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# Factors Associated with Neonatal Jaundice and Validity of the Clinical Assessment at A Referral Hospital in Tanzania: A Cross-Sectional Study

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**Abstract**

***Background***

Neonatal jaundice is a common morbidity encountered during the first week of life. The causes of which are variable with an underlying pathology and if left unchecked can lead to bilirubin-induced encephalopathy and its antecedent long-term neurological sequelae. There is limited data on prevalence, factors associated with neonatal jaundice and the validity of using clinical assessment of neonatal jaundice in Tanzania.

***Objective***

To determine the proportion of neonates admitted with jaundice, factors associated, and the validity of the clinical assessment of neonatal jaundice at Muhimbili National Hospital.

***Methodology***

A hospital-based cross-sectional study at the neonatal unit of MNH from December 2018 to February 2019. Jaundiced infants were investigated for levels of bilirubin and other laboratory parameters. Frequencies and percentages, along with Chi-square tests and logistic regression analysis were done. The coefficient of Correlation of the Laboratory levels and Kramer's criteria was also done with Receptor Observation Curves (ROC) made for the parameters.

***Results***

Neonatal jaundice was found in 51.1% of the 432 enrolled participants. Term infants were 51.4%. Factors associated with neonatal jaundice were ABO incompatibility, rhesus incompatibility, sepsis, peripheral hemolysis, and positive coombs test. The level of jaundice correlated well with the clinical assessment of jaundice. The sensitivity of clinical assessment was found to be 51.1% with a specificity of 100% and correlated well with the laboratory findings as calculated from the ROC curve.

***Conclusion***

Neonatal jaundice is very common in our unit and the commonest cause is ABO incompatibility and Sepsis. Clinical assessment is still a very reliable method of assessment of neonatal jaundice. A proper clinical judgement using Kramer's rule should be supplemented and confirmed with a total serum bilirubin to increase the sensitivity.

***Key words***: *Neonatal jaundice, Kramer's rule, Laboratory testing.*

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**Important Definitions**

Kramer's rule: Is the clinical assessment of the severity of jaundice as identified from the various levels in the body following cephalo-caudal progression (1).

Probable sepsis: In this study was diagnosed in a newborn with any of the 2 out of the 7 listed clinical signs and symptoms (as per WHO-IMCI guideline), together with a CRP value above 5mg/dl (2).

Critically Ill infant 0-59 days: Convulsions, Unable to feed at all, Unconscious, and Temperature below 35.5 degrees Celsius (2).

**Introduction**

Neonatal jaundice is a common condition and heralds a mild physiological situation to a serious life-threatening underlying cause. It affects approximately half of all newborns in their first week of life and may cause an increased mortality or long-term neurodevelopment impairments induced by high bilirubin levels necessitating effective evaluation and treatment (3). Neonatal jaundice maybe caused by blood incompatibilities, sepsis, decreased excretion like biliary atresia and other conditions such as hypothyroidism and increased haemolysis from cephalohematoma. We have limited data on the validity of the clinical method used in diagnosing and grading for its severity. Factors associated with neonatal jaundice include sepsis, prematurity and very low birth weight, trauma and bruises like cephalhematoma, ABO incompatibility, and Rhesus incompatibility among others (3). Visual assessment is the key for early identification of neonates with jaundice because typically, in neonates, the dermal icterus is first noted in the face and when the bilirubin level rises, it proceeds to the body and then to the extremities. This condition is common in 50%–60% of newborns in the first week of life (3).

To reduce neonatal morbidity in our setting, neonatal jaundice needs to be addressed, since it is a common problem in our setting affecting almost 30-50% of admitted neonates (4). In low-resource settings jaundice regularly goes undetected due to lack of proper and accurate diagnostic tools to measure bilirubin levels. Left untreated, jaundice can lead to permanent neurological damage and mortality, the vast majority of which currently occurs in low-resource settings, the common methods for evaluation of neonatal jaundice include visual examination (Kramer's grading system), transcutaneous and serum bilirubin level with the first two used for screening or initial assessment and the later used for evaluation of severity as well as monitoring progress and response to treatment (5)Clinical judgment is important,

as much as the laboratory tests. We compared the clinical assessment with serum bilirubin and tested haemoglobin reticulocyte count and red cell indices, blood group and Rhesus factor among others. to describe the factors associated with neonatal jaundice.

This study therefore was done with the objective of finding the proportion of neonates with jaundice, factors associated and correlation with clinical assessment.

## Methods

### *Study Setting*

This was a hospital-based cross-sectional study at the Muhimbili National Hospital (MNH), neonatal unit from December 2018 to February 2019. The Neonatal Unit has a capacity of accommodating 120 neonates, and during the high season the unit takes up to 30 admissions in a day. It has a special care, high dependency and intensive care unit.

The unit provides Continuous Airway pressure ventilation, Phototherapy, Intravenous therapy for sepsis, high dependency care for post-operative neonates, and currently neonatal intensive care including ventilation. In neonates with jaundice, the baby is screened for sepsis, a complete blood count, and total and differential serum bilirubin done from the laboratory. Clinical assessment and treatment with phototherapy are also instituted.

### Study population

Neonates admitted in the neonatal unit at MNH during the study period were included in the study.

Inclusion: all babies whose mothers agreed to participate and signed the written informed consent.

Exclusion: Re-admitted neonates and critically ill neonates. sample size estimation of 418 was calculated using the Fischer's formula. The confidence level was 1.96 and estimated prevalence of 55% from a study done by Britis et al in South Africa in 2017.

Probable sepsis was diagnosed in those neonates with 2 among the 7 listed below signs and symptoms with laboratory results of C-Reactive Protein of above 10mg/dl as per WHO IMCI (2).

i) History of difficulty in feeding.
ii) Movement only when stimulated.
iii) Respiratory rate of more than 60 breath/minute.
iv) Severe chest in drawing.

v) Axillary temperature above 37.5 degrees Celsius.
vi) Bulging anterior fontanelle.
vii) Signs of infection on the skin with pus.

*(For those who were critically ill: Convulsions, not feeding at all, unconscious and temperature below 35.5 degrees Celsius, were excluded from the study)*

Blood was drawn from the neonate's superficial vein on the dorsum of the hand for investigations. Antenatal cards were used to provide other obstetric information such as GA using the last menstrual period, blood group and PMTCT status.

Weight was taken by using a digital SECA® weighing scale with a neonate undressed. The weighing scale was calibrated to zero before starting to weigh the neonates. Axillary body temperature was measured using a digital clinical thermometer (Omron®). The digital thermometer was placed in the axilla and readings were recorded. A body temperature of more or equal to 37.5°C was regarded as febrile while temperature less than 35.5°C was regarded as hypothermia.

Gestational Age (GA) was calculated by rounding the additional days to the nearest whole GA number, those who exceeded 3days in a week were rounded to the next complete week such that 36 weeks and 4 days was considered 37 weeks GA.

***Laboratory measurements***

Four millilitres of venous and divided into 3 aliquots of 2 mls , one for Complete Blood Count , peripheral smear and reticulocyte count in purple top bottle, and one ml for ABO and Rh antigen typing and Coombs test in red top bottle and 1 ml in green top bottle for CRP and bilirubin measurement. The dorsum of the hand was used for blood collection. using a sterile disposable syringe and needle after a thorough cleaning of the venepuncture site with a swab soaked in 70% alcohol.

***Data entry and analysis***

Data were entered and analysed using SPSS window version 20. Frequencies and percentages were used to summarize socio-demographic characteristics. Association of categorical variables and neonatal jaundice were assessed using the chi-square test ($X^2$ test). Factors that showed association were entered in logistic regression for the elimination of confounders. Sensitivity and specificity were calculated using two by two table, Receiver Operating Characteristic curve was used to find the accuracy of Clinical assessment.

### Ethical consideration

Ethical clearance was obtained from the MUHAS institutional review board. Permission to conduct the study was obtained from MNH administration and mothers of each participant were requested to sign a written informed consent form prior to recruitment. All neonates with hyperbilirubinemia, with ABO and rhesus incompatibility, probable sepsis, prematurity who were enrolled in this study, received the standard management as per MNH protocol and their laboratory results were handled to the treating team for their management.

### Results

A total of 880 neonates were admitted, of which 450 neonates had jaundice (51.1%) and were recruited in the study, among these, 18 neonates were excluded due to missing data and withdrawal of consent (due to?) and therefore 432 neonates participated in the study.

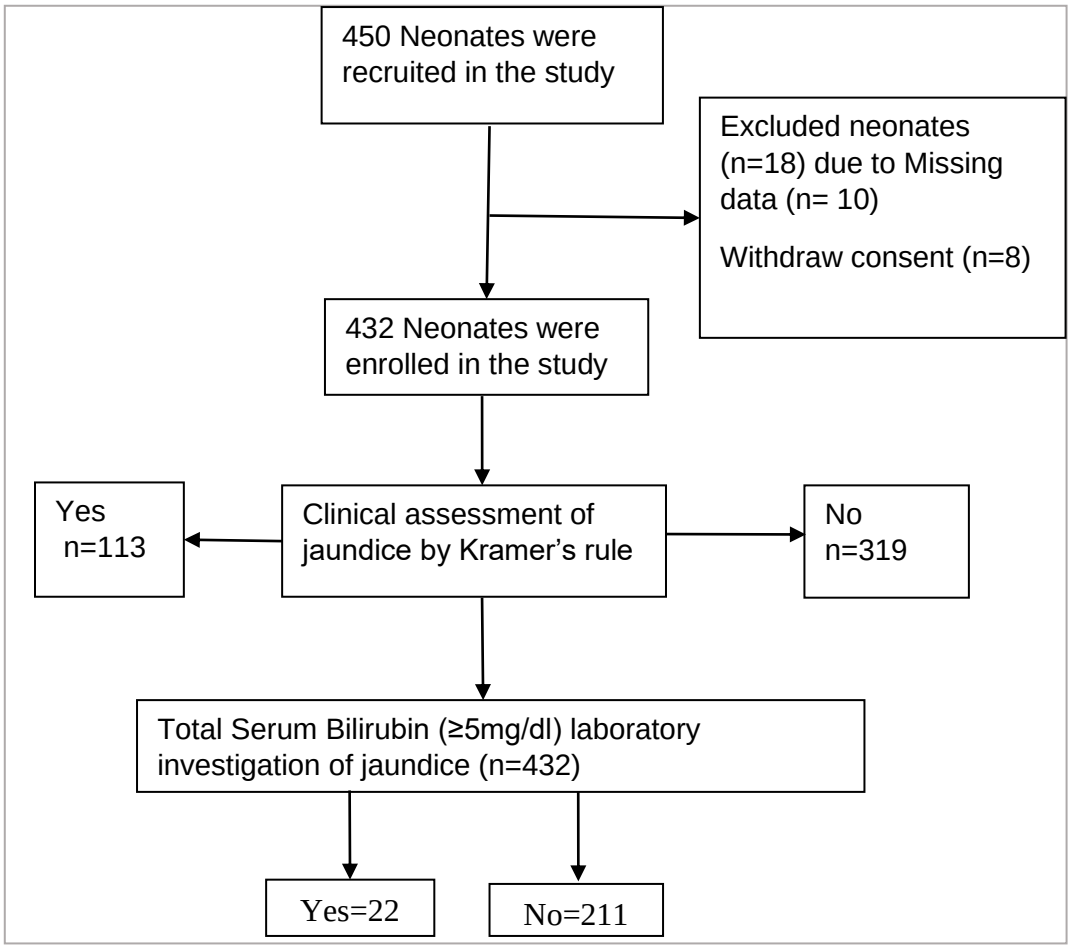



**Figure 1. Flow chart showing recruitment of study participants**

A total of 432 were enrolled in the study. More than half of participants (71.9%) were aged between 1st day to 7th day of life, 40.7% of neonates had a birth weight above 2.5kg. 56.3% of the mothers were aged between 26 to 35 years, 69.9% were married and 96.3% reside in Dar-es-Salaam, 58.8% of mothers have a secondary level of education, 27.8% of mothers were employed and 8.1% mothers were PMTCT1 (Table 1).

**Table 1: Socio-demographic characteristics of the neonates and their mothers admitted at MNH during the study period**

| Variable | Frequency N=432 | Percentage (%) |
|---|---|---|
| **Sex of neonate** | | |
| Male | 192 | 44.4 |
| Female | 240 | 55.6 |
| **Gestational age at birth** | | |
| Premature | 210 | 48.6 |
| Term | 222 | 51.4 |
| **Age of the mother** | | |
| 15-25 | 145 | 33.6 |
| 26-35 | 243 | 56.3 |
| 36-45 | 44 | 10.2 |
| **Marital status of the mother** | | |
| Single | 302 | 69.9 |
| Married | 124 | 28.7 |
| Divorced/Widowed | 6 | 1.4 |
| **Residential address** | | |
| Dar-es-Salaam | 416 | 96.3 |
| Outside Dar-es-Salaam | 16 | 3.7 |
| **Mother's level of education** | | |
| No formal education | 11 | 2.5 |
| Primary education | 63 | 14.6 |
| Secondary education | 254 | 58.8 |
| Higher level of education | 104 | 24.1 |
| **Occupation** | | |
| Employed | 120 | 27.8 |
| Not employed | 312 | 72.2 |
| **HIV status of the mother** | | |
| Positive | 35 | 8.1 |
| Negative | 397 | 91.9 |

Among the 432 neonates who were examined and investigated for jaundice, 113 (26.2%) were clinically jaundiced and 319 were clinically not jaundiced. 211(51.2%) had a significant elevation of the total serum bilirubin of 5mg/dl and above.

Among the factors which were studied for their association with neonatal jaundice, using bivariate analysis, probable sepsis, ABO incompatibility, rhesus incompatibility, positive Coombs test, and peripheral blood smear If there was abnormal anisocytosis, spherocytosis, abnormal cells or elliptocytes, it was reported abnormal, otherwise it was normal.) revealed statistically significant association with the p-value < 0.005 (Table 2).

**Table 2: Associated factors for neonatal jaundice among neonates admitted at MNH during the study period**

| Variable | Total serum bilirubin | | p-value |
|---|---|---|---|
| | Normal N=211 | Elevated N=221 | |
| **Infections** | | | ***0.024*** |
| Probable sepsis | 64 (41.6) | 90 (58.4) | |
| Sepsis unlikely | 147 (52.9) | 131 (47.1) | |
| **Prematurity** | | | *0.762* |
| Term | 101 (48.1) | 109 (51.9) | |
| Preterm | 110 (49.5) | 112 (50.5) | |
| **ABO incompatibility** | | | ***0.021*** |
| Present | 21 (35.0) | 39 (65.0) | |
| Absent | 190 (51.1) | 182 (48.9) | |
| **Rhesus incompatibility** | | | ***0.037*** |
| Present | 3 (21.4) | 11 (78.6) | |
| Absent | 208 (49.8) | 210 (50.2) | |
| **Coombs test** | | | ***0.002*** |
| Positive | 24(32.4) | 50(67.8) | |
| Negative | 187(52.2) | 171(47.8) | |
| **Reticulocyte count** | | | *0.261* |
| >6 | 4(30.8) | 8(69.2) | |
| ≤6 | 207(49.4) | 212(50.6) | |
| **Peripheral smear** | | | ***0.001*** |
| Normal | 188(52.5) | 170(47.5) | |
| Haemolysis | 23(31.1) | 51(68.9) | |
| **Birth injury** | | | *0.123* |
| Present | 1 (14.3) | 6 (85.7) | |
| Absent | 210 (49.4) | 215 (50.6) | |
| **Mode of delivery** | | | *0.151* |
| SVD | 104 (48.4) | 112 (51.9) | |

| | | | | |
|---|---|---|---|---|
| Caesarean section | 93 (47.4) | 103 (52.6) | | |
| Vacuum | 14(70.0) | 6 (30.0) | | |
| **Sex of the child** | | | | *0.591* |
| Male | 91 (47.4) | 101 (52.6) | | |
| Female | 120 (50.0) | 120 (50.0) | | |
| **HIV status of the mother** | | | | *0.460* |
| Positive | 15 (42.9) | 20 (57.1) | | |
| Negative | 196 (49.4) | 201 | 0.6) | |

The criteria of adding in the regression model was those with a 0.02 value from table 2 and those which were considered biologically plausible. multivariate logistic regression of factors associated with neonatal jaundice showed probable sepsis (AOR = 1.66; 95 % CI: 1.11-2.50), ABO incompatibility (AOR = 1.98; 95 % CI: 1.11-3.53), rhesus incompatibility (AOR = 4.05; 95 % CI: 1.09-15.05), positive coombs test (AOR = 1.87; 95 % CI: 1.04 -3.36) and peripheral blood smear which showed haemolysis (AOR = 2.33; 95 % CI: 1.35- 4.02) (Table 3).

**Table 3: Multivariate logistic regression of factors associated with neonatal jaundice**

| Variable | Crude Odds Ratio (95% CI) | p-value | Adjusted Odds Ratio (95% CI) | p-value |
|---|---|---|---|---|
| **Infections** | | | | |
| Probable sepsis | 1.58 (1.06-2.35) | *0.024* | 1.66 (1.11-2.50) | *0.015* |
| Sepsis unlikely | Ref | | Ref | |
| **ABO incompatibility** | | | | |
| Present | 1.94 (1.01-3.42) | *0.021* | 1.98 (1.11-3.53) | *0.020* |
| Absent | Ref | | Ref | |
| **Rhesus incompatibility** | | | | |
| Present | 3.632 (1.00-13.21) | *0.037* | 4.05 (1.09-15.05) | *0.037* |
| Absent | Ref | | Ref | |
| **Coombs test** | | | | |
| Positive | 2.28(1.34-3.87) | *0.001* | 1.87(1.04-3.36) | *0.035* |
| Negative | Ref | | Ref | |
| **Peripheral smear** | | | | |
| Normal | Ref | | Ref | |
| Haemolysis | 2.45(1.44-4.18) | *0.002* | 2.33(1.35-4.02) | *0.002* |
| **Birth injury** | | | | |
| Present | 5.86 (0.7-49.10) | *0.123* | 4.61 (0.53-39.90) | *0.165* |
| Absent | Ref | | Ref | |
| **Mode of delivery** | | | | |
| SVD | Ref | | Ref | |

| | | | | |
|---|---|---|---|---|
| caesarean section | 1.02 (0.70-1.52) | 0.887 | 1.10 (0.74-1.64) | *0.629* |
| Vacuum | 0.40 (0.15-1.07) | *0.069* | 0.42 (0.15-1.15) | *0.090* |

*Ref: Reference variable was selected from biological plausibility of association.*

**Table 4: Performance of Clinical Assessment using Kramer rule compared to laboratory results of Total Serum bilirubin**

| Clinical assessment | Total serum bilirubin | | Total |
|---|---|---|---|
| | Jaundiced | Not jaundiced | |
| Jaundiced | 113 | 0 | 113 |
| Not jaundiced | 108 | 211 | 319 |

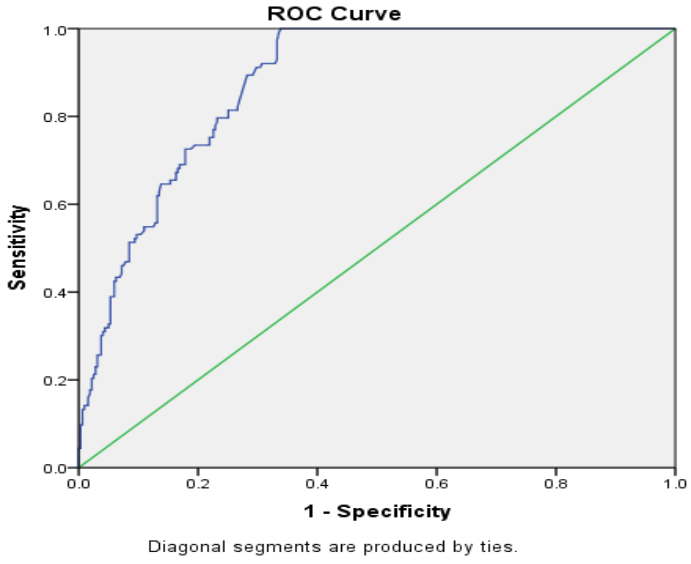
*Sensitivity of visual assessment was 51.1%

*Specificity of visual assessment was 100%

PPV=100%

NPV=66.1%

Receiver operating characteristic (ROC) curve of clinical assessment of neonatal jaundice with reference to the standard method using the results obtained after clinical assessment of jaundice in each study participant versus the total serum bilirubin results of each study participant, with the calculated area under the curve of 0.875 (Figure 2).




Correlation r: 0.875

**Figure 2. Receiver operating characteristic curve of clinical assessment of neonatal jaundice with reference to the standard method (Total serum bilirubin)**

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Further assessment of validity of clinical assessment using the results of Kramer's rule at each level by finding the average of total serum bilirubin levels of all the participants which were found to have the same level at each level respectively, Kramer's rule at level 0 corresponded to total serum bilirubin below 5 mg/dl (not clinically significant), and level 5 had serum bilirubin above 13 mg/dl.

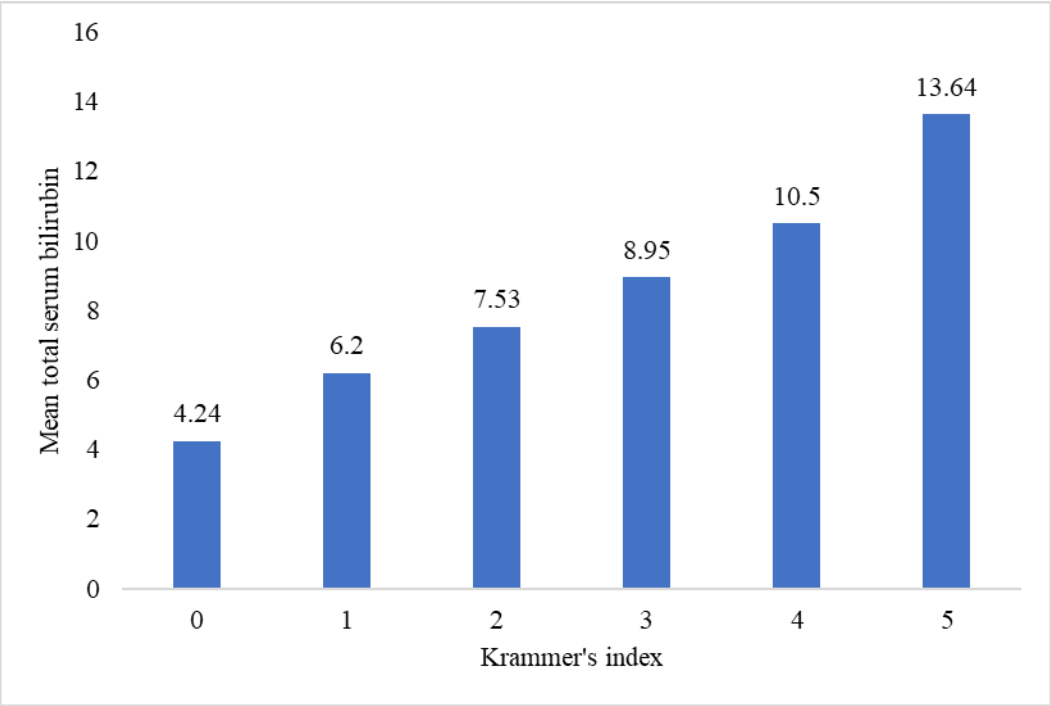


**Figure 3. Mean of total serum bilirubin vs levels of Kramer's rule**

## Discussion

During the study period, a total of 880 neonates were admitted of which 450 (51.1%) were screened to have jaundice, and 432 recruited in study (Figure 1). Neonates below 2.5 kg and those between 1-7 days were more than half of the neonates. This high proportion is very similar to what is seen in other African countries, whose prevalence is slightly higher. Studies done by Brits *et al* in South Africa and Kolawole et al in Nigeria have reported prevalence of 55% and 52.6% respectively (7,8). The high proportion may be due to selection bias of admitting sick neonates in the unit. However, the findings are not like in the study done by Chime *et al* in Nigeria who reported a lower prevalence of 32.6 %, (9). The observed difference between Chime's study and the current study may be attributed by variation in sample size, we enrolled 432 neonates as compared to 272 in the study done by

Chime, and due to a higher cut off point of laboratory jaundice of 15mg/dl used by Chime which as compared to 5mg/dl cut off used in our study.

The magnitude of neonatal jaundice is reported to have been reduced even in low and middle-income countries, however, there is a lack of population-based data from most countries, especially low and middle-income countries (LMIC) (10). There is a need to truly quantify the impact of neonatal jaundice so as to know how to integrate screening. Data from WHO OF 2020 FROM Global effective perinatal care reported the prevalence of hyperbilirubinemia in term newborns is 50% and in preterm newborns is 80%. A clinical, reliable method in the community can be used to provide prevalence and severity of jaundice (9).

Infections and Blood group incompatibility were the leading cause of neonatal jaundice (Table 2 and Table 3). Probable sepsis was observed to be associated with neonatal jaundice and accounted for 58.4%. Similarly, Kolawole *et al* (2013) and Onyearugha *et al* (2009) in Nigeria observed that neonatal sepsis was highly associated with neonatal jaundice (66.7%, 32.5% respectively) (8,11). During infection there is increased RBCs haemolysis, there is a direct injury to the liver by the increased circulating cytokines which result in impaired conjugation of bilirubin in the liver, this results in an increased level of serum bilirubin hence neonatal jaundice. Poor infection control in our settings as reported from the synthesis report of Ndeki *et al* increases the chances of neonatal infection (12). Contrary to Canadian study done by Sgro *et al* and Iran by Maamouri *et al* sepsis has been observed to be associated with neonatal jaundice in low proportions of 1.07% and 1.7% respectively. It is well known that in high income or developed countries there are comprehensive infection control strategies as compared to under-developed countries (13,14).

Neonatal Infections has been found to be the leading associated factor for neonatal jaundice in low- and middle-income countries (LMIC) ~~as~~ when compared to high income countries (HIC) (13,14). Studies done by Sgro et al in Canada and by Maamouri et al in Iran showed that 1.07% and 10% of neonates with hyperbilirubinemia had neonatal jaundice respectively (13,14). As opposed to studies done by Kolawole et al in Nigeria, Israel et al in Benin and Onyearugha et al in Nigeria were 66.7%, 45% and 32.5% of neonates with hyperbilirubinemia were found to have neonatal sepsis respectively this shows that in LMIC neonatal sepsis is the leading associated factor of neonatal jaundice as compared to HIC (8, 11,15).

As for Prematurity study done by Omekwe *et al,* in Southern Nigeria, showed that 40.7% of neonates who had neonatal jaundice were premature also is similar to the findings reported by Onyearugha *et al* on the prevalence and factors associated with neonatal jaundice, in which prematurity was the second factor from the top of the list, it was also concluded that early, regular and effective antenatal clinic visits can curb preterm birth and hence reduce the burden(11). A study by Israel Ainan *et al* on factors associated with neonatal jaundice in Nigeria concluded that early and proper management of prematurity can reduce jaundice cases as they are in an increased risk of getting jaundice (15).

In our study, ABO incompatibility accounted for 65% which is high as compared to the findings reported by Sgro *et al* who reported 48% of neonates with jaundice had ABO incompatibility (13). Regardless of the difference in percentages in both studies high number of jaundiced babies with ABO incompatibility has been observed in the two studies, ABO incompatibility results in haemolysis of foetal erythrocytes due to reaction of maternal anti-A or anti-B antibodies to the A or B antigen on the red blood cells of the foetus or newborn and result in neonatal jaundice. Low percentages of ABO incompatibility as compared to our study findings have been reported by Patel *et al* 13.7% and by Adoba et al 18%. These studies had enrolled a small sample size as compared to our study. ABO incompatibility results in haemolysis of foetal erythrocytes and may lead to hyperbilirubinemia. It is a common cause in high-income countries, a study done by Sgro et al in Canada showed a prevalence of ABO incompatibility of 48% (12). Low prevalence of ABO incompatibility has been reported in low and middle-income countries as reported by Patel et al and Adoba et al with prevalence of 13.7% and 18% respectively (17, 18)

Another factor with neonatal jaundice was rhesus incompatibility, among 14 neonates with rhesus incompatibility 78.6% had jaundice, this is in contrary with the study by Patel *et al* in India who observed that 1.37% of neonates with Rhesus incompatibility had jaundice(17).In the present study contribution of rhesus incompatibility to jaundice may be explained by the lack of awareness and inability to afford the use of anti-D immunoglobulin by mothers who had been exposed to rhesus negative foetus. Moreover, in developed countries awareness on rhesus incompatibility and the use of anti-D immunoglobulin is high this has led to a low number of jaundice cases due to rhesus incompatibility. Rhesus incompatibilities take place when maternal antibodies which were made during previous exposure react against the foetus's RBCs, this is not as common as in the past, this is due to the use of anti-D to rhesus

negative mothers after they have their first exposure to rhesus positive antigens, as shown in the study done by Osaro et al (19).

In the HIC, this is much rare as compared to LMIC as shown in the done by Patel et al in India which showed that Rhesus incompatibility was found in 1.37% from the total of 220 newborns with jaundice (17). This could have been contributed by lack of awareness and inability to afford anti D immunoglobulin in Africa countries as compared to India. Prompt treatment of the newborn with Rh incompatibility is necessary as the manifestations can start as early as in utero, the newborn need to be investigated and start phototherapy immediately and early assessment for the need of Exchange blood transfusion need to be done.

In our study 51.1% of participants with neonatal jaundice could be identified by clinical assessment, this is low as compared to the study done by Aprillia *et al*, who reported that assessment of neonatal jaundice revealed a sensitivity of 76.92%. High sensitivity is a requirement in screening for neonatal jaundice so as to be detected early, to enable early treatment so as to prevent kernicterus which can result in permanent disability. The low sensitivity obtained in our study can be due to different races between these two countries, assessment of jaundice visually in dark skin is difficult compared to fair skin neonates, other contributory factors can be different assessment environment and experience in assessing the neonates, due to these causes of variability a lot of neonates with significant bilirubin levels were not identified (20, 21).

In a recent study the prevalance of neonatal jaundice was found to be 49.8% by Kramer's method and 63.5% by Transcutaneous bilirubinometer. The Sensitivity, Specificity, PPV, and NPV of Kramer's method were 70.5, 86.1, 89.8, and 62.6%, respectively. With a moderate agreement between Kramer's method and Total serum bilirubin. The authors concluded that due to low sensitivity it may not be used for screening and considered the limitation of dark-skinned neonates (22).

In contrast, as seen in Table 4, the sensitivity of using visual screening is 51%, however the specificity of 100% shows that all of those who were found to have jaundice by visual assessment were also found to be jaundiced by gold standard method of total serum bilirubin, this shows that once visually identified to have jaundice, the levels of serum bilirubin are always high. Thus, any visual appearance of jaundice in our babies must be taken seriously for further evaluation. (20,21,22).

A total of 108(48.7%) neonates were missed by visual assessment in our study, which is almost like the findings reported by Brits et al who screened using Bili check

(Transcutaneous Bilirubinometer) and 38 of neonates who were found to be jaundiced only 17(44.7%) of them were identified clinically (9). As seen in figure 2, it is worth noting the analysis of ROC yielded area under the curve of 0.875 which indicate that clinical assessment is a reliable method, it is worth doing clinical assessment rather than not doing at all, when we don't have laboratory facilities clinical method can be used, this is like the findings reported by Moyer et al (21). From our study there is correlation of clinical assessment and total serum bilirubin only at low level as represented by Kramer's rule in level 0, which correlated with total serum bilirubin of less than 5mg/dl. At higher levels of Kramer's assessment, the correlation was less significant. Rai et al showed there is correlation of Kramer's rule and serum bilirubin at lower levels, no correlation at higher levels confirmation with total serum bilirubin levels should be performed as seen in the mean values in relation to Kramer value in Figure 3. (23).

A study done by Aprillia *et al* reported a sensitivity of 76.92% of clinical assessment of jaundice among neonates with jaundice (20). Reliability of clinical assessment has been studied by Moyer *et al*, the study reported area under the curve from the receiver operating characteristic curve of 0.86 which concluded that it is worth doing a clinical assessment of jaundice in neonates (21).

**Study Limitations**

The proportion of neonatal jaundice was high, and this was used as a proxy of prevalence during discussion. Some of the neonates were assessed at presentation at nigt, and a good lighting in natural light is the best way of observing jaundice. Some f the laboratory results may be reading lower due to delay in measurement and exposure of specimen to sunshine. The number of neonates screened were 880 and 450 were found to have jaundice.

**Conclusion**

In Conclusion, the proportion of neonatal jaundice among neonates admitted at MNH is high. Probable sepsis, ABO incompatibility, and rhesus incompatibility have been found to be the commonest factors associated with neonatal jaundice. Visual assessment of neonatal jaundice always indicated significant hyperbilirubinemia (Kramer's Rule), which is also recommended in the National Guidelines for assessing jaundice and corresponds to the envisaged values, thus laboratory tests are mandatory after a positive screen.

**Declarations**

Ethics approval was provided by the Muhimbili University College of Health Sciences (MUHAS) IRB Ref. No. DA.287129 and written informed consent to participate obtained from all the mothers whose neonates were included in the study. All methods were carried out in accordance with relevant guidelines, regulations, and management protocols.

**New Information from this study**

1. Neonatal Jaundice in this unit is common with a proportion of 51% of all admissions.
2. Commonest cause is sepsis followed by ABO incompatibility.
3. Kramer's rule is reliable screening tool, with a co-efficient of correlation of 0.86.

**Availability of data and materials**

The data is available in the MUHAS Directorate of Research and Publication upon request: www.muhas.ac.tz /drp, Attn: Dr. Nahya Salim, and www.muhas.ac.tz/dpgs, Attn: Prof. Emmanuel Ballandya.

**Competing interests**

Authors have no competing interests.

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**Authors' contributions**

JJS conceptualised, wrote the proposal, conducted the field activity, and wrote the first draft and revised final draft. FF Revised protocol, supervised the study, revised the manuscript, reviewed the final draft. KM is a senior supervisor, revised and finalised the manuscript and is the corresponding author. All authors have agreed to submit the manuscript.

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