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CC –BY **An evaluation of phototherapy services in newborn units in Kaduna State Nigeria**

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**Abstract: Background**

Phototherapy (PT) for unconjugated hyperbilirubinaemia remains an important and invaluable intervention in the management of neonatal jaundice when appropriately and optimally employed. The efficiency of PT greatly depends on the irradiance of the device, which is measured using an irradiance meter. Available optimal phototherapy is a key desirable newborn service that should be offered and accessible in secondary and tertiary health care facilities.

**Objective:** The study aimed at determining the availability and irradiance measure of phototherapy devices in neonatal units in Kaduna state, Northwestern Nigeria.

**Materials and Methods:** The study was an action research survey of all hospitals providing newborn care in Kaduna state including public and private profit and nonprofit faith based facilities. Phototherapy devices in use in the facilities were documented (types, brand and bulbs). The average irradiance of PT device was measured using model 22 Olympic Bili – Meter™ at facility traditional PT distance and distance of optimal irradiance was also determined and documented. Facilities were introduced to and educated on protocols on neonatal jaundice and how to ensure optimization of irradiance and management of neonatal jaundice.

**Results:** None of the 31 public secondary health care facilities operated a newborn unit nor provided management for neonatal jaundice. Overall 15 facilities provided PT services of which 87% were non-government facilities made up of 15% faith based and 85% private for profit facilities. Only 13.3% facilities had PT devices which offered irradiance ( $> 10 \mu\text{W}/\text{cm}^2/\text{nm}$ ) suitable for conventional PT at the facilities' traditional PT distance this however, increased to 7 (46.7%) facilities with adjusted distances. Only 3 (20%) facilities had devices that could offer intensive PT (irradiance  $> 30 \mu\text{W}/\text{cm}^2/\text{nm}$ ) at varying distances. None of the surveyed facilities had a radiometer nor knew irradiance of their PT devices and neither did any have a written protocol for the management of neonatal jaundice. Expertise for and availability of exchange blood transfusion (EBT) services was available only in 26.7% of the facilities.

**Conclusions:** Private health care facilities constitute a major provider of neonatal jaundice health-care services however the services were grossly suboptimal and inadequate and will need significant and urgent improvement to enhance newborn health and indices.

**Keywords:** phototherapy, neonatal jaundice, newborn care, kernicterus, action research

**Introduction**

Neonatal Jaundice, a common cause of newborn morbidity, occurs in about 60% and 80% of term and pre-term newborns respectively.<sup>1</sup> The unconjugated type may be associated with increased mortality particularly when severe, while survivors may have life-changing complications which are rampant in developing coun-

tries due to lack of timely recognition and access to intervention as compared to developed countries.<sup>1-3</sup>

Phototherapy (PT), a key component in the management of unconjugated neonatal hyperbilirubinaemia, significantly reduces both the need for exchange blood transfusion (EBT) and neurologic complications of hyperbilirubinaemia.<sup>4-7</sup> The efficiency of phototherapy is influenced by several factors including the wavelength of

the bulbs used, the distance of the light source from the newborn and the surface area exposed to the light.<sup>5</sup> Arguably, of more importance however, is the amount of photo-energy – the irradiance - produced by the phototherapy device, which is a measure of the light energy at the skin surface expressed as  $\mu\text{W}/\text{cm}^2/\text{nm}$ ; the higher the irradiance the more efficient the PT device.<sup>3, 7-9</sup> The American Academy of Pediatrics recommends an irradiance of at least  $30 \mu\text{W}/\text{cm}^2/\text{nm}$  for intensive phototherapy.<sup>7, 8</sup> For conventional phototherapy, the limits are less well defined; generally, an irradiance of  $8-10 \mu\text{W}/\text{cm}^2/\text{nm}$  is thought to be effective.<sup>10, 11</sup> Concerns have been expressed about translating measured irradiance to clinical efficacy; however, currently there are no practical alternatives to measure efficiency of phototherapy other than measuring the irradiance of the PT device.<sup>12</sup> Irradiance measurement, achieved using an irradiance meter, is a standard procedure in many centers in developed countries.<sup>11, 13</sup> Studies have shown wide variability in the irradiance levels of phototherapy devices between hospitals in developed countries.<sup>8, 10, 14, 15</sup> Availability of expensive medical equipment, such as a radiometer, in resource-constrained communities is limited because of lack of affordability and maintenance capability.<sup>12</sup> It is conceivable therefore, that centers in such communities may be offering inefficient PT services.

In an effort to contribute towards ending preventable deaths of newborns and reducing neonatal mortality, one of the targets of SGD<sub>3</sub>, we set out to conduct an action research on phototherapy services in hospitals offering neonatal care in Kaduna state, Northwestern Nigeria with the aim to

1. Document availability of phototherapy devices in use in newborn care facilities in Kaduna state
2. Document the irradiance of phototherapy devices in newborn care facilities in Kaduna state

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## Method

The study was an action research cross sectional survey of all hospitals providing newborn care in Kaduna state including public nonprofit, private profit and faith based facilities. Government facilities providing secondary and tertiary health care were identified from the HMIS from the ministry of health while those offering neonatal services were subsequently identified by contact and phone conversation. Private and faith based facilities were identified via contact and from the guild of private medical practitioners. Each facility identified and included in the research was visited and after properly securing clearance and permission from the appropriate authority an interaction with the neonatal staff ensued using a predesigned proforma to document their neonatal jaundice services. The Ahmadu Bello University Teaching Hospital Zaria (ABUTH), a federal tertiary health facility with more than 30 intensive phototherapy devices and from where the protocols were designed was excluded from the survey to remove bias. Phototherapy devices in use in the facilities were identified and infor-

mation on brand of phototherapy, types and colour of tubes/ light source used, frequency and reason of replacing bulbs and distances at which phototherapy was being conducted as well as the irradiance measure at the facility standard distance and distance of best irradiance were documented. Irradiance was measured using model 22 Olympic Bili – Meter™ and phototherapy classified as conventional/ simple or intensive phototherapy. Units were also asked for guidelines for commencing and discontinuation of phototherapy, when and whether or not exchange blood transfusion is conducted and by whom. Neonatal unit staff were then introduced to protocols for the management of neonatal jaundice and were practically walked through how to improve the efficiency of their PT devices and how to determine when to change device tubes particularly stressing the significance and use of an irradiance meter. A stake holders meeting was planned through the state ministry of health to formerly present the findings of the survey and disseminate useful tools and information to improve and to standardize the management of neonatal jaundice in neonatal units in Kaduna state.

The study was approved by the health research ethics committee of the Kaduna state ministry of health.

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## Results

There were 31 secondary and 7 tertiary public nonprofit health care facilities in Kaduna state. Twenty eight of the secondary facilities are state owned and are distributed across the 23 local government area of the state. Three (3) of the 31 secondary health care facilities are federal government owned and ran by institutions for staff. One (14%) of the tertiary health care facilities is owned by the state government and ran by a tertiary institution while the other 6 (86%) are federal owned institutions. Three (50%) of the 6 federal owned tertiary health care institutions are mono -specialty facilities while the other 3 provided multi-specialty care including paediatric services out of which only 2 offered neonatal health care services. One of these 2 facilities was the ABUTH which was excluded from subsequent analysis. A total of 15 non-government facilities made up of 13 private for profit and 2 faith- based non-profit health care facilities providing neonatal health care services were identified within the state. Two (2) private for profit facilities declined consent and were excluded from the study

None of the 31 secondary health care facilities operated a newborn unit nor provided phototherapy and or management for neonatal jaundice. Overall 15 facilities provided Phototherapy services of which 13/ 15 (87%) were non-government facilities made up of 2/13 (15%) faith based and 11/13 (85%) private for profit facilities. The only state owned tertiary institution operated a neonatal unit and offered neonatal jaundice management services. None of the surveyed facilities had a radiometer nor knew irradiance of their PT devices and neither did any have a written protocol for the management of neonatal

jaundice. All facilities except 2 will change their PT device's bulbs only when the tubes became dim or no longer lit or after 2 years, while the 2 exceptions, which were private for profit, changed tubes after 2000 – 3000 hours. The decision to commence or discontinue phototherapy was largely on visual assessment of jaundice in 6 (40%) of the facilities while in the remaining facilities varying levels of serum bilirubin (SB) ranging from 6 to 15 mg/dl was considered starting levels; 3 of the facilities will commence phototherapy at SB of < 10 mg/dl, 4 will commence at 10- 14 mg/dl while only in 1 facility will phototherapy be commenced at SB  $\geq$  15 mg/dl. In one of the facilities commencement of PT was based on Serum bilirubin levels and age in days. None of the facilities discontinued PT at SB  $\geq$  15 mg/dl, 2 will discontinue at SB 10- 14 mg/dl while 5 of the facilities discontinued PT only when SB was < 10 mg/dl.

Expertise for and availability of exchange blood transfusion (EBT) services were available only in 4/ 15 (27%) of the facilities made up of 3 (75%) private for profit and the state owned tertiary facility

A total of 54 PT devices were studied. Eight (15%) of the PT devices were located in the 2 government tertiary facilities while the remaining 30 (56%) and 16 (29%) were located in the private and faith based facilities respectively. The highest number of PT devices found in any single facility was (14) in a faith based facility. Only 6 (11%) of the PT devices used special blue lights (light source with intense energy and narrow blue spectrum wavelength in the range 450- 470 nm) while majority of the devices 43 (80%) used ordinary blue and 5 (9%) devices used white light. All the PT devices used fluorescent tubes. Twenty two (41%) of the PT devices were commercially sourced branded devices while the majority (59%) were varyingly fabricated devices with no two facilities having a similar fabricated device. All the (8) PT devices in the 2 government facilities were branded devices accounting for 36% (8/22) of the commercial devices. Only 2 (13.3%) facilities had PT devices which offered irradiance ( $> 10 \mu\text{W}/\text{cm}^2/\text{nm}$ ) suitable for conventional phototherapy at the facilities' traditional PT distance this however, increased to 7 (46.7%) facilities with varying PT distances up to a minimum of 10 cm to obtain best irradiance. Only 3 (20%) facilities had devices that could offer intensive phototherapy (irradiance  $> 30 \mu\text{W}/\text{cm}^2/\text{nm}$ ) at varying distances. (Table 1)

**Table 1:** The irradiance of Phototherapy devices at traditional distance for phototherapy

Facility	Irradiance at traditional distance ( $\mu\text{W}/\text{cm}^2/\text{nm}$ )	traditional distance of phototherapy (cm)	Maximum attainable irradiance ( $\mu\text{W}/\text{cm}^2/\text{nm}$ )	Distance at Maximum irradiance (cm)
F1	5.1	55	11.1	35
F2	2.7	50	8.8	10
F3	3.3	50	11.5	10
F4	-	-	-	-
F5	3.2	55	6.2	10
F6	13.6	50	32.9	25
F7	5.7	45	11	10
F8	3.1	47	4.6	10
F9	5.1	50	6	10
F10	3.8	55	8.4	10
F11	1.6	40	2.3	10
F12	9.4	75	34.5	25
F13	33	25	40	10
F14	9.7	40	10.5	10
F15	6	45	26.1	25

## Discussion

Newborn jaundice healthcare services were provided mainly (85% PT, 75% EBT) by non-government facilities in Kaduna state as documented in the study. This establishes an important role being played by private health facilities in the provision of specialized neonatal care, a key step towards reducing neonatal and under-five mortality in the state and the country at large. It was difficult however, to identify which facilities provided newborn services from the HIMS in the state ministry. This suggests a gap that may make partnership and supervision to improve efficiency of specialized newborn care suboptimal. The fact that none of the government secondary health care facilities offer neonatal jaundice healthcare services also implies that services are possibly insufficiently available to the large number of newborns that may develop jaundice and require care and thus leaves them with the alternative to explore and patronize other unorthodox and perhaps even harmful care.

The provision of services across facilities in the survey where quite varied. While none of the facilities had a written protocol for management of neonatal jaundice, practice varied remarkably. As many as 40% of the surveyed facilities will commence phototherapy with visual/ clinical jaundice, a highly subjective method of assessment of level or severity of jaundice which may lead to inappropriate and inefficient management of jaundice as it may lead to under or over treatment of jaundice. This becomes even more worrisome when this finding is compared with the efficiency of the units being used to offer intensive phototherapy; where there is need to urgently bring down the level of serum bilirubin such that a baby subjectively assessed to have jaundice though high enough is exposed to a not optimal treatment. It also makes communication and research difficult as practice cannot be compared as no standards are being followed and as such efficiency of interventions in the state and across centres cannot be reliably studied. Overall, protocols provide minimum standard guides for care and, with respect to neonatal jaundice, will guide

providers in the entire management of newborns with jaundice but more so define who receives intensive PT. Availability of EBT services was found in only 27% of the facilities  $\frac{3}{4}$  of which were private for profit which suggests a dearth of facilities providing such services and may at the same time mean increase work burden for the few facilities providing this service with a tendency to inefficiency. All these will negatively impact on the desired target of reducing neonatal mortality a major target of the SDG<sub>3</sub>.

Eighty five percent of the facilities which provided phototherapy services were non-government facilities and fabricated PT devices were commonly used possibly because they were cheaper, more affordable and available in comparison to the branded devices which were likely to be more expensive and unavailable. The use of local fabricated devices though encouraging as it ensured availability, however, did not, like the branded, guarantee efficient phototherapy. Overall majority (86.7%) of the phototherapy devices studied at the facility traditional PT distance provided irradiance of  $< 10 \mu\text{W}/\text{cm}^2/\text{nm}$  which is sub optimal. A similar study in Netherland found 50% of the devices studied below this threshold.<sup>17</sup> The low suboptimal irradiance in this study is attributable to the protocol for the use and features of the PT devices. These include not measuring or knowing the irradiance of devices before commencement of phototherapy and lack of satisfactory irradiance for simple phototherapy from the devices even after assessment of the devices. The latter resulting from use of inappropriate bulbs (ordinary blue as against the special blue tubes, few tubes and poorly lighting/ expired tubes) and use of devices at a distance which gave poor irradiance. Though in a few of the devices some improvement was made by varying the distance, in others this could not be done either because the devices were fixed or could not be further adjusted due to design. For some of the devices which had improved irradiance suitable for simple PT ( $\geq 10 \mu\text{W}/\text{cm}^2/\text{nm}$ ) after distance adjustment, the effective irradiance distance (10 cm) was found not clinically suitable for phototherapy as the device became too close to the neonate and increased the risk of hyperthermia with its sequelae of increased insensible loss and dehydration as well as physical injury including burns.

Only 20% of the studied facilities and all of which were private for profit could provide intensive phototherapy which helps to reduce the rate of EBT. Owa and colleagues<sup>2</sup> in their study of 12 neonatal centres in South-western Nigeria found none able to provide intensive phototherapy. Similarly the expertise for and availability of EBT services were available only in 4/ 15 (27%) of the facilities made up of 3 private for profit and a state owned tertiary facility. These imply that neonates with severe jaundice who require intensive PT or EBT with

PT have 0% chance of having Intensive PT and a 25% chance of having EBT with PT in a public facility. Overall these findings suggest a great limitation in provision of services for the management of severe neonatal jaundice and neonates with this condition are unlikely to access the required intervention and therefore highly at risk of bilirubin encephalopathy.

None of the facilities had an irradiance meter a simple tool to measure the irradiance of devices. Availability of such tool will empower facilities to evaluate their devices and take appropriate measures to improve and attain the desired irradiance for optimal PT.

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## Conclusion

Private health care facilities constitute a major provider of neonatal jaundice healthcare services which may constitute a limitation to accessibility and affordability in view of their profit orientation. Overall, however, the services including protocol availability, phototherapy and EBT were grossly suboptimal and inadequate and will need significant and urgent improvement to enhance newborn health and indices and as well guarantee a positive march towards attainment of SDG<sub>3</sub>.

## Recommendation

We recommend that the SMOH should update and generate a comprehensive documentation of all healthcare facilities (government and non-government) that provide different specialized newborn health care in the state. The ministry should lead and improve partnership with private health facilities providing newborn care with an aim to support, standardize and improve neonatal jaundice care services. This should include focus on improving efficiency of locally fabricated PT devices and provision of protocols and guidelines for management of neonatal jaundice.

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**Conflict of interest:** None

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