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OVERVIEW OF THE EFFECTIVENESS OF LIGHT EMITTING DIODE (LED) AND COMPACT FUORESCENT LAMP (CFL) PHOTOTHERAPY ON NEONATORY JAUNDICE BILIRUBIN LEVELS

Tia Setiawati, Maya Amalia*, Sipa Dwi Astuti
Universitas 'Aisyiyah Bandung, Jl. K.H. Ahmad Dahlan Dalam No.6, Turangga, Lengkong, Bandung, Jawa Barat 40264, Indonesia
*mayaamalia@unisa-bandung.ac.id

ABSTRACT
Neonatal jaundice is the condition of a newborn with high levels of bilirubin, which can cause various negative impacts on the baby, such as neurological abnormalities, mental retardation and seizures. The main treatment that can be done is by administering light phototherapy. Preliminary studies in the city of Bandung, there are still hospitals in Bandung that use phototherapy with the Compact Flourescent Lamp (CFL) type of lamp and there are also hospitals that use phototherapy with the Light Emitting Diode (LED) type. Objective: The aim of this research is to identify the effectiveness of LED and CFL phototherapy in reducing bilirubin levels in babies with neonatal jaundice in Bandung City. Method: This research method is a quasi-experiment with a retrospective approach. The sample for this study was 72 babies who were given phototherapy from January to July 2023. The data collection technique used data recorded at hospitals in Bandung City. Data was collected with checklist sheets and data analysis using the independent sample t test. The research locations were Bandung Kiwari Hospital and Bandung Muhamadiyah Hospital. Results: The results of the independent t-test showed a significant difference in total serum bilirubin values in the two groups before and after phototherapy (sig coefficient = 0.000 < 0.05). The group of neonates with CFL had a bilirubin value of 9.3989 which was higher compared to the group of neonates with LED phototherapy, namely 6.4189. LED phototherapy is more effective in reducing bilirubin compared to CFL phototherapy. Conclusions: Hospital policies to add LED phototherapy facilities can be considered, because they are more effective in reducing bilirubin levels.

Keywords: hyperbilirubinemia; jaundice; LED; newborns; phototherapy

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INTRODUCTION

One of the health problems that often occurs in neonates is neonatal jaundice, where a condition where serum bilirubin levels increase in newborns, or is called hyperbilirubinemia. In Indonesia, the mortality rate for babies aged 0 to 12 months is around 28 deaths out of 1000 live births, one of the causes of death is neonatal icterus. Infant mortality due to neonatal jaundice reached 5.6%(Indonesian Ministry of Health, 2018). Data shows that of 272 newborns, 139 neonates (51.1%) experienced neonatal jaundice (Luciano et al., 2019). Neonatal jaundice is considered pathological if hyperbilirubinemia appears in the first 24-36 hours of life, serum bilirubin increases at a rate of more than 5 mg/dl/day, jaundice persists after 10-14 days of life, conjugated bilirubin levels > 2 mg/dl (Wiegert & Mai, 2022). The impact that can occur is the risk of neurological damage due to bilirubin poisoning or death in newborns with low birth weight (Pace et al., 2019). Complications in the form of kernicterus are caused by the deposition of bilirubin in the brain which causes bilirubin encephalopathy and neurodevelopmental defects and is permanent(Asghar et al., 2021). The high level of bilirubin that causes neurotoxicity in each baby varies and depends on several factors such as acidosis, gestational age, postnatal age, rate of increase in serum bilirubin, serum albumin

concentration, and related diseases (Gutta et al., 2019). Management of neonatal jaundice is aimed at reducing the level of unconjugated bilirubin in the blood to return to normal, so that the value does not reach high-risk levels that can damage the nervous system (neurotoxic) (Joel et al., 2021). The main therapy recommended is light therapy or phototherapy (Augurius, C., Susanto, S., & Septiana, 2021).

Phototherapy has a fairly high level of efficiency and safety in reducing serum bilirubin levels and can prevent or reduce neurotoxic effects on the nervous system of new babies (Wang, J., 2021). The current uses of phototherapy are diverse. The type that has long been used is conventional phototherapy, which uses a compact fluorescent lamp (CFL), replaced according to maximum age and the phototherapy equipment is placed at a distance of 30 cm from the patient. According to Santosa el al (2020), conventional phototherapy can reduce bilirubin levels for longer than intensive phototherapy, thus potentially causing inefficiency. The research results of Santosa et al., (2020) state that conventional phototherapy is effective in reducing bilirubin levels but is less efficient. This relates to the average time of use of CFL phototherapy of 60.27 hours. Comparative analysis between bilirubiun levels before and after phototherapy showed a significant decrease in bilirubiun ($p<0.001$) from 17.23 +- 5.04 mg/dl to 10.18 +- 2.02 mg/dl. And the average length of stay was 4.48+--4.47 days, with a rate of decrease in bilirubiun levels of 0.12 mg/dl per hour.

Phototherapy is the main choice in the treatment of neonatal hyperbilirubinemia throughout the world because of its non-invasive nature, affordable costs, and minimal risk of side effects. This therapy is most effective when using light with a wavelength between 420 to 490 nm, which is in the blue to green spectrum, to reduce serum bilirubin levels (Purkait & Mondal, 2020). In general, phototherapy devices also provide guidance regarding crucial factors that must be considered, such as radiation intensity, the amount of blue-green light emitted, the area of skin exposed to light, and the decrease in bilirubin levels in the first 4-6 hours after a phototherapy session. Phototherapy with blue light (430-490 nm) is the main therapy for treating non-conjugative hyperbilirubinemia because it stimulates the isomerization of bilirubin which allows it to be excreted in the urine, reducing the liver's workload. Phototherapy using Light Emitting Diode (LED) in the form of a bag or blanket has been proven to be more effective in reducing bilirubin levels more quickly than Compact Fluorescent Light phototherapy or conventional phototherapy. The use of LEDs also reduces the side effects associated with phototherapy, reduces the time required for phototherapy sessions, reduces the light exposure required to reduce unconjugated bilirubin, and reduces costs and hospital days (Widhiastuti, 2024).

Based on the type of phototherapy that is commonly used, it consists of UVB Phototherapy (Ultraviolet B). UVB Phototherapy is a treatment method that uses short-wave ultraviolet radiation. There are two types of UVB phototherapy, namely broadband UVB which utilizes the full spectrum from 300 nanometers to 320 nanometers, and narrowband UVB which focuses on a wavelength of 311 nanometers. Side effects that may occur in the short term include dry skin, an itchy red rash appearing within 6-24 hours after treatment, and sometimes sunburn. There is also a risk of reactivation of the herpes simplex virus, which can be prevented by using a sunscreen balm on the lips. Phototherapy can also worsen pre-existing skin conditions or trigger photodermatosis. In addition, sometimes there is increased pigmentation in the treated area. In the long term, side effects include skin aging and an increased risk of skin cancer. Individuals who have undergone more than 500 treatment sessions may require special monitoring for this risk (WoS, 2021)

PUVA Phototherapy (Psoralen Plus Ultraviolet A) The next type of phototherapy is Psoralen Plus Ultraviolet A or PUVA, also known as photochemotherapy. This type of phototherapy combines UVA light with the drug psoralen. Psoralen medication can be taken in pill form or applied topically to the skin. Psoralen can help the skin become more sensitive to UVA rays. PUVA is usually performed when treatment using UVB phototherapy is unsuccessful. PUVA (Psoralen Plus Ultraviolet A) can cause a number of side effects that need to be taken into account. These include reactions such as burning of the skin, itching, and nausea that may occur during or after therapy. PUVA therapy can produce a tanning process that makes the skin appear tanned for several months. However, even if the skin appears tanned, sensitivity to sunlight remains high, and the skin can still burn quickly if exposed to sunlight. In the long term, the use of PUVA can risk eye damage, such as cataracts or pterygium, and has the potential to accelerate skin aging. In addition, PUVA therapy also increases the risk of developing skin cancer, so long-term use should be considered carefully and closely monitored by medical professionals (Li et al., 2022)

Recent studies show that the use of LED phototherapy results in a more effective reduction in total bilirubin (TSB) levels. All effective phototherapy methods are able to reduce TSB to a safe range. The evidence is that double LED phototherapy has proven effective in managing hyperbilirubinemia in newborn babies (Abrams et al., 2023., Widhiastuti, 2024). Conventional phototherapy units use light sources such as compact fluorescent lamps (CFLs), halogen spotlights, and fiber optic blankets for contact applications. However, these devices have significant drawbacks such as high heat production and limited exposure area. In contrast, new gallium nitride-based light-emitting diodes (LEDs) have been developed with higher radiation intensity, narrower spectrum wavelengths, and minimal heat production. LEDs also have a much longer lifespan, averaging 20,000 hours compared to 2000 hours for CFLs. This LED unit can be placed very close to newborn babies without causing significant side effects (Purkait & Mondal, 2020)

Currently, phototherapy equipment has been developed with a type of lamp that has an intensive light-emitting diode (LED) in an effort to shorten the duration of phototherapy. The rate of reduction in bilirubin between compact fluorescent lamp (CFL) phototherapy and LED phototherapy is not significantly different (Ebbesen et al., 2023) but some experts state that LED is better (Reda et al., 2019). (Khunte et al., 2019) assessed the significant difference between total and initial bilirubin levels during the first four days of using phototherapy with CFL lamps and super LED phototherapy lamps. This study stated that there was a difference in the amount of total serum bilirubin after using LED lights, namely 11.71 mg/dl and 8.86 mg/dl after using CFL lights. The total serum bilirubin count when using LED lights decreased from 11.12 to 5.30, and from 9.11 to 6.32 when using CFL lights. However (Shoris et al., 2023). states that a wider illumination area and a higher intensity value indicate that flourescent lamps are more effective compared to LED lamps.

Preliminary studies were carried out in Bandung City, at Muhamadiyah Bandung Hospital and Bandung Kiwari Hospital. These two hospitals received approximately 150 neonatorum jaundice in the last 3 months. Muhamadiyah Hospital Bandung still uses CFL light type phototherapy, while Bandung Kiwari Hospital uses LED phototherapy. The aim of this study is to describe and identify the effectiveness of phototherapy with LED and CFL types in reducing bilirubin levels in neonatal jaundice. It is hoped that the benefits of this research will increase information and can be used as material for evaluating the implementation of management and improving subsequent management from a medical and management perspective so that better service quality can be achieved in the future.

METHOD

This research uses a quasi-experimental type with a retrospective approach. The study population was newborn babies with a medical diagnosis of icterus neonatorum. The population with neonatal jaundice in these two hospitals during the last 3 months (February - April 2023) was 150 babies. The number of samples based on Slovin's calculations resulted in a sample of 72 babies who would be divided into 2 groups evenly. The first group consisted of 36 baby data recorded using phototherapy from a CFL lamp and the second group included 36 baby data using phototherapy from an LED lamp. The type of data is secondary data, including complete bilirubin values before and after phototherapy at both hospitals, as well as data on the baby's weight and gestational age. Researchers have given informed consent to the medical records at both hospitals in the data collection process. Next, the researchers carried out an apperception with enumerators, namely executive nurses at Muhamadiyah Hospital Bandung and nurses at Bandung Kiwari Hospital in the data collection process. The enumerator then collects recorded data on the status of patients who have completed treatment at the hospital.

Data normality testing in this study used Shapiro-Wilk because the sample was less than 50 respondents for each group. The homogeneity test used in this research used the anova test. Hypothesis testing in this research will use the independent sample t test. This t test is used to compare the means of two groups that are not related to each other. This aims to find out whether the two groups have the same average or not. Ethical approval for this research from the Ethics Committee of 'Aisyiyah Bandung University with Number: 683/KEP.01/UNISA-BANDUNG/IX/2023.

RESULTS

Table 1.
Demographic Characteristics of Newborns with Hyperbilirubinemia (n=36)

Characteristics	CFLs (n = 36)			LEDs (n = 36)			P value
Weight	2774.44	±	356.33	2722.33	±	510,825	0.617
Age	37.83	±	0.74	36.81	±	2,315	0.013

The results of this study show that the characteristics of neonatal jaundice using CFL phototherapy are at Muhamadiyah Hospital Bandung with a sample size of 36 people, with an average body weight of 2774.44.± 356.33 whereasgestational age 37.83±0.74. Meanwhile, the characteristics of neonatal jaundice using LED phototherapy were at Kiwari Hospital Bandung with a total of 36 samples, with an average body weight of 2722 grams.± 510.825, and gestational age 36.81 ± 2.315. From statistical analysis, the two groups did not have a significant difference regarding body weight (p = 0.617) while there was a significant difference in age (p = 0.013). However, if you look at it theoretically, the gestational age of newborn babies aged 36 and 37 is almost the same, namely close to the mature age of neonates.

Table 2.
Comparison of Bilirubiun Values Before and After Being Given CFL and LED Phototherapy on Total Bilirubin from Nenatorum Jaundice (n=36)

Types of phototherapy	Pretest			Posttest			P Value
CFL	14.67	±	1.49	9.40	±	1,393	0,000
LEDs	13.15	±	1.82	6.42	±	1,614	0,000

The bilirubiun values before phototherapy and the bilirubiun values after phototherapy in table 2 show that there was a decrease in bilirubiun after phototherapy. The neonatal icterus group with CFL phototherapy before being given phototherapy was 14.67±1.49, after being given CFL phototherapy it became 9.40±1,393. Meanwhile, the neonatal icterus group with

LED phototherapy before therapy was 13.15± 1.82to 6.42±1,614. Both types of therapy have a statistically significant effect as proven by the p value = 0.000.

Table 3.
Differences in the Effectiveness of CFL and LED Phototherapy on Total Bilirubin in Hyperbilirubin Neonates (n=36)

Types of phototherapy	CFLs (n = 36)			LEDs (n = 36)			P Value
Pretest	14.67	±	1.49	13.15	±	1,815	0,000
Posttest	9.40	±	1.39	6.42	±	1,614	0,000

The difference in the effect of the two phototherapies can be seen in table 3. The neonatal icterus group with LED phototherapy experienced a decrease in bilirubin levels to 6.42.±1.614, while the icterus neonatorum group with CFL was 9.40±1.393, where both p values = 0.000. The effectiveness of LED phototherapy in reducing bilirubin is lower than the effectiveness of CFL phototherapy. So it can be said that LED phototherapy is more effective than CFL phototherapy.

DISCUSSION

Phototherapy has been the mainstay of treatment with minimal side effects for neonatal icterus since the late 1950s. As time has gone by, the emergence of newer and better types of phototherapy has increased the options for use and also created confusion. Many types of lights have been used to provide phototherapy, from blue fluorescent lights in the late 50s to today's LED lights. They all have drawbacks ranging from heating issues, intensity issues to wavelength matching. The latest advancement is the use of LED phototherapy in all areas which is marketed as a better, safer and more efficient option than CFL types (MK et al., 2017). The success of phototherapy depends on changing the structure of the bilirubin molecule and allowing the photoproduct to be eliminated by the kidneys and liver without being metabolically changed. Therefore, the basic mechanism of action of phototherapy is the use of photoenergy to convert bilirubin into a more water-soluble product (Ismai, 2020).

In this study, 76 babies with icterus neonatorum received different interventions, namely 36 babies at Muhamadiyah Hospital Bandung received CFL phototherapy intervention and 36 babies at Bandung Kiwari Hospital received LED phototherapy intervention. The results of the study stated that there was an influence from both types of phototherapy, both of which reduced the bilirubin value before and after giving phototherapy with a p value = 0.000. However, from different test results, the reduction in bilirubin with LED was 6.42±1.614, while the icterus neonatorum group with CFL was 9.40±1.393, so the effectiveness of LED phototherapy in reducing bilirubin is lower than the effectiveness of CFL phototherapy. So it can be said that LED phototherapy is more effective than CFL phototherapy. This research is in line with Gutta et al., (2019), the results of the study stated that there was a significant difference in the average reduction in TSB (mol/L/hour) in the LED group (5.3 ± 2.91) when compared with the conventional group (3.76 ± 2.39) (p <0.001). However, research is different from research (Hidayat Fahrul, 2023). where bilirubin levels both decreased before and after phototherapy, but the difference was not significant. The mean in the LED group at baseline was 13.64 ± 5.98 gm/dl, while in the LED group it was 15.88 ± 5.44 gm/dl. Bilirubin examination after being given phototherapy in the LED group, the average bilirubin level after 24 hours was 8.47 ± 4.96 gm/dl and in the CFL group it was 9.538 ± 5.35 gm/dl. In both cases, there was a significant decrease in bilirubin within 24 hours, but there was no significant difference in the average bilirubin level after 24 hours (p-value = 0.30).

LED phototherapy is currently increasingly popular and is replacing previous sources of phototherapy. LED phototherapy is blue light in the form of a spotlight, or permanently

attached to the baby's bed unit or incubator. Uniform light, simple dimensions, light weight and high efficiency in power usage. LEDs last longer than other types of light sources (Ridhani et al., 2022). LED phototherapy systems using gallium nitride LEDs are the newest devices. These lamps emit light at the wavelengths most effectively absorbed by bilirubin and can be adjusted using varying proportions of blue, blue-green, and green lights. This material produces little heat and is safe to use near baby's skin (Gutta et al., 2019). Apart from that, LED phototherapy uses equipment that is energy efficient, has a longer service life, and is portable with minimal heat production. LED phototherapy has been shown to be effective in reducing total serum bilirubin levels, at the same rate as conventional phototherapy (Husnayain et al., 2023). In contrast to CFL phototherapy, LED phototherapy does not cause significant transepidermal water loss, because LEDs emit much less infrared radiation. During routine infant care, the average weight gain was 0.7%, independent of the light source (Shoris et al., 2023).

The importance of knowing the effectiveness of phototherapy is closely related to reducing bilirubin in the blood. Apart from being related to the dangerous impact of high bilirubin, this is also related to the duration of phototherapy use. The longer you use phototherapy, the side effects that can arise due to phototherapy in newborns include hemolysis, allergies, DNA damage, dehydration, or cancer (Wang et al., 2021). The results showed that phototherapy can increase the risk of genotoxicity in infant lymphocytes(Mesbah-Namin et al., 2017). Phototherapy carried out over a long period of time can cause erythema, dehydration, hyperthermia, diarrhea, hypocalcemia and retinal damage.(Kuboi T, Kusaka T, Okada H, Arioka M, Nii K, Takakashi M, 2019; Asghar et al., 2021; Shrestha et al, 2021; Gheshmi et al, 2015; Barekatain et al, 2016). Therefore, the quicker you use phototherapy to reduce bilirubin, the more side effects of phototherapy itself can be reduced

CONCLUSION

Neonatal jaundice is a condition where the bilirubin level in the blood increases more than 10 mg/dl. If good management is not given, this condition of hyperbilirubinemia can have negative impacts on newborn babies, such as neurotoxicity. The main treatment is phototherapy. The results of this study prove that LED phototherapy is more effective than CFL in reducing the average total serum bilirubin. From both phototherapy, no significant side effects were found. Further research regarding differences in length of stay, position and distance of the baby to the lamp may be able to influence better effectiveness

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