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Evaluation of New Portable Phototherapy Device for Neonatal Hyperbilirubinemia

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Abstract

The Airlangga Bilirubin Nesting (AirBiliNest) is a novel portable phototherapy device developed to address the challenges of treating neonatal hyperbilirubinemia in resource-limited and home-based care settings. By integrating blue monochromatic LEDs into a sleeping bag model, it enables safe light delivery while allowing parental bonding and uninterrupted breastfeeding. This study aimed to evaluate the device's thermal regulation, irradiance output, and irradiance decay over time, as well as to assess acceptance and usability among healthcare providers. A simulation study was conducted in the Neonatology Unit of Airlangga Teaching Hospital using a neonatal mannequin over a 48-hour period, with standardized measurements of surface temperature, light irradiance, and decay rates taken every 12 hours at varying intensity levels. Temperature monitoring demonstrated that the device maintained safe thermal limits at 10–20 μW/cm²/nm, while overheating was noted at 30 μW/cm²/nm after 24 hours. The device delivered adequate irradiance levels for standard and intensive phototherapy (ranging from 11.29 to 34.65 μW/cm²/nm), with decay rates between 0.012 and 0.057 μW/cm²/nm per hour. A questionnaire administered to 32 healthcare professionals revealed favourable responses regarding the device's perceived usefulness, ease of use, and potential for clinical adoption. In conclusion, the AirBiliNest meets essential safety and performance standards for phototherapy, while also showing promising acceptance among healthcare providers. Further clinical studies are recommended to assess its effectiveness in real patient settings.

Keywords: AirBiliNest, Neonatal Healthcare, Phototherapy Device, Technology Acceptance Model, Temperature and Irradiance Control.

Introduction

Hyperbilirubinemia is a significant clinical problem, constituting approximately 1.1 million babies annually, predominantly in Southeast Asia (1). This condition is characterized by the rise in serum unconjugated bilirubin and resultant jaundice within the first 24 hours of life and is diagnosed when serum bilirubin levels exceed 5 mg/dL (86 mmol/L) (2). Without intervention to lower bilirubin levels, the condition can lead to Bilirubin-Induced Neurological Dysfunction (BIND), resulting in complications such as hearing loss, cerebral palsy, or even mortality (3). Initial therapy for unconjugated hyperbilirubinemia typically involves exposing the baby to blue light in the 430-490 nm wavelength range. This treatment facilitates the conversion of bilirubin into a soluble form that can be excreted (4, 5). The effectiveness of phototherapy depends on factors such as the light source's wavelength, spectral irradiance, the area of the body surface exposed, and the distance from the body (6). Ideally, phototherapy devices emit light that covers the largest possible body surface area, are durable, and can produce optimal wavelengths and irradiance (460-490 nm and

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≥30W/cm^2/nm) (7, 8). A recent study investigated the performance of phototherapy devices in 17 hospitals on Java, Indonesia (9). The study found that in nine hospitals, the irradiance levels were below the standard required for effective PT (<10 μW/cm^2/nm), and in eight hospitals, the levels did not reach the criteria for intensive phototherapy (30 μW/cm^2/nm). This may be due to the widespread use of fluorescent tubes, which are known to have higher irradiance decay, requiring more maintenance and more frequent bulb changes than LEDs (10). LEDs are advantageous due to their narrower wavelength range, minimal heat generation, and low maintenance requirements, making them particularly beneficial for low-resource settings (11, 12). Conventional phototherapy in hospitals often separates the newborn from their parents and suspends breastfeeding during the treatment period. This has raised concerns about the need for alternative methods of effective phototherapy while maintaining the importance of family-centered care (13). The uses of portable phototherapy devices potentially become a new strategy to reduce barriers to breastfeeding and family care. This study introduces the Airlangga Bilirubin Nesting (AirBiliNest), a novel wearable phototherapy device consisting of blue monochromatic LEDs integrated into a sleeping bag. AirBiliNest offers portability and controlled dosage via a mobile phone interface. Its portability supports the maternal bond and facilitates breastfeeding. However, to implement these devices, there is a need for validation of their temperature, irradiance, and irradiance decay. Therefore, this study aims to evaluate the temperature, irradiance, and irradiance decay of AirBiliNest at different intensities. The acceptance of healthcare personnel also needs to be confirmed to understand their opinion on implementing these devices in the future.

Methodology

Study Design

A study mimicking phototherapy practice was conducted at the Neonatology Unit of Airlangga Teaching Hospital, Surabaya, Indonesia, to evaluate the performance of the AirBiliNest phototherapy device and its acceptance among healthcare workers. Using a mannequin, researchers measured the temperature, irradiance, and irradiance decay of the AirBiliNest lamp over a 48-hour period, with measurements recorded every 12 hours with standardized instruments. Concurrently, AirBiliNest was introduced to medical personnel at Airlangga Teaching Hospital, Surabaya, and Abadi Regional Public Hospital, Samboja. Following a preface training session, participants completed a questionnaire assessing the device's accessibility and potential for future use in healthcare services. This study gained ethical approval from the Ethical Committee of Airlangga Teaching Hospital (No. 066/KEP/2024) as per the Declaration of Helsinki.

AirBiliNest

The AirBiliNest is a novel phototherapy device designed to provide effective jaundice treatment in neonates while ensuring portability and controlled light intensity. It consists of multiple components, including the electrical network, controller, blanket model, and overall component arrangement to optimize performance. The light source of the AirBiliNest consists of high luminance InGaN standard light-emitting diodes (LEDs) encased in 5 mm transparent plastic capsules, rated IP65, emitting light in the spectrum of 460-470 nm.

Figure 1: AirBiliNest

The blanket features four LED panels on the upper side and six on the lower side, each panel containing an array of 8x27 LEDs spaced 1 cm apart. Energy distribution across the blanket is achieved through parallel-series-parallel circuit schemes. The device demonstrates a maximum blue light intensity of 32 $\mu W/cm^2/nm$ across all sides of the blanket. Figure 1 provides a visual representation of the device, measuring 39 cm x 71 cm x 2 cm and weighing 1550 grams. A controller is used to control the intensity of the LEDs. It supplies electricity to the LEDs and the humidity and temperature sensors. The controller consists of two main components: the voltage regulator and the microcontroller, as seen in the controller function diagram in Figure 2. When power from the battery enters, it flows to the power control MOSFET and the controller via a step-down converter. The microcontroller then adjusts the power regulator using a pulse-width modulation (PWM) signal, which is connected to the LED lights on the blanket. The microcontroller being used is the ESP8266 which has a WiFi module integrated with it that can be used for communication with mobile phones. When the controller is turned on it creates a wifi hotspot that the user can connect with their smartphone with the given password, on the application, the user can see and adjust the intensity of the phototherapy light via the slider button, and see the temperature and humidity of the blanket bellow the intensity button. When the intensity is changed via the application it sends the information to the microcontroller, letting it change the power to the light, thus increasing or decreasing the intensity according to the user.

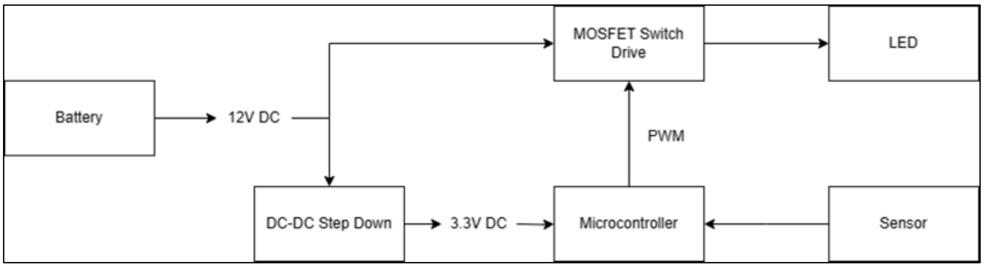

Figure 2: Controller Function Diagram

AirBiliNest functions like a typical sleeping bag, with its inner surface in contact with the baby's skin. It is crucial to consider the system's temperature to ensure the baby's comfort. AirBiliNest is designed with a zippered closure, allowing it to be used in an enclosed system or opened for air circulation to prevent hyperthermia. The desired temperature measured at the touch surface between the sleeping bag layer and the baby's skin should be within the average baby temperature of around 37°C-38°C. Although LED lamps emit less heat compared to incandescent and fluorescent lamps, they still generate some heat. Traditional methods to mitigate LED heat involve incorporating thermal grease and heat sinks (14). However, due to the constraints of the AirBiliNest's shape and flexibility, this approach is not viable. Therefore, efforts focused on minimizing heat transfer from the LEDs to the outermost surface in contact with the baby's skin. The challenge lies in finding a material that remains translucent, allowing LED light to penetrate while effectively reducing heat transfer. To address this, a polyester-based component was added between the LED and the contact surface. A sheet of 1 cm polyester (dacron layer) is used as the stuffing material for the sleeping bag, as shown in Figure 3A. Dacron adds a layer of softness and cushioning, providing a comfortable surface. The upper polyester (organza coating) is used to make the baby's skin-touch area comfortable. A layer of organza in the shape of a pocket is also added for additional heat absorption, as shown in Figure 3B. Organza is a sheer and lightweight fabric known for its fine mesh-like structure, which allows air to pass through.

The Figure 4 shows a blanket model that resembles a pocket to store a series of LED strip lights inside. All the parts are arranged into one blanket when the baby is used and wrapped. The top polyester (Organza) helps make the area touched to the baby's skin comfortable as a warmth absorber produced by the LED strip light as a blanket model that resembles a pocket and an additional layer that is glued with Velcro, the series of LED strips can be easily inserted and removed. Thus, other components outside the LED strip series can be washed repeatedly to maintain cleanliness.

Figure 3: Dacron Layer (A) and Organza Coating (B)

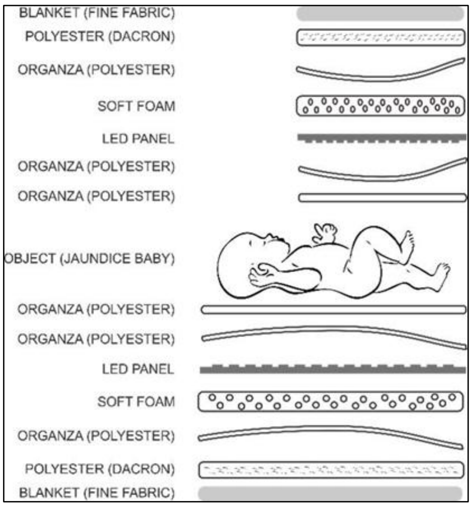

Figure 4: The Components Arrangement in the Phototherapy Blanket

The AirBiliNest phototherapy blanket has received an industrial patent (P00202102166). The system is smart with a technical design consisting of a smartphone (1), bluetooth connection systems (2), controller (3), sensor (5), and LED phototherapy (4). The microcontroller is integrated with a smart calculator and bundled with an intensitimeter. The AirBiliNest is designed as a nest to provide a womb-like environment for premature infants. During use, premature infants must be repositioned every 2 hours for proper growth and to prevent pressure sores.

Temperature Measurement

The testing took place by placing the AirBiliNest with a baby doll as a substitute for the baby and closing the blanket's zipper (enclosed system) in an open crib infant warmer. The temperature values were measured on the surface in contact with the baby doll's skin. Throughout the trial, the temperature in the infant incubator was maintained within the normal range. The infant warmer used in this test also features a thermostat that functions as a safety device; if the temperature exceeds the safe limit, the thermostat disconnects the heater, and a buzzer sound is activated. The temperature and humidity measurements were displayed on the LCD. The temperature sensor used in this research is a phototherapy control unit-recommended temperature sensor, the DHT22, which measures using a digital temperature sensor with an accuracy of 0.5°C. The DHT22 can measure temperatures between -55°C and 125°C (15).

Irradiance Measurement

Measurements were made based on the area due to the arrangement of LEDs (16). Measurements were made at 28 points with the same size of 8 cm × 9 cm to determine the average temperature distribution and irradiance value of each area. The voltage to be set on the voltage regulator is about 12V DC. Irradiance data was collected five times for each point to examine the consistency of the resulting values. Irradiance measurements (μW/cm^2/nm) were recorded using a duly calibrated Ohmeda BiliBlanket Meter II over a 48-hour period. This spectroradiometer was chosen for its widespread use and its sensitivity across a broad spectral range (400–520 nm, with peak sensitivity at 450 nm) and dynamic range (0.1–299.9 μW/cm^2/nm) (17). Its spectral and dynamic ranges align with both the bilirubin absorption spectrum and the phototherapy delivery range. Once all data sampling was finished, the Δ difference of irradiance in μW/cm^2/nm was calculated, and the irradiance decay of each PT device was compared. The irradiance decay velocity (μW/cm^2/nm/hour) of use was also measured.

Technology Acceptance Model (TAM) Questionnaire

The AirBiliNest was introduced to healthcare workers, including midwives, pediatric residents, and pediatricians, at Airlangga Teaching Hospital, Surabaya, and Abadi Regional Public Hospital, Samboja. After the introductory training session, participants were asked to complete a questionnaire regarding their views on the ease of use and potential future use of AirBiliNest. The questionnaire used for this study was adapted and developed from Davis' Technology Acceptance Model (TAM) (18). The questionnaire had four main parts: Perceived usefulness; Perceived ease of use; Subjective norms, and Intention to use AirBiliNest in the future. There were 14 questions in total, and seven possible answers could be given for each question, ranging from 1 (strongly disagree) to 7 (strongly agree).

Results

Temperature

Temperature measurements during the use of AirBiliNest are shown in Table 1. There were no signs of overheating in the cables, connectors, or LED strip lights. A comparative analysis of temperature changes in AirBiliNest was conducted at intensities of 10 μW/cm^2/nm, 20 μW/cm^2/nm, and 30 μW/cm^2/nm. The results revealed that at an intensity of 10 μW/cm^2/nm, was the lowest temperature change across all time measurements. At an intensity of 30 μW/cm^2/nm, the temperature after 24 hours exceeded 40°C.

Table 1: Temperature Measured During the use of AirBiliNest

Intensity Set	Location	Temperature, °C (Mean) Initial Measurement	24 Hour Measurement	48 Hour Measurement
10	Room	29.4	29	29
	AirBiliNest	29.4	34.5	34.6
20	Room	30	29	28
	AirBiliNest	29.6	39.1	39.6
30	Room	29	29	30
	AirBiliNest	28.2	41.8	41.5

Irradiance

Irradiance measurements during the use of AirBiliNest are shown in Table 2. The results revealed that at an intensity of 10 μW/cm^2/nm, the AirBiliNest provided 15.39 ± 0.4 μW/cm^2/nm and 11.29 ± 0.3 μW/cm^2/nm for the upper and lower parts, respectively. In all intensity settings, the light intensity values were lower in the lower part than in the upper part of AirBiliNest.

Table 2: Irradiance Measured During the Use of AirBiliNest

Intensity Set	Blanket Part	Irradiance, μW/cm2/nm (Mean ± SD)
10	Upper	15.39 ± 0.4
	Lower	11.29 ± 0.3
20	Upper	26.77 ± 0.8
	Lower	19.51 ± 0.7
30	Upper	34.65 ± 0.8
	Lower	28.29 ± 1.0

Table 3: Irradiance Decay over Hours of AirBiliNest

Intensity Set	Blanket Part	Irradiance, μW/cm2/nm (Mean ± SD) Initial Measurement	24 Hour Measurement	48 Hour Measurement	Delta	Decay Velocity (Per hour of use)
10	Upper	15.39 ± 0.4	14.54 ± 0.3	14.81 ± 0.4	0.58	0.012
	Lower	11.29 ± 0.3	10.89 ± 0.4	11.05 ± 0.4	0.24	0.005
20	Upper	26.77 ± 0.8	24.33 ± 0.7	28.52 ± 0.9	1.75	0.035
	Lower	19.51 ± 0.7	18.65 ± 0.8	19.16 ± 0.7	0.35	0.007
30	Upper	34.65 ± 0.8	31.88 ± 0.9	31.89 ± 0.7	2.76	0.057
	Lower	28.29 ± 1.0	26.85 ± 1.1	26.85 ± 1.0	1.44	0.030

Irradiance Decay

Irradiance decay measurements during the use of AirBiliNest are shown in Table 3. The irradiance decay per hour of use at an intensity of 10 μW/cm^2/nm was 0.012 μW/cm^2/nm. Higher intensity usage resulted in higher irradiance decay per hour of use. The upper part consistently showed higher irradiance decay than the lower part.

Technology Acceptance Model Questionnaire

The technology acceptance model questionnaire results are shown in Table 4. A total of 32 participants were included, with 11 participants from Airlangga Teaching Hospital and 21 participants from Abadi Regional Public Hospital. Most participants were aged below 40 years and worked as nurses. The educational background and years of experience varied. The average responses of participant's favored better perceived usefulness, perceived ease of use, subjective norms, and intention to use. From a 7-point Likert scale, the average answer for almost all statements was above 5, with one question regarding "AirBiliNest enables you to evaluate the effectiveness of phototherapy treatments performed" having an average answer of 4.82 ± 2.6.

Table 4: Participants Characteristics and Results of Technology Acceptance Model Test

Variables / Statement	Airlangga University Teaching Hospital	Abadi Regional Public Hospital
Age		
20-29 years	4 (36%)	4 (19%)
30-39 years	1 (9%)	10 (48%)
40-49 years	2 (18%)	7 (33%)
50-59 years	4 (36%)	0 (0%)
Educational Background		
Diploma	5 (45%)	9 (43%)
Bachelor	1 (9%)	0 (0%)
Bachelor + Profession	2 (28%)	6 (28.5%)
Specialist	3 (27%)	6 (28.5%)
Years of Experience as Healthcare Worker		
0-4 years	2 (18%)	5 (24%)
5-9 years	3 (27%)	7 (33%)
10-14 years	1 (9%)	7 (33%)
15-19 years	1 (9%)	2 (10%)
>20 years	4 (36%)	0 (0%)

Profession		
Nurse	8 (73%)	6 (28.5%)
Midwife	0 (0%)	6 (28.5%)
General Practitioner	0 (0%)	4 (19%)
Pediatrician	3 (27%)	5 (24%)
Answer of Questionnaire, average from 7-point likert scale		
Perceived usefulness (Mean ± SD)		
1. AirBiliNest helps you provide phototherapy for jaundiced babies quickly.	5.09 ± 2.65	5.95 ± 0.79
2. AirBiliNest assists you in managing the execution of phototherapy treatments.	5.36 ± 2.47	6.05 ± 0.90
3. AirBiliNest helps you improve the quality of phototherapy outcomes.	5.09 ± 2.62	5.86 ± 0.71
4. AirBiliNest enables you to evaluate the effectiveness of the phototherapy treatments performed.	4.82 ± 2.6	5.90 ± 1.06
Perceived ease of use (Mean ± SD)		
1. Learning to use AirBiliNest is easy for you.	5.36 ± 2.33	6.05 ± 0.84
2. You find that AirBiliNest makes it easy to obtain information on the intensity of phototherapy provided to the baby.	5.36 ± 2.45	6.10 ± 0.92
3. You feel that the intensity information displayed by AirBiliNest is clear.	5.45 ± 2.42	6.05 ± 0.79
4. You find AirBiliNest flexible to use.	5.36 ± 2.42	6.24 ± 0.75
Subjective norms (Mean ± SD)		
1. Your colleagues consider AirBiliNest important for you.	5.45 ± 2.24	5.62 ± 1.36
2. It is important to your colleagues that you recommend using AirBiliNest.	5.45 ± 2.35	5.67 ± 1.04
3. Your colleagues expect that you will continue to use AirBiliNest.	5.18 ± 2.28	5.76 ± 0.87
Intention to use (Mean ± SD)		
1. You intend to use AirBiliNest at your workplace.	5.64 ± 2.24	6.10 ± 0.81
2. You predict that you will use AirBiliNest at your workplace.	5.64 ± 2.24	5.95 ± 0.84
3. You plan to use AirBiliNest at your workplace.	5.55 ± 2.24	6.05 ± 0.84

Discussion

Temperature

Several specific considerations related to the infant's clinical condition influence the choice of using AirBiliNest. Infants are sensitive to temperature changes, especially preterm babies (19). The environmental temperature for infants in neonates is maintained to achieve a core temperature at rest between 36.7°C and 37.3°C. This varies based on postnatal age and body weight, as described by the neutral thermal environment (20). Monitoring temperature changes in AirBiliNest while being used in an infant warmer is essential to determine the optimal intensity with a temperature that remains comfortable for the baby. This is also a general safety measure to ensure that the device functions properly and does not pose a risk of dehydration or hyperthermia to the baby (21). An intensity of 10 μW/cm²/nm indicates stable temperature changes with low increases, making it suitable with the neutral thermal environment recommendation. The use of 20 μW/cm²/nm resulted in higher temperatures than required. The temperature can be decreased by opening the system every 15 minutes to prevent hyperthermia. However, this may require continuous temperature observation, which is not ideal due to healthcare worker overload (22). Therefore, new modifications are needed to reduce the temperature of AirBiliNest at intensities of 20 μW/cm²/nm or above.

Irradiance

The American Academy of Pediatrics defines the required light intensity value as a minimum of 10 μW/cm²/nm for standard phototherapy and 30 μW/cm²/nm for intensive phototherapy (23). Optimal phototherapy can be achieved either by increasing the intensity or increasing the infant's body surface area exposed to the light (24). Our results showed that the intensity delivered from the AirBiliNest device at the upper and lower parts exceeds the minimum recommended for standard phototherapy. Moreover, when the intensity is set to 30 μW/cm²/nm, it can exceed the recommended minimum for intensive phototherapy. As seen in the results, higher irradiance is provided from the upper part than the lower part of the AirBiliNest device. This can be explained by the imbalance in power consumption. With the same power input, the power consumption on the lower layer is divided into 6 LED panels, while on the upper layer it is only divided into 4 LED panels. The parallel format of light placement may account for this issue, and further effort is needed to calculate the average intensity received by the baby during the use of AirBiliNest (25).

Irradiance Decay

The irradiance decay velocity at all intensities ranged from 0.012 to 0.057 μW/cm²/nm per hour of use. This is comparable to the overhead phototherapy device irradiance decay velocity in Indonesia, which ranges from 0.01 to 0.08 μW/cm²/nm per hour of use (12). The results also revealed notable differences in the hourly intensity decay velocity between the upper and lower parts of the phototherapy blanket. This discrepancy could be attributed to differences in intensity derived from the upper and lower parts of the phototherapy blanket. Higher intensity settings typically increase heat generation within the phototherapy device, especially in the LEDs. This heat can accelerate the degradation of the LEDs, leading to faster decay in irradiance over time (10).

Technology Acceptance Model

Feedback from healthcare workers obtained through the Technology Acceptance Model (TAM) questionnaire indicates a positive perception of the AirBiliNest in terms of perceived usefulness, ease of use, subjective norms, and intention to use. This suggests that the device has the potential to be well-received and integrated into clinical practice. This also seems in agreement with another study from other low-middle income countries which delved into acceptance among healthcare workers, suggesting that the use of portable phototherapy came in handy for curtailing workload in healthcare services (26). Furthermore, an emerging body of literature has inferred how portable home phototherapy devices were effective in declining serum bilirubin levels in newborns (27, 28). These accede to the potential of AirBiliNest, as another instance of such a medical technology, for a wider use in Indonesia.

Effectively and Safety

The AirBiliNest's design features, including its zippered closure system, arrangement of LED panels, and incorporation of temperature and humidity sensors. Strategically arranged LED panels delivers stable and uniform irradiance for effective bilirubin reduction, therefore addressing the practical challenges associated with effectivity of neonatal phototherapy. The use of LED technology offers advantages in terms of energy efficiency, heat generation, and durability compared to traditional light sources (11). The integrated temperature and humidity sensors provide real-time mobile monitoring of patient safety. The use of cost-effective, locally sourced materials and a portable configuration reduce production costs relative to conventional devices. The use of blanket phototherapy device increase the accessibility, by provide their availability in resource-limited settings and supports maternal bonding and breastfeeding. This makes it suitable for both hospital NICUs, where mobile monitoring and controlled irradiance complement standard protocols, and for rural home-based care, where conventional equipment is often inaccessible (29). AirBiliNest's performance expected to be in line with previous studies using blanket phototherapy device compare to conventional phototherapy. Study by Costello *et al.,* reported almost similar treatment durations between conventional phototherapy and the BiliBlanket (mean durations of 44 and 42 hours, respectively) and both methods were well accepted by parents and healthcare staff (30). However, one of the blanket trials in the KMC programme demonstrated a significantly greater reduction in bilirubin levels with the blanket phototherapy device compared to conventional device. This finding supports the potential of innovative phototherapy devices to minimizing mother-and-child separation which contributes meaningfully to the humanisation of newborn care (31). Previous study found no significant different of side effects reported in either group (30). Similarly, Montealegre *et al.*, in the trial using the Bilicocoon Blanket, found no significant differences in final temperatures, rehospitalization rates, adverse effects, or mortality compared to conventional methods (31). Although a minor occurrence of exanthema was observed in blanket phototherapy group, this difference was not statistically significant. These results confirm the comparable efficacy between blanket and conventional phototherapy. Studies report that LED phototherapy does not induce significant oxidative DNA damage or adversely affect oxidant/antioxidant status in neonates (32, 33). Similarly, another research demonstrated that LED phototherapy not only effectively reduces bilirubin levels but also presents a safer profile in terms of oxidative stress markers compared to conventional methods, with minimal adverse effects (34). These findings support the short-term safety of LED-based devices like AirBiliNest; however, comprehensive long-term follow-up studies are essential to fully validate the safety of this innovative approach in neonatal care.

Limitation

This study acknowledges several key aspects that require further investigation. First, this study was limited to laboratory test without human subjects; the findings are preliminary and cannot yet be generalized to clinical practice. Second, a comprehensive cost analysis comparing the AirBiliNest with traditional phototherapy equipment still not detailed in this study. Third, these studies only provide descriptive analysis, and not incorporate statistical measures that would allow more precise quantification of the device's efficacy and safety. Finally, the evaluation was confined to short-term used, leaving long-term used impacts unaddressed. These limitations underscore that while the initial findings are promising; these results remain preliminary and necessitate further investigation through comprehensive studies before generalizing the results to broader clinical applications.

Conclusion

AirBiliNest demonstrates efficacy in delivering phototherapy, as evidenced by its ability to maintain irradiance levels within acceptable ranges for effective treatment of hyperbilirubinemia. The AirBiliNest addresses the challenges associated with neonatal hyperbilirubinemia, offering a combination of efficacy, safety, and accessibility, especially for providing optimal standard phototherapy. Improving temperature control to provide a neutral thermal environment is crucial for supporting the implementation of AirBiliNest for intensive phototherapy. Further research and clinical validation are warranted to confirm its long-term effectiveness and impact on patient outcomes and parental satisfaction.

Abbreviations

AirBiliNest: Airlangga Bilirubin Nesting, BIND: Bilirubin-Induced Neurological Dysfunction, DHT22: Digital Humidity and Temperature Sensor, IP65: Ingress Protection Rating (Dust-tight and Water-resistant), LED: Light-Emitting Diode, PWM: Pulse-Width Modulation, TAM:Technology Acceptance Model, WiFi: Wireless Fidelity, $\mu W/cm^2/nm$: Microwatts per Square Centimeter per Nanometer.

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None.

Author Contributions

Mahendra Tri Arif Sampurna: conceptualization, methodology, supervision, writing – original draft, review and editing, Andi Hamim Zaidan: funding acquisition, resources, supervision, writing – review and editing, Muhammad Nafik Hadi Ryandono: data curation, formal analysis, visualization, writing – original draft, Valentinus Mahendra Aaron Quendangen: data curation, formal analysis, visualization, writing – original draft, Visuddho Visuddho: investigation, validation, software, writing – review and editing, Syah Reza Budi Azhari: project administration, methodology, writing – review and editing. Surya Ayu Audina: resources, visualization, writing – review and editing, Muhammad Pradhiki Mahindra: formal analysis, validation, writing – review and editing, Muhammad Pradhika Mapindra: investigation, writing – original draft, writing – review and editing.

Conflict of Interest

The authors stated that there is not conflict of interest.

Ethics Approval

The study received ethical approval from the Ethical Committee of Airlangga Teaching Hospital (No. 066/KEP/2024).

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