pagepress

Phototherapy services for newborns with jaundice: Availability and practices in Southeast Nigeria

Chijioke E. Ezeudu,[1,2] Chidiebere D.I. Osuorah,[3] Ogochukwu N. Iloh,[4] Kenechukwu K. Iloh,[4] Vivian O. Onukwuli,[4] Obianuju O. Igbokwe,[4] Linda Nwokeji–Onwe,[5] I. Ezinne Nwaneli,[1,2] Kosisochukwu E. Udeogu[6]

[1]Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra, Nigeria; [2]Department of Pediatrics, Faculty of Medicine, Nnamdi Azikiwe University, Nnewi, Anambra, Nigeria; [3]Prairie Mountain Health Region, Manitoba, Canada; [4]Department of Pediatrics, College of Medicine, University of Nigeria, Ituku/Ozalla, Enugu, Nigeria; [5]Department of Pediatrics, Alex Ekwueme University Teaching Hospital, Abakiliki, Ebonyi, Nigeria; [6]University of Nigeria Teaching Hospital, Ituku, Ozalla, Nigeria

Abstract

Severe neonatal hyperbilirubinemia remains a cause of neurologic damage in children in low-income countries. Phototherapy, which is the standard of care for neonatal hyperbilirubinemia is not only necessary but an essential neonatal service that should be readily available in all health facilities with maternal and newborn services. The study describes the availability and distribution of phototherapy service in secondary health facilities in Southeast Nigeria. This was a cross-sectional descriptive study carried out in four of the largest cities in Southeast Nigeria using purposive and convenient sampling methods. A questionnaire was administered and information regarding the availability of phototherapy machines, its use and availability of personnel was obtained. A total of 77 facilities were surveyed. Fifty-five (71.4%) of the studied facilities manage jaundice in their facility. Of these, 45/55 (81.8%) use phototherapy in the management of jaundice in newborns. The most used phototherapy is Light-Emitting Diode (LED) (42.2%). Others were fluorescent (26.6%), fabricated LED (11.1%) and fabricated fluorescent (20%). Routine serum bilirubin assay was done in 60 (77.9%) facilities even though majority was done in laboratories outside the facility. Non-invasive serum bilirubin monitoring was available in only two facilities. Only 21 (47.7%) had a servicing protocol for their phototherapy machines, and just 12 (27.7%) of these services were offered by a biomedical engineer. Phototherapy use in secondary health facilities is suboptimal. There is urgent need for states health authorities to collaborate with private health facilities especially those offering maternal and child services in provision of phototherapy machines and help in the training health workers for optimal management of neonatal hyperbilirubinemia.

Correspondence: Obianuju O. Igbokwe, Department of Pediatrics, College of Medicine, University of Nigeria, Ituku/Ozalla, Enugu, Nigeria.
E-mail: obianuju.igbokwe@unn.edu.ng

Key words: phototherapy, newborns, hyperbilirubinemia, jaundice, southeast Nigeria.

Funding: None.

Conflict of interest: The authors declare no potential conflict of interest.

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate: Ethical approval for the study was obtained from the University of Nigeria Teaching Hospital (UNTH) Research and Ethics Committee. Additionally, permission to interview and inspect the phototherapy units of the surveyed health facilities was obtained from the owners of the hospitals or their designates.

Informed consent: Informed consent was obtained from the director of the hospital in all surveyed health facilities. Afterwards, a questionnaire was administered to the director or their designates.

Received for publication: 25 September 2022.
Accepted for publication: 24 November 2022.

Licensee PAGEPress, Italy
Annals of Clinical and Biomedical Research 2022; 3:240
doi:10.4081/acbr.2022.240

Introduction

Severe hyperbilirubinemia is an important clinical and public health issue, with rising incidence of bilirubin encephalopathy around the world.[1] The continued occurrence of kernicterus in newborns has been attributed to a health systems failure in neonatal service delivery.[2,3] In Nigeria for instance, Neonatal Jaundice (NNJ) accounts for 9–45% of neonatal admissions[4-7] with up to 30% of the admitted to tertiary health institutions already having features of kernicterus[8,9] subsequently leading to high neonatal mortality rates of 5–14%.[6,7]

Phototherapy (PT) is the standard treatment for neonatal hyperbilirubinemia. Since its advent 60 years ago, PT has reduced the need for Exchange Blood Transfusions (EBT) and has improved neurodevelopmental outcomes of infants with jaundice.[10] It is non- invasive and has fewer complications when compared to EBT.[11] Phototherapy is therefore an essential neonatal service that should be readily available to all newborns. The World Health Organization (WHO) in its medical device priority, listed

phototherapy as a priority medical device at the district level hospital[12] needed to provide essential neonatal and child health services in Low- And Middle-Income Countries (LMICs).

The efficacy of PT is quantified, in part, by the intensity or irradiance the light source can deliver, the dimensions of the irradiance footprint relative to the patient's Body Surface Area (BSA), and the duration of treatment. Irradiance is measured with a spectro radiometer and is usually expressed in terms of microwatts per square centimetre per nanometre ($\mu W/cm^2/nm$) over a given wavelength range, usually 400–520 nm. Irradiance is not only determined by the intensity delivered by the light source, but also by the distance between the light source and the skin to be treated.[13] The current American Academy of Pediatrics (AAP) recommendations for PT state that a conventional PT device should deliver a spectral irradiance of 8 to 10 $\mu W/cm^2/nm$ in the 430–490 nm band, and intensive PT should have a spectral irradiance of at least 30 $\mu W/cm^2/nm$ over the same bandwidth delivered to as much of the infant's BSA as possible.[14,15] To the best of our knowledge, there is paucity of published data on the availability and distribution of PT at the secondary level of care in Nigeria especially in the southeast. Knowledge of the availability and distribution of phototherapy services in Nigeria will guide health systems planning and aid reduction of morbidity and mortality from hyperbilirubinemia and its adverse consequences. This study was therefore done to describe the availability and distribution of phototherapy services in secondary health institutions in Southeast Nigeria as one of the WHO essential medical tools for optimal neonatal care.

Materials and Methods

Study area

This cross-sectional descriptive study was carried out in 4 of the largest cities in southeast Nigeria namely Enugu (in Enugu State), Abakaliki (in Ebonyi State), Awka and Nnewi (both in Anambra State). These sampling locations were purposively chosen because of the presence of tertiary health institution which serve as referral centers for private and faith-based health facilities located within these cities. Within each study location, health facilities with maternal and child health services were selected to be enrolled using convenience sampling.

The selected health facilities were visited by at least one of the researchers. Informed consent was obtained from the director of the hospital in all surveyed health facilities. Afterwards, a questionnaire was administered to the director or their designates. Information obtained included but was not limited to: number and qualification of healthcare personnel involved in the care of newborns with NNJ, availability of laboratory diagnosis of Serum Bilirubin (SB) and the number of functional phototherapy units in the health facilities were inspected and documented.

Data collection and analysis

The questionnaires used for data collection were administered by the researchers.

The study variables were collected in the relevant sections of the questionnaire. In the first section, some of the characteristics of healthcare facilities surveyed and its ownership were collected and categorized as follows: i) professional qualification of facilities owners was categorized as obstetrician, general practitioner, and non-doctors; ii) type of ownership was categorized as faith-based and private; iii) whether jaundice is managed in facility was categorized as yes or no; iv) method used for diagnosis of jaundice categorised as skin observation and serum bilirubin, serum bilirubin only and skin observation only; v) use of phototherapy machine to manage jaundice was grouped into yes and no; vi) type of phototherapy was classified into Light-Emitting Diode (LED), fluorescent, fabricated LED, and fabricated fluorescent; vii) availability of pediatrician in health facility was categorised as yes and no; viii) type of pediatrician engagement was categorized as full time, regular schedule and visit on request. The second section of the questionnaire collected information on principles of phototherapy that measured parameters assessing adequate use of phototherapy units. These parameters included: i) training on phototherapy use was categorized as yes or no; ii) availability of phototherapy guidelines categorized as yes and no; iii) type of phototherapy guideline if available was categorized as National Institute for Health and Care Excellence (NICE) and America Academy of Pediatrics (AAP); iv) routine serum bilirubin assay done in-facility was categorized as yes or no; v) type of non-invasive serum bilirubin monitor used was categorized as Transcutaneous Bilibinometer (TB) and bili stick; vi) frequency of serum bilirubin check during phototherapy was categorized as daily, every 48 hours, every 72 hours and only as needed; vii) total number of functional phototherapy machines in facility was categorized as 1, 2, 3 and ≥4; viii) availability of servicing protocol for the phototherapy machines was categorized as yes or no; ix) maintenance personnel used for phototherapy machines servicing was categorized as biomed assigned technicians and regular electrician

Data was entered into the relevant sections of the questionnaire and subsequently transferred into a Microsoft Excel sheet. Data collected was categorized and reported in percentages and ratio. The Chi-square analysis was used to assess initial associations between the predictor and outcome variables. Data analysis was done using Epi Info version 7.2 and statistical significance was set at $p<0.05$. Respondents with missing information were excluded from the data analysis.

Results

A total of 77 health facilities located in 4 cities in southeast Nigeria were surveyed. Thirty-three (42.9%) of hospitals surveyed were in Enugu, while others were located thus; Abakaliki (26%), Awka (18.2%) and Nnewi (13%). Seventy-four (96.1%) of the health facilities surveyed were privately owned. Forty-nine (63.6%) of the 77 surveyed hospital were owned by medical doctors who are specialists in obstetrics. The median annual birth rate of these facilities was approximately 120 (IQR 30 – 300; Table 1).

Table 1. Facilities whose phototherapy services were explored.

Parameters	Variable	N	(%)
HEQ of hospital owner (N=77)	Obstetrician	49	63.6
	General practitioner	25	32.5
	Non-doctor	3	3.9
Level of care ownership (N=77)	Private	74	96.1
	Faith-based	3	3.9
Hospital location (N=77)	Enugu	33	42.9
	Nnewi	10	13.0
	Abakaliki	20	26.0
	Awka	14	18.2
Annual birth rate	Median	120	IQR=60-300

HEQ, Highest Educational Qualification; IQR, Interquartile Range

Table 2 shows the management of jaundice and the use of phototherapy in the various facilities. Fifty-five facilities diagnose jaundice using both skin observation and SB estimation, while 17 (22.1%) use only skin observation. Fifty-five (71.4%) of the studied facilities manage jaundice in their facility while 22 (28.6%) refer their jaundice cases to other secondary or tertiary facilities.

Out of the fifty-five facilities that manage jaundice in their facility, 45 (81.8%) use phototherapy in the management of jaundice in newborns. The type of phototherapy used varied in the different facilities as shown in Figure 1, with 19 (42.2%) of the facilities using LED phototherapy. Forty-four (80%) of the facilities that manage jaundice have a pediatrician. However, only about a tenth (9.1%) engage them on a full-time basis. Others engage pediatrician at regular schedule (18.2%) and most based on the need (52.7%; Table 2).

Considering the treatment protocol used in various facilities, only 10 (13%) of these facilities had formal training on use of phototherapy and even fewer (9.1%) follow guidelines (NICE and AAP guidelines) during use. Routine serum bilirubin assay was done in most facilities 60 (77.9%), even though most of them were done in laboratories outside the facility. Non-invasive serum bilirubin was only available in two of the facilities who used transcutaneous bilirubinometers. None of the studied facilities had an irradiance meter and most facilities (32.5%) monitor serum bilirubin every 48 hours (Table 3).

Table 4 shows equipment and servicing protocol in surveyed facilities. Among the 44 health facilities that managed newborn jaundice using phototherapy machines, the vast majority (54.5%) had only one functional while 8 (18.2%). 5 (11.4%) and 7 (15.9%) had 2,3 and 4 or more functional unit respectively. In most of these facilities, the bulbs of the phototherapy units were replaced as the need arises. Servicing protocol for the machines exists in approximately half (52.3%) of the facilities and maintenance of these units was done by regular electricians with no special training in maintenance of phototherapy units. Measurement of irradiance was not done in any of the surveyed facilities (Table 4).

Table 2. Management of jaundice in the various facilities.

Parameters	Variable	N	(%)
Diagnosis of jaundice (N=77)	Skin observation and serum bilirubin	55	71.4
	Serum bilirubin only	5	6.5
	Skin observation only	17	22.1
Jaundice managed in facility (N=77)	Yes	55	71.4
	No	22	28.6
Use of phototherapy to manage jaundice (N=55)	Yes	45	81.8
	No	10	18.2
Type of phototherapy (N=45)	LED	19	42.2
	Fluorescent	12	26.6
	Fabricated LED	5	11.1
	Fabricated fluorescent	9	20.0
Availability of pediatrician in facility (N=55)	Yes	44	80.0
	No	11	20.0
Type of engagement (N=55)	Full time	5	9.1
	Regular schedule	10	18.2
	Visit on request	29	52.7
	Non-response	11	20.0

LED, light-emitting diode

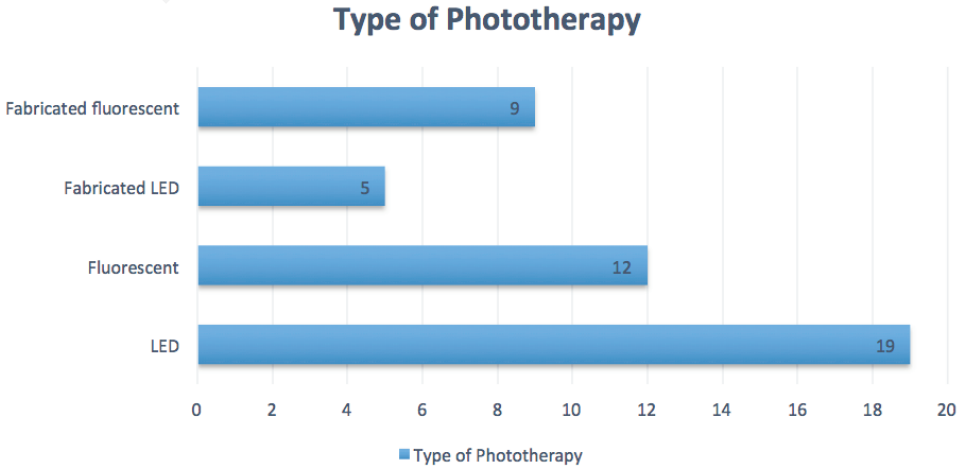

Figure 1. Chart showing the use of phototherapy used in management of jaundice in newborns.

Table 5 shows the relationship between certain variables including location, ownership and type of the facilities, and the use of phototherapy in the management of jaundice. The use of phototherapy for jaundice management was significantly higher in Enugu 46.9% and Abakaliki 40.6% compared to Nnewi (6.3%) and Awka (6.3 (x^2=10.932, p=0.012). Health facilities owned by specialists (64.4%) were shown to use phototherapy more compared to those whose owners who were general practitioners (28.9%) and non-doctors (6.7%) (x^2=2.572, p=0.276). Finally, faith-based institutions were also noted to use phototherapy more than private facilities 93.3% *vs* 6.7% respectively (x^2=2.220, p=0.136).

Table 3. Treatment protocol used in the various facilities.

Parameters	Variable	N	(%)
Training on phototherapy use (N=77)	Yes	10	13.0
	No	35	45.5
	Not applicable	32	41.6
Availability of phototherapy guidelines (N=77)	Yes	7	9.1
	No	39	50.6
	Not applicable	31	40.3
Type of phototherapy guideline (N=7)	NICE	3	42.9
	AAP	4	57.1
Routine serum bilirubin assay (N=77)	Yes	60	77.9
	No	17	22.1
Where does the facility do serum bilirubin assay (N=60)	In house	25	41.7
	Sent out	35	58.3
Availability of non-invasive serum bilirubin monitoring (N=77)	Yes	2	2.6
	No	75	97.4
Type of non-invasive serum bilirubin monitor (N=2)	TB	2	100.0
	Bilistick	0	0.0

TB, Transcutaneous Bilibinometer; NICE, National Institute for Health and Care Excellence; AAP, America Academy of Pediatrics

Table 4. Equipment and servicing protocols in surveyed facilities.

Parameters	Variable	N	(%)
Total number of phototherapy machines present in facility (N=44)	1	22	50.0
	2	10	22.7
	3	5	11.4
	≥4	7	15.9
Number of functional phototherapy machines (N=44)	1	24	54.5
	2	8	18.2
	3	5	11.4
	≥4	7	15.9
Servicing protocol for the machines available (N=44)	Yes	23	52.3
	No	21	47.7
Maintenance of phototherapy machines (N=44)	Biomed	12	27.3
	Regular electrician	32	72.7
Measurement of irradiance (N=44)	Yes	0	0.0
	No	44	100.0

Table 5. Determinants of phototherapy use in management of jaundice in newborns and selected variable.

Parameter	Variable	Use of phototherapy to manage jaundice Yes	No	X^2	p-value
HEQ hospital owner	Obstetrician	29 (64.4%)	20 (62.5%)	2.572	0.276
	General practitioner	13 (28.9%)	12 (37.5%)		
	Other	3 (6.7%)	0 (0.0%)		
Ownership	Private	42 (93.3%)	32 (100.0%)	2.220	0.136
	Faith-based	3 (6.7%)	0 (0.0%)		
City of hospital location	Enugu	18 (40.0%)	15 (46.9%)	10.932	0.012
	Nnewi	8 (17.8%)	2 (6.3%)		
	Abakaliki	7 (15.6%)	13 (40.6%)		
	Awka	12 (26.7%)	2 (6.3%)		

† non-doctors and other healthcare providers. HEQ, Highest Educational Qualification. X^2=Chi-square; Bold p-value test statistic is significant at 0.05 level.

Discussion

The role of phototherapy in the management of neonatal jaundice has been well documented.[16,17] This study examined the availability of phototherapy services among secondary health facilities in South-east Nigeria.

It was noted that the diagnosis of neonatal jaundice was made by only clinical observation in some of the health facilities surveyed. This trend is worrisome. It has been documented that clinical examination for neonatal jaundice is unreliable and prediction of serum bilirubin concentration using clinical examination alone could be inaccurate.[18] The implication is that a good proportion of babies with jaundice may be missed especially in our environment where most newborn are dark skinned.

Our study also noted that over half of the surveyed facilities manage jaundice in their facilities, while others refer jaundiced babies to other secondary or tertiary hospitals for treatment. This is contrary to the recommendation of AAP which states that all hospitals providing newborn services and treating infants should provide every necessary equipment for intensive phototherapy.[15] Likewise, WHO also recommended phototherapy as an essential intervention in every hospital where newborns are managed.[19] Referral should be discouraged as most mothers may not go to the referral hospital and the babies will subsequently be lost to follow-up thereby worsening the morbidity and mortality associated with NNJ. It has been documented that mothers prefer that their babies to be managed at the hospital of delivery.[20]

Forty-five 45 out of 55 hospitals surveyed used phototherapy in the management of NNJ. This is in keeping with the study in Kaduna state by Abdulkadir *et al.*[21] where 13 out of 15 facilities offered phototherapy services, but at variance with study done by Toma *et al.*[22] in Jos where 11 (36.7%) out of the 30 facilities surveyed offered phototherapy services.

Additionally, in terms of the type of phototherapy used by the surveyed hospitals in this study, LED accounted for 42.2% and 11.1% of cases, the light source is the customized and fabricated types of devices respectively. LED lights have been shown to be the safest and most efficacious for administering phototherapy, as they emit the least heat and so are associated with the lowest risk of hyperthermia and dehydration. However, because these LED units are more expensive,[23-25] most healthcare facilities had substandard light sources as noted in our study. Financial constraints limit the ability of health care facilities in low- and middle-income countries to procure standard PT devices. As a result, efforts have gone into local fabrication of devices for use in health care facilities in Nigeria. In the present study, 31.15% of the machines were fabricated locally, while Abdulkadir *et al.*[21] in Kaduna state Nigeria reported that 85% of the facilities in the state use the fabricated type. Fabricated type of phototherapy does not give assurance for effective phototherapy due to poor irradiation. This would lead to an increase in length of hospital stay as well as likelihood for exchange blood transfusion among newborns on treatment for jaundice.

Also noted in this study was the presence of non-functional or poorly functioning PT machines available in surveyed health facilities. This may result to either 2 babies sharing a machine, prolonged light exposure and sometimes referring babies out of the facilities where they were delivered. All these should be discouraged as they may increase the morbidity and mortality associated with NNJ.

Only 9% of percent of the facilities assessed have treatment protocol for the management of jaundice and this was similar to the findings by Abdulkadir *et al.*[21] in Kaduna where none of the facilities in the study had any written protocol for management of neonatal jaundice. This practice has a negative impact on the management of neonatal jaundice and calls for provision of protocols as well as training and retraining of health care professionals involved in the treatment of neonatal jaundice so as to acquaint them with use of such protocols.

It has been recommended that monitoring of irradiance of the phototherapy machine should be done at the commencement of the therapy and used to monitor the efficacy of therapy.[26] Unfortunately, none of the facilities surveyed had an irradiance meter. This is unacceptable because ineffective phototherapy prolongs morbidity, duration of hospital stay, increases the cost of treatment, and may predispose to the development of acute bilirubin encephalopathy. It is also commendable that more than half of the facilities have a servicing/maintenance protocol for the phototherapy machines. This should be encouraged, though it is still preferable that the maintenance of this machine be done by biomedical engineers who have undergone quality training. This was not the case in this study as most (72.7%) of the facilities engage the service of regular electricians.

In this study, only less than a quarter of the facilities assessed monitored serum bilirubin every 48 hours. This is not in keeping with current recommendations that serum bilirubin be monitored every four to six hours.[27] Of all the health facilities assessed, only 2.6% of them used transcutaneous bilirubinometer. This poor monitoring will cause delays in identification of a case that may require intensive phototherapy or EBT.

The authors noted that level of qualification did not impact significantly on phototherapy use as 20 (62.5%) of facilities owned by obstetricians that do not use phototherapy. This calls for creation of awareness and enforcement of WHO recommendation on phototherapy use. Though three hospitals in the survey were faith-based, it is commendable that all of them use phototherapy.

Conclusions

There are deficiencies in the number and distribution of phototherapy services in secondary health facilities in Southeast Nigeria. Where available the phototherapy machines are neither properly maintained nor frequently serviced for optimal function. In addition, there is need for increased awareness on recent guidelines for management of neonatal jaundice in secondary health care facilities.

References

1. GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015;385:117–71.
2. Kamath BD, Thilo EH, Hernandez JA. Jaundice. In : Gardner SL, Carter BS, Enzman – Hines M, Hernandez JA, eds. Merenstein and Gardner's handbook of intensive neonatal care. Missouri, USA: Mosby Elsevier Inc. 2011:531-52.
3. Bhutani VK, Johnson L. A proposal to prevent severe neonatal hyperbilirubinemia and kernicterus. J Perinatol 2009;29:S61-7.
4. Owa JA, Osinaike AI. Neonatal morbidity and mortality in Nigeria. Indian J Pediatr 1998; 65:441-9.

5. Okechukwu AA, Achonwa A. Morbidity and mortality patterns of admissions into the Special Care Baby Unit of University of Abuja Teaching Hospital, Gwagwalada, Nigeria. Niger J Clin Pract 2009;12:389–94.
6. Toma BO, Ige OO, Abok II, et al. Pattern of neonatal admissions and outcome in a tertiary institution in North Central Nigeria. J Med Trop 2013;15:121-5.
7. Onyearugha CN, Onyire BN, Ugboma HAA. Neonatal jaundice: Prevalence and associated factors as seen in Federal Medical Centre Abakaliki, Southeast Nigeria. J Clin Med Res 2011;3:40-5.
8. Ogunlesi TA, Dedeke IO, Adekanmi AF, et al. The incidence and outcome of bilirubin encephalopathy in Nigeria: a bi-centre study. Niger J Med 2007;16:354-9.
9. Adebami OJ. Factors associated with the incidence of acute bilirubin encephalopathy in Nigerian population. J Ped Neurol 2011;9:347-53.
10. Owa JA, Ogunlesi TA. Why we are still doing so many exchange blood transfusion for neonatal jaundice in Nigeria. World J Pediatr 2009;5:51-5.
11. Bhutani VK, Wong RJ. Bilirubin neurotoxicity in preterm infants: risk and prevention. J Clin Neonatol 2013;2:61–9.
12. Tan KL. Phototherapy for neonatal jaundice. Acta Paediatr 1996;85:277-9.
13. World Health Organization. Interagency list of priority medical devices for essential interventions for reproductive, maternal, newborn and child health. Available from: http://www.who.int/ medical_devices/ md_maternal_BOOK_May201 6_D.pdf
14. Maisels MJ, McDonagh AF. Phototherapy for neonatal jaundice. N Engl J Med 2008;358:920–8.
15. American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics 2004; 114:297–316.
16. UNICEF. Phototherapy Light – Jaundice Management, UNICEF November 2022. Available from: phototherapy%20%20services/phototherapy-light-TPP.pdf
17. Olusanya BO, Osibanjo FB, Mabogunje CA, et al. The burden and management of neonatal jaundice in Nigeria: A scoping review of the literature. Niger J Clin Pract 2016;19:1-17
18. Moyer VA, Ahn C, Sneed S. Accuracy of Clinical Judgment in Neonatal Jaundice. Arch Pediatr Adolesc Med 2000;154:391–4.
19. WHO. Interagency list of priority medical devices for essential interventions for reproductive, maternal, newborn and child health. Available from: http://www.who.int/ medical_devices/ md_maternal_BOOK_May201 6_D.pdf
20. Ekwochi U, Osuorah CD, Ndu IK. Determinants of delay in presentation and clinico-laboratory features of newborns admitted for neonatal jaundice in a tertiary hospital in south-east Nigeria. J Med Trop 2018;20:128-34
21. Abdulkadir I, Adebiyi NM, Adeoye G, Ogala WN. An evaluation of phototherapy services in newborn units in Kaduna State Nigeria. Niger J Paediatr 2018;45:76-80.
22. Toma BO, Diala UM, Ofakunrin AOD, et al. Availability and distribution of phototherapy services and healthcare providers for neonatal jaundice in three local government areas in Jos, North - Central Nigeria. Niger J Paediatr 2018;45:1–5.
23. Kumar P, Chawla D, Deorari A. Light-emitting diode phototherapy for unconjugated hyperbilirubinaemia in neonates. Cochrane Database of Systematic Reviews, 2011;2011:CD007969.
24. Morris BH, Tyson JE, Stevenson DK, et al. Efficacy of phototherapy devices and outcomes among extremely low birth weight infants: Multi-center observational study. J Perinatol 2013;33:126-33.
25. Eggert P, Stick C, Schröde H. On the distribution of irradiation intensity in phototherapy: Measurements of effective irradiance in an incubator. European J Pediatr 1984; 142:58-61.
26. Borden AR, Satrom KM, Wratkowski P, et al. Variation in the Phototherapy Practices and Irradiance of Devices in a Major Metropolitan Area. Neonatology 2018;113:269-74.
27. Maisels MJ. Managing the jaundiced newborn: a persistent challenge. CMAJ 2015;187:335-43.