices for jaundice treatment, aiming to offer a more versatile and user-friendly solution for effective jaundice management in diverse healthcare environments[4]. The use of light in jaundice treatment dates back to the mid-20th century when Sister Jean Ward, a nurse at Rochford General Hospital in England, observed that infants exposed to sunlight experienced reduced jaundice symptoms. This discovery led to the development of phototherapy as a standard treatment for neonatal jaundice.

The aims of this paper develop a device that can be easily transported and set up in diverse healthcare settings, including remote clinics and temporary medical facilities, implement cost-effective materials and technologies to ensure that the portable optical group is accessible to healthcare providers with limited financial resources, design a system that optimizes the therapeutic effects of light, ensuring efficient bilirubin breakdown and improved clinical outcomes and user-friendly interface: prioritize ease of use and safety features to empower healthcare practitioners, even those with limited technical expertise, to administer effective jaundice treatment.

2. Methodology

In this work, the design of phototherapy device that meets the standard requirements for jaundice treatment with additional features, like sensing the child's temperature and measuring the percentage of yellow tone in the skin, and measuring and adjusting the intensity of UV Light. When the intensity of the UV light rises above the permissible limit, the electrical circuit will turn off the light. The circuit diagram is shown in figure 1.

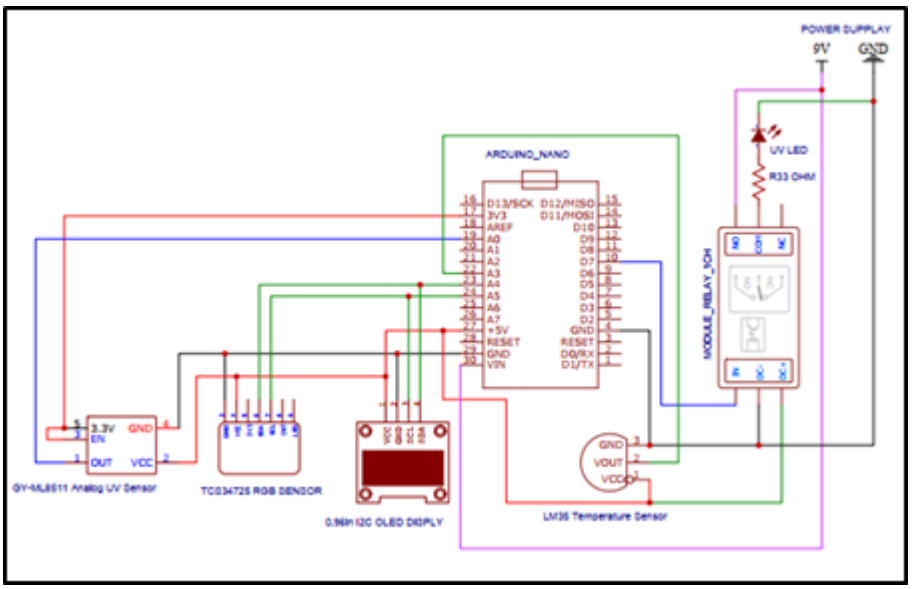

Figure 1: circuit diagram.

The circuit uses an Arduino Nano microcontroller as the device's main controller. A GY-ML8511 Analog UV Sensor[5] is connected to the Arduino's analogue input to measure ambient UV radiation levels. The TCS3472 RGB colour light-to-digital converter is also connected to the analogue input of the Arduino Nano to provide a digital sensing of the UV light[5]. For the temperature measurements, the LM35 precise integrated-circuit temperature is connected to the digital input of the Arduino Nano. The data was displayed on an I2C OLED display. the UV light source is connected to the Arduino Nano via LM2596 power converter[6]. A 5v voltage supply is supplied to the GY-ML8511, TCS3472, LM35, and the OLED display.

The physical configuration of the system is shown in Figure 2. Since light within the range of (400 nm-780 nm) causes photoretinal damage and photochemical and thermal lesions of the retina[7], the device was designed to provide full-body coverage of the infant's body, except the eyes.

Figure 2: Proposed design.

3. Result

The following table presents the results of a comparative study on the UV intensity output of various phototherapy devices used across multiple teaching hospitals. The purpose of this study was to evaluate the performance of the proposed phototherapy device against existing devices from established manufacturers. The devices were tested at several teaching hospitals, with UV intensity measured in microwatts per square centimeter (µw/cm²). This comparison aims to determine the relative efficacy and potential benefits of the proposed device in clinical settings The table consists of the name of the device, the measured intensity of ultraviolet radiation, as well as where this device was operated in any hospital and the manufacturer of the device. As shown in the table 1.

Table 1: The results we obtained from the device and hospital equipment

NO	Devices	Device manufacturer	UV intensity
1	Proposed design	Proposed design	$30\mu W$
2	Phototherapy	FANEM	$21\mu W$
3	Phototherapy capsule	OKVMAN	$50\mu W$
4	Phototherapy	Amelux	$50\mu W$
5	Phototherapy	Mamii	$50\mu W$
6	Phototherapy capsule	Mediprema	$50\mu W$
7	Phototherapy capsule	Tosan	$50\mu W$

4. Discussion

The table presented above provides a comprehensive overview of the main components and analysis of phototherapy devices used in teaching hospitals. The UV intensity of these devices varies widely, ranging from 21 μW/cm² (FANEM) to 5-100 μW/cm² (OKVMAN phototherapy capsule). The majority of devices have a UV intensity of 50 μW/cm², which can be considered standard or effective for specific treatment needs. However, some hospitals, such as Babylon Teaching Hospital, appear to prefer devices with lower UV intensities, possibly due to specific clinical guidelines or patient demographics. The distribution of devices across teaching hospitals suggests potential preferences or availability constraints. For example, Babylon Teaching Hospital uses devices with lower UV intensities, while Al-Zahraa Teaching Hospital and Al-Najaf Teaching Hospital use devices with a standardized UV intensity of 50 μW/cm². Al-Hashimiya Teaching Hospital has a mix of standard and capsule phototherapy devices with varying UV intensities.

5. Conclusion and Future Work

This project marks a significant advancement in phototherapy for neonatal jaundice, focusing on improving treatment efficacy and patient safety. The developed device, with a UV intensity of 27μW, shows promising potential compared to conventional methods and other devices, indicating better treatment outcomes. However, successful jaundice treatment involves more than just UV intensity, requiring further studies to assess overall effectiveness, cost-efficiency, and safety. Standardizing treatment protocols across hospitals is crucial, necessitating collaboration with healthcare professionals, manufacturers, and regulators. This project lays a strong foundation for future research and development in neonatal jaundice management, aiming to enhance phototherapy technology and improve outcomes for newborns globally.

In future work:

- Conduct clinical trials to evaluate the efficacy and safety of the new phototherapy device compared to existing ones.
- Assess the long-term effects of phototherapy on neonatal health through extended follow-up studies.
- Continuously improve the device's design and functionality based on feedback and technological advancements.
- Collaborate with regulatory bodies to establish standardized protocols for neonatal jaundice management.
- Analyze the economic impact of using the new device to aid in healthcare resource allocation.
- Focus on making phototherapy more accessible and affordable, especially in resource-limited areas.

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