# Evaluation of A Mobile Application Tool (BiliNorm) To Improve Care for Newborns with Hyperbilirubinemia in Indonesia

**Mahendra Tri Arif Sampurna** ( mahendra.tri@fk.unair.ac.id )
Universitas Airlangga Fakultas Kedokteran https://orcid.org/0000-0002-7529-8142
**Kinanti A. Ratnasari**
Universitas Airlangga Fakultas Kedokteran
**Zahra S. Irawan**
Universitas Airlangga Fakultas Kedokteran
**Risa - Etika**
Universitas Airlangga Fakultas Kedokteran
**Martono Tri Utomo**
Universitas Airlangga Fakultas Kedokteran
**Brigitta I. R.V. Corebima**
Universitas Brawijaya Fakultas Kedokteran
**Pieter J.J. Sauer**
Universitair Medisch Centrum Groningen
**Arend F. Bos**
Universitair Medisch Centrum Groningen
**Christian V. Hulzebos**
Universitair Medisch Centrum Groningen
**Peter H. Dijk**
Universitair Medisch Centrum Groningen

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# Abstract

**Background:** Hyperbilirubinemia is more frequently seen in low- and middle-income countries such as Indonesia than in high-income countries. A lack of adherence to existing guidelines for the diagnosis and treatment of hyperbilirubinemia might be one of the factors contributing to this difference. In Indonesia, we developed a new national guideline for hyperbilirubinemia. To assist healthcare workers in the use of this guideline, we developed a web-based app (BiliNorm) to be used on a smartphone. It shows the bilirubin level of the patient on the nomogram and advises which treatment should be started. We evaluated whether this app was helpful and whether it improved care for infants with hyperbilirubinemia.

**Methods:** Health care workers from two teaching hospitals in East Java, Indonesia, were trained in the use of the BiliNorm app. Six months after the introduction of the app, a questionnaire was sent to those who worked with the app asking about their experiences. A chart review of infants with hyperbilirubinemia at these two hospitals was then performed for two time epochs. Hyperbilirubinemia management in the six-month period before the introduction of the app was compared with that in the seven-month period after its introduction.

**Results:** Forty-three participants completed the questionnaire. The majority (72%) of the respondents indicated that the BiliNorm app was well received and easy to use; 84% of respondents indicated that the BiliNorm app was helpful in the decision to start phototherapy. The chart review of 255 infants before and 181 infants after the introduction of the app indicated that significantly more infants received treatment according to the guidelines (38% vs 51%, p=0.006). After the introduction of the app fewer infants received phototherapy, without a bilirubin measurement (14% vs 7%, p=0.024). The percentages of infants that were over- and undertreated were not different (34% vs 32% and 14% vs 10%, respectively)

**Conclusions:** The web-based decision tool BiliNorm seems to be a valuable app. It is easy for healthcare workers to use, and it helps them adhere to guidelines. BiliNorm improves care for infants with hyperbilirubinemia and may help to reduce the incidence of severe hyperbilirubinemia in Indonesia.


# Background

Severe hyperbilirubinemia is frequently observed in newborn infants in developing countries such as Indonesia [1]. Without adequate treatment, this condition can lead to bilirubin-induced acute and chronic encephalopathy and may even cause neonatal death [2]. Guidelines for diagnosing and treating hyperbilirubinemia have been created to assist health care workers who care for newborn infants, such as midwives, general practitioners and paediatricians. In a previous study, we found that awareness of and adherence to these guidelines is low amongst midwives and general practitioners in Indonesia [3]. Only 23% of the general practitioners and 29% of the midwives indicated using these hyperbilirubinemia management guidelines. In a survey conducted at Dr Soetomo General District Hospital, Surabaya, Indonesia, we found that 43% of term babies and 59% of near-term babies received phototherapy (PT) despite total serum bilirubin (TSB) levels below phototherapy (PT) thresholds. Additionally,

undertreatment was found in 30% of preterm babies. A previous study in the USA reported that almost 60% of paediatricians initiated PT at TSB levels lower than those recommended by the American Academy of Pediatrics (AAP) in newborns more than 72 hours of age, demonstrating that paediatricians do not always adhere to guidelines [4]. Low adherence to guidelines by health care workers may be caused by difficulty accessing the available guidelines [3, 5]. Fifty percent of paediatricians in Surabaya indicated having difficulties obtaining access to a guideline [3]. Recently, a new guideline for the diagnosis and treatment of hyperbilirubinemia was issued by the Indonesian Paediatric Society [6]. To make it easier for paediatricians, midwives and general practitioners to adhere to this guideline, we developed a web-based decision-making application based on this new guideline for use with a smart phone.

In this paper, we describe the characteristics of this web-based application (app), called BiliNorm [7], and the perception of this app by paediatricians and other health care workers. We also aim to evaluate whether the introduction of this app influenced the accuracy of treatment for infants with hyperbilirubinemia.

# Methods

BiliNorm is based on the Indonesian National Guideline on Hyperbilirubinemia [6]. It can be accessed at www.bilinorm.babyhealthsby.org with two language options: Indonesian and English [7]. When opening the BiliNorm app, users have to fill in the following patient data: gestational age (weeks), date and time of birth, date and time of record, birth weight (g), TSB level (mg/dL or μmol/L) and risk factors (Figure 1A). The risk factors incorporated in this tool were adapted from the American Academy of Pediatrics (AAP) guidelines [8] and include ABO/Rhesus incompatibility, haemolysis (G6PD deficiency or spherocytosis), other illnesses (asphyxia, infection) and hypoalbuminemia (< 30 mg/L). When “no risk factors” is selected, the case is regarded as uncomplicated hyperbilirubinemia. When “unknown risk factors” is selected, the patient is categorized as having risk factors other than those listed or as not being able to check the risk factors. After these data are provided, the actual TSB level of the infant is shown in the TSB nomogram, which displays treatment thresholds for PT and exchange transfusion over time. Advice for the caretaker regarding how to treat the infant is provided as follows: no treatment, start PT or immediately start intensive PT and consider exchange transfusion. Figure 1 shows an example of the data entered into the BiliNorm app for a preterm infant born at 33 weeks of gestation. She was admitted to a neonatal unit with jaundice at day two. Her birth weight was 2100 grams. Blood tests showed ABO incompatibility and a TSB of 17.2 mg/dL. After all data were entered, the results section showed the treatment thresholds for PT and exchange transfusion for this patient. The recommendation for the paediatrician for this patient is to immediately start intensive PT and consider exchange transfusion.

Different nomograms are included in the BiliNorm app: one for infants with a gestational age of more than 35 weeks and four for preterm infants. Infants born before 35 weeks have different thresholds than term babies according to the new Indonesian National Guideline on Hyperbilirubinemia. In Indonesia, it is

often difficult to determine exact gestational age; therefore, guidelines for preterm babies are categorized by birth weight categories: ≤1000 g, 1001-1499 g, 1500-1999 g, and >1999 g.

In addition to providing advice about potential treatments for hyperbilirubinemia, information is provided about the risks of complications due to acute bilirubin encephalopathy (ABE). This information is based on the modified Bilirubin Induced Neurological Dysfunction-Modified (BIND-M) scoring, adapted from Radmacher *et al*. [9]. Mental status, muscle tone, altered cry, and altered gaze need to be examined. The results are given in four categories: 0: no ABE, 1-4: mild ABE, 5-6: moderate ABE, and >6: severe ABE. In the example case, the patient had mild hypotonia and a high-pitched cry, so the BIND-M score is 2, which is classified as mild ABE with a likely low risk of neurological complications (if appropriate treatment is provided in a timely manner).

Another feature of the BiliNorm is the advice to complete a follow-up examination at the outpatient clinic. This is based on the possible diagnosis of kernicterus spectrum disorder (KSD) and consists of a scoring system that includes the highest TSB level, the presence of risk factors, the findings of neurological examinations performed at first presentation and at follow-up, the presence of enamel dysplasia, the results of the auditory brainstem response (ABR) test, and MRI findings [10]. The result is given as one of four categories: definite kernicterus (10-14), probable kernicterus (6-9), possible kernicterus (3-5) and no kernicterus (0-2). This feature might help professionals to prepare for the possible long-term complications of severe hyperbilirubinemia.

Communication with the patients' family is often neglected and can be difficult for health care workers in low- and middle-income countries, especially in Indonesia. Therefore, the BiliNorm also provides an educational checklist on what should be told to the patients' family. The checklist was adopted and adapted from the NICE guidelines on neonatal jaundice [11].

We introduced the BiliNorm app to health care workers, including midwives, paediatric residents and paediatricians, from two general district hospitals in East Java (Dr Soetomo General Hospital, Surabaya, Indonesia, and Dr. Saiful Anwar General Hospital, Malang, Indonesia) in March 2019. After the introduction of the app, we asked the participants to use BiliNorm.

To evaluate how BiliNorm was perceived in practice, we sent a questionnaire via Google form to health care workers who had used the application. This questionnaire used for this study was adapted and developed from Davis' Technology Acceptance Model (TAM) [12]. The questionnaire had four main parts: 1. Perceived usefulness; 2. Perceived ease of use; 3. Subjective norms, and 4. Intention to use BiliNorm in the future. There were 22 questions in total, and for each question, seven possible answers ranging from 1 (strongly disagree) to 7 (strongly agree) could be given. The English version of our questionnaire is shown in the Supplementary File 1.

To investigate whether the introduction of the BiliNorm app had an effect on the treatment of infants with hyperbilirubinemia, we collected data from the medical records of all patients with neonatal hyperbilirubinemia admitted to the neonatal units of both hospitals during the six-month period before

BiliNorm was introduced (September 2018 to March 2019) and the seven-month period after its introduction (April to September 2019).

Data on gestational age, birth weight, birth date, risk factors, and TSB were collected to determine which treatment should have been given to the patients based on the Indonesian Hyperbilirubinemia Guideline. Next, the actual treatment that was given was compared with the treatment that was indicated by the guidelines. All cases were divided into four groups: under-treatment, correct treatment, over-treatment, and inappropriate treatment. Under-treatment meant that the infant did not receive any treatment despite having a TSB level above the PT threshold. Over-treatment meant that the baby received PT despite having a TSB level below the PT threshold. Correct treatment was defined as treatment consistent with the Indonesian Hyperbilirubinemia Guideline. Inappropriate treatment indicated that treatment was given without any TSB measurement.

Ethical approval was granted by the Ethical Committee in Health Research of Dr Soetomo General Hospital Surabaya (Number 1060/KEPK/III/2019). Written informed consent was obtained from all participating health care workers and from the parents of all infants included in this study.

# Data and Statistical Analysis

The data collected from the medical records were analysed using SPSS for Windows, Version 21 (IBM., Corp. Armonk, N.Y., USA). Pearson's chi-square test was used to calculate the p value of the proportion of infants within a gestational age category, birth weight category, risk factor category, and treatment classifications for the pre-introduction period versus the post-introduction period of the BiliNorm. We also calculated the p values of correct treatment, under-treatment, over-treatment and inappropriate treatment pre- versus post-introduction of the BiliNorm using Pearson's chi-square test. Probability values $< 0.05$ were considered statistically significant.

## Results

# Questionnaire study

In Table 1, we present the questions included in the questionnaire and their responses. Forty-three users of the BiliNorm app returned the questionnaires. Fifty-six percent of the respondents strongly agreed and another 28% agreed that the BiliNorm helped to determine whether the initiation of PT is indicated in newborn infants with jaundice. It also led to better quality of hyperbilirubinemia management (56% strongly agreed and 28% agreed). Eighty-one percent agreed or strongly agreed that it helped to provide better communication, information, and education to the parents and family regarding hyperbilirubinemia and its effects. In the section “perceived ease of use”, 49% strongly agreed and another 23% agreed that it was easy to use BiliNorm. No respondent indicated it was difficult to use. A small minority (5%) of the respondents reported slight disagreement with the three statements regarding the clarity and flexibility of BiliNorm and the skills needed to use it. On the questions regarding the subjective norms, 42% strongly

agreed and another 28% agreed that colleagues felt that BiliNorm is important for the responder. In addition, 42% of the respondents strongly agreed and 32% agreed that they intended to use BiliNorm in the near future.

Table 1
Technology acceptance model results for the BiliNorm questionnaire

| Item | | Answer N (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **A. Perceived usefulness** | | | | | | | | |
| 1. | BiliNorm helps you quickly determine the need for phototherapy in jaundiced babies | 0 | 0 | 1 (2) | 5 (12) | 1 (2) | 12 (28) | 24 (56) |
| 2. | BiliNorm helps you be more aware of acute bilirubin encephalopathy | 0 | 0 | 0 | 6 (14) | 2 (5) | 11 (25) | 24 (56) |
| 3. | BiliNorm helps you be more aware of kernicterus | 0 | 0 | 0 | 4 (9) | 2 (5) | 12 (28) | 25 (58) |
| 4. | BiliNorm helps you improve your hyperbilirubinemia management | 0 | 0 | 0 | 4 (9) | 3 (7) | 12 (28) | 24 (56) |
| 5. | BiliNorm helps you improve communication with information and education for parents about hyperbilirubinemia and its effects | 0 | 0 | 0 | 6 (14) | 2 (5) | 13 (30) | 22 (51) |
| 6. | BiliNorm helps you improve the follow-up for babies with hyperbilirubinemia | 0 | 0 | 0 | 4 (9) | 2 (5) | 14 (33) | 23 (53) |
| **B. Perceived ease of use** | | | | | | | | |
| 1. | Learning to use BiliNorm is easy for you | 0 | 0 | 0 | 6 (14) | 6 (14) | 10 (23) | 21 (49) |
| 2. | With BiliNorm, is easy to get the Information that you want for improving your management of hyperbilirubinemia | 0 | 0 | 0 | 8 (19) | 4 (9) | 10 (23) | 21 (49) |
| 3. | You find BiliNorm clear and understandable | 0 | 0 | 2 (5) | 4 (9) | 2 (5) | 15 (35) | 20 (46) |
| 4. | You find BiliNorm flexible to use | 0 | 0 | 2 (5) | 3(7) | 7 (16) | 10 (23) | 21 (49) |
| 5. | It is easy for you to become skilful in using BiliNorm | 0 | 0 | 2 (5) | 3(7) | 6(14) | 13 (30) | 19 (44) |
| 6. | You find BiliNorm easy to use | 0 | 0 | 0 | 5 (12) | 5 (12) | 11 (25) | 22 (51) |
| **C. Subjective norms** | | | | | | | | |

The questions were translated from Bahasa Indonesia into English. Data are presented as numbers and (percentages). Answer categories: 1. Strongly disagree, 2. Disagree, 3. Slightly disagree, 4. Neither agree nor disagree, 5. Slightly agree, 6. Agree, 7. Strongly agree.

| Item | | Answer N (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Your colleagues think that BiliNorm is important to you | 0 | 0 | 2 (5) | 6 (14) | 5 (11) | 12 (28) | 18 (42) |
| 2. | It is important to your colleagues that you continue to use BiliNorm | 0 | 0 | 1 (2) | 8 (19) | 4 (9) | 13 (30) | 17 (40) |
| 3. | It would not really matter to your colleagues if you stopped using BiliNorm | 2 (4) | 2 (4) | 3 (7) | 9 (21) | 8 (19) | 7 (16) | 12 (28) |
| 4. | Your colleagues would expect you to continue to use BiliNorm | 0 | 1 (2.3) | 1 (2.3) | 6 (14) | 6 (14) | 13 (30) | 16 (37) |
| 5. | None of your colleagues would truly be surprised if you stopped using BiliNorm | 0 | 1 (2) | 3 (7) | 12 (28) | 5 (12) | 9 (21) | 13 (30) |
| 6. | Your colleagues would probably be disappointed in you if you stopped using BiliNorm | 0 | 2 (5) | 0 | 13 (30) | 4 (9) | 11 (26) | 13 (30) |
| 7. | Your colleagues would probably make you feel guilty if you stopped using BiliNorm | 0 | 3 (7) | 1 (2) | 11 (26) | 7 (16) | 10 (23) | 11 (26) |
| **D. Intention to use BiliNorm** | | | | | | | | |
| 1. | You intend to use BiliNorm in the coming months | 0 | 0 | 0 | 5 (12) | 6 (14) | 14 (32) | 18 (42) |
| 2. | You predict that you will use BiliNorm in the coming months | 0 | 0 | 1 (2) | 6 (14) | 5 (12) | 12 (28) | 19 (44) |
| 3. | You plan to use BiliNorm in the coming months | 0 | 0 | 1 (2) | 6 (14) | 4 (9) | 14 (33) | 18 (42) |

The questions were translated from Bahasa Indonesia into English. Data are presented as numbers and (percentages). Answer categories: 1. Strongly disagree, 2. Disagree, 3. Slightly disagree, 4. Neither agree nor disagree, 5. Slightly agree, 6. Agree, 7. Strongly agree.

# Chart review

We collected 436 medical records from 255 infants with hyperbilirubinemia seen in the six-month period before the introduction of the BiliNorm and from 181 infants with hyperbilirubinemia seen in the seven-month period after its introduction. The demographic data of these infants are presented in Table 2. The percentage of infants that received correct treatment was significantly higher after the introduction of the BiliNorm than before the app was introduced (38% vs 51%: $p < 0.006$). There were fewer cases of under- and over-treatment, but the difference was not statistically significant. Treatment with PT without measuring the TSB level decreased from 14–7% ($p = 0.024$).

Table 2
Patient characteristics before and after the introduction of BiliNorm

| Characteristics | All infants<br>n = 436 | Pre-introduction<br>n = 255 | Post-introduction<br>n = 181 | *p* |
|---|---|---|---|---|
| Gestational age (weeks) | 34.7 ± 2.8 | | | 0.348 |
| < 35 weeks | | 137 (54) | 89 (49) | |
| ≥ 35 weeks | | 118 (46) | 92 (51) | |
| Birth weight (gram) | 2197 ± 701 | | | 0.786 |
| < 1000 grams | | 2 (0.8) | 1 (0.6) | |
| 1000–1499 grams | | 22 (8.6) | 20 (11) | |
| 1500–2499 grams | | 149 (58.4) | 99 (54.7) | |
| ≥ 2500 grams | | 82 (32.2) | 61 (33.7) | |
| Postnatal age (days) | 4.1 ± 2.7 | | | |
| Total serum bilirubin (mg/dL) | 12.6 ± 3.9 | | | |
| Risk factors | | | | 0.614 |
| ABO/Rhesus incompatibility | | 2 (0.8) | 1 (0.6) | |
| Haemolysis: G6PD deficiency, spherocytosis, genetic predisposition | | 0 (0) | 1 (0.6) | |
| Illness: asphyxia, infection, sepsis, acidosis | | 144 (56.5) | 106 (58.6) | |
| No risk factors | | 86 (33.7) | 53 (29.2) | |
| Unknown risk factors | | 23 (9) | 20 (11) | |
| Treatment classification | | | | 0.016* |
| Correct treatment | | 97 (38) | 93 (51) | 0.006* |
| Over-treatment | | 87 (34) | 57 (32) | 0.566 |
| Under-treatment | | 35 (14) | 18 (10) | 0.234 |
| Inappropriate treatment | | 36 (14) | 13 (7) | 0.024* |

Data are presented as the means ± SD or numbers (percentages). *: $p < 0.05$ before versus after introduction of the BiliNorm.

In Fig. 2, we present the results for infants with gestational ages above and below 35 weeks. The incidence of correct treatment did not change for infants older than 35 weeks gestation (from 44 to 50% ($p = 0.393$)), it but increased for preterm infants younger 35 weeks gestation (from 33 to 53% ($p < 0.003$)). The rates of over- and under-treatment did not change significantly in either age group. The rate of treatment with PT without measuring TSB did not change significantly (from 9 to 7% ($p = 0.660$)) in the infants older than 35 weeks and decreased from 18 to 7% ($p < 0.014$) in the infants younger than 35 weeks gestation.

# Discussion

To improve the usage of the newly developed Indonesian Guideline for the diagnosis and treatment of hyperbilirubinemia, we developed a web-based application, BiliNorm, to be used with a smart phone. A survey of a group of healthcare workers who were introduced to the app indicated that the app was perceived as helpful and easy to use. The majority of the users indicated that they would continue using the app. An analysis of hospital charts to determine the use of PT before and after the introduction of the BiliNorm indicated a higher correct use of PT and less use of PT without measuring the TSB level, especially in preterm infants with a gestational age less than 35 weeks, after the app was introduced.

Studies have shown that the introduction of guidelines on how to diagnose and treat hyperbilirubinemia in newborn infants can help to improve care for them. The introduction of a guideline alone, however, is not sufficient. Atkinson *et al.* [13] found that paediatricians only provided PT to 54% of infants in whom it was recommended according to the AAP guidelines. Apparently, campaigns are needed to encourage healthcare workers to use guidelines. Tartaglia *et al.* [14] started a campaign aimed at increasing awareness of the AAP guideline in the Children's Hospital in Columbus, Ohio, USA. The compliance score increased from 60% before the intervention to 90% thereafter. Darling *et al* [15] investigated the implementation of new guidelines from the Canadian Paediatric Society in 100 hospitals in Canada. Seventy-nine of these hospitals indicated having implemented these guidelines. However, only 70% of these hospitals implemented the measurement of TSB level before discharge, although this is recommended in the guidelines. The implementation of guidelines might help to reduce the incidence of severe hyperbilirubinemia [16]. Sgro *et al.* found that after the implementation of the Canadian guidelines, the incidence of severe hyperbilirubinemia decreased from 1 in 2480 to 1 in 8352 live-born infants.

Guidelines established for high-income countries (HIC) might not be suited for LMIC countries such as Indonesia because of the limited availability of well-equipped health care facilities. Therefore, a new Indonesian guideline for the diagnosis and treatment of hyperbilirubinemia was developed [6]. The treatment thresholds for starting PT are lower in this guideline than in guidelines used in HICs. This change was made to increase the safety margin, as daily control of the TSB level of a jaundiced infant is more difficult in Indonesia than in HICs. We developed a web-based application to make the use of this guideline easier. In a previous study, paediatricians indicated having difficulties finding the existing guideline, which hampered their use of it [3].

Comparable programmes to assist health care workers in caring for newborn infants with hyperbilirubinemia have been developed. Three of these, BiliTool, BiliApp and the Northern California Neonatal Consortium (NCNC) app [2, 17, 18], are based on the AAP guideline of 2004 or on the NICE guideline. Most of these decision-making tools are applicable for infants born after 35 weeks of gestation, whereas others are also suitable for preterm infants. The existing decision-making tools only provide advice for infants without risk factors. The user of the apps should make adjustments when risk factors are present. The BiliRecs programme [19] was designed for infants with a gestational age of less than 35 weeks, but the app is unsuitable for infants with a postnatal age of less than 2 days.

The BiliNorm app is different from these published tools in several ways. First, its treatment recommendations take risk factors into account if present. Second, the tool can be used in both term and preterm infants. Thirdly, advices are regarding follow-up is given based on clinical signs of ABE in the postnatal period and on a KSD risk calculation. Fourth, BiliNorm provides information for parents on jaundice and treatment strategies. Finally, our app can be used with a smart phone. Our app is designed for use in low- and middle-income countries and is available in English and Bahasa because it is based on guidelines for Indonesia.

Our study indicated that after our app was introduced in two hospitals, the incidence of correct treatment for all infants increased from 38 to 51%. Both over- and under-treatment of hyperbilirubinemia decreased slightly but did not reach statistical significance overall. Nevertheless, more than 40% of the infants received treatment without good indications or did not receive treatment when indicated. The rate of PT use without a TSB measurement decreased substantially and was 7% after the introduction of the BiliNorm. Our results indicate that preterm infants younger than 35 weeks gestational age benefit the most from the introduction of the BiliNorm; correct treatment increased from 33–53%, and inappropriate treatment reduced by more than half, from 18–7%.

More studies are needed to understand why some health care workers either do not use or do not follow current guidelines for the diagnosis and treatment of hyperbilirubinemia. Long-term studies are needed to determine whether the BiliNorm app will lead to improvements in the outcomes of infants with hyperbilirubinemia and to a reduction in the incidence of severe hyperbilirubinemia and kernicterus.

# Conclusions

In conclusion, to improve the management of hyperbilirubinemia in Indonesia, we developed a novel web-based application called BiliNorm. This decision support tool is based on the Indonesian National Guideline on Hyperbilirubinemia. The results of a questionnaire indicated that users found the tool user friendly and helpful in making the decision to start treatment/phototherapy, and the participants indicated they planned to continue using the app in the future. Use of the BiliNorm promotes correct treatment of hyperbilirubinemia, but the proportion of under- or overtreated infants remains substantial.

# Disclaimer

The content of BiliNorm is designed to improve the management of jaundiced infants by qualified health care workers. BiliNorm is based on the Indonesian National Guideline on Hyperbilirubinemia. Nothing in the content of BiliNorm should be considered or used as a substitute for medical advice, diagnosis or treatment. BiliNorm and its contents do not replace professional medical advice, diagnosis or treatment. The use of all content of BiliNorm is entirely at your own risk. The authors of this article and the designer are not liable for any damage that may arise from the use of BiliNorm. If you are dissatisfied with this disclaimer, then the only option is to stop using the application.

# List Of Abbreviations

ABE : acute bilirubin encephalopathy

AAP : American Academy of Pediatrics

BIND-M : Bilirubin Induced Neurological Dysfunction-Modified

HIC : high-income countries

KSD : kernicterus spectrum disorder

LMIC : low- and middle-income countries

NCNC : Northern California Neonatal Consortium

NICE : The National Institute for Health and Care Excellence

PT : phototherapy

TAM : technology acceptance model

TSB : total serum bilirubin

# Declarations

### Ethics and consent to participate

Ethical approval was given by the Ethical Committee in Health Research of the Dr Soetomo General Hospital Surabaya Number 1060/KEPK/III/2019. Written informed consent was obtained from all participants, including the infants' parents and health personnel.

### Consent for publication

Not applicable.

### Availability of data and materials

The dataset used and/or the analyses performed in the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no conflicts of interest to declare.


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### Authors' contributions

MTAS, PJJS, and AFB conceived of the idea of developing the application and wrote the first draft of the manuscript. CVH and PHD participated in designing the study and assisted in the data analysis and interpretation. MTAS, KAR, ZSI, RE, MTU, and BIRVC developed the application, provided training on its use, and collected the data. MTAS, KAR and ZSI performed the data analysis and created the figures and tables. RE, MTU, and ES helped with the literature review and revised the manuscript. CVH helped with the methodology of the data and revised and edited the manuscript. PHD revised the manuscript and edited the table. AFB also participated in designing the study and carried out the interpretation. PJJS assisted and edited the final version of the manuscript. All authors have read the manuscript. All authors approved the final version.


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# Figures

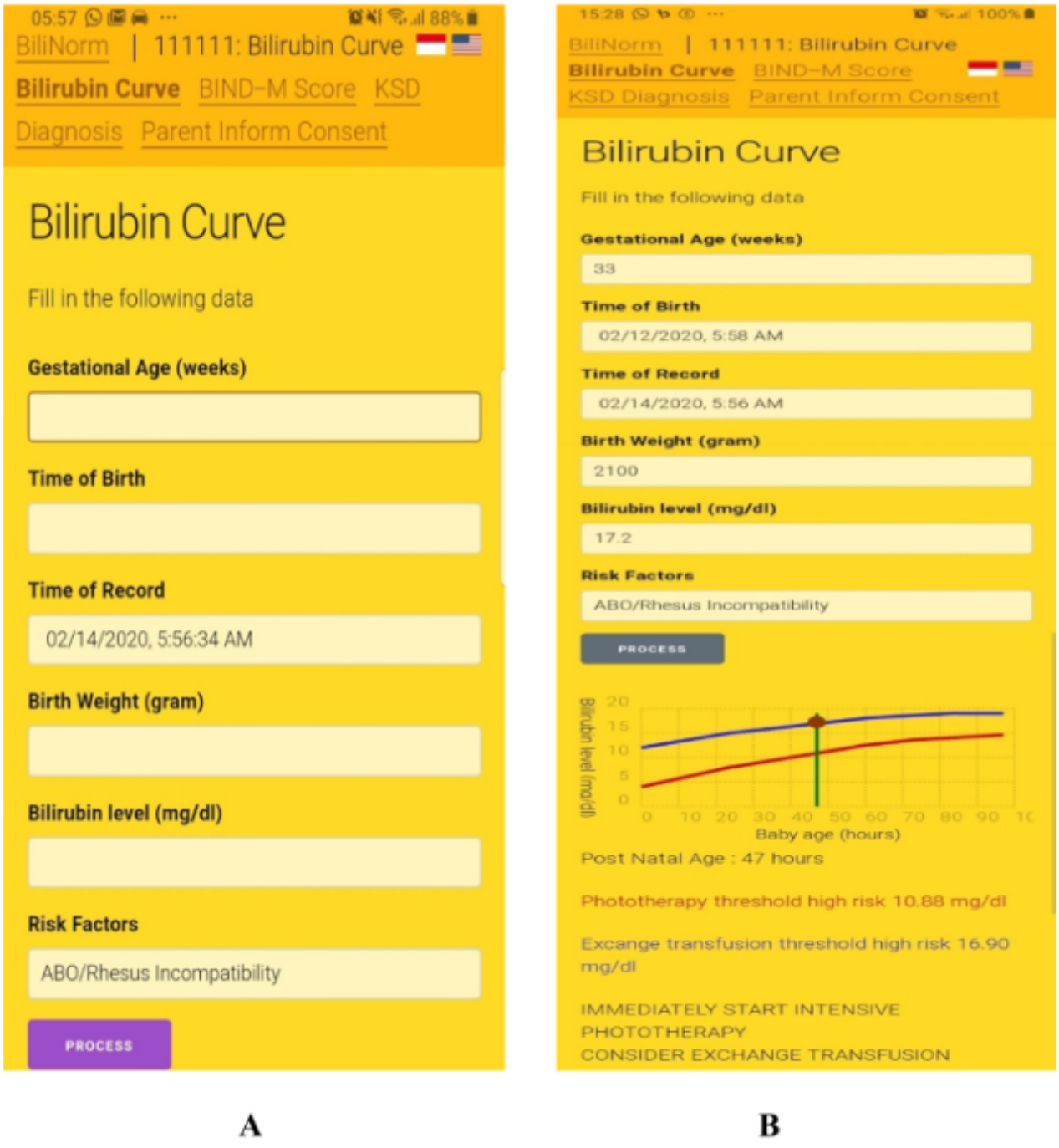
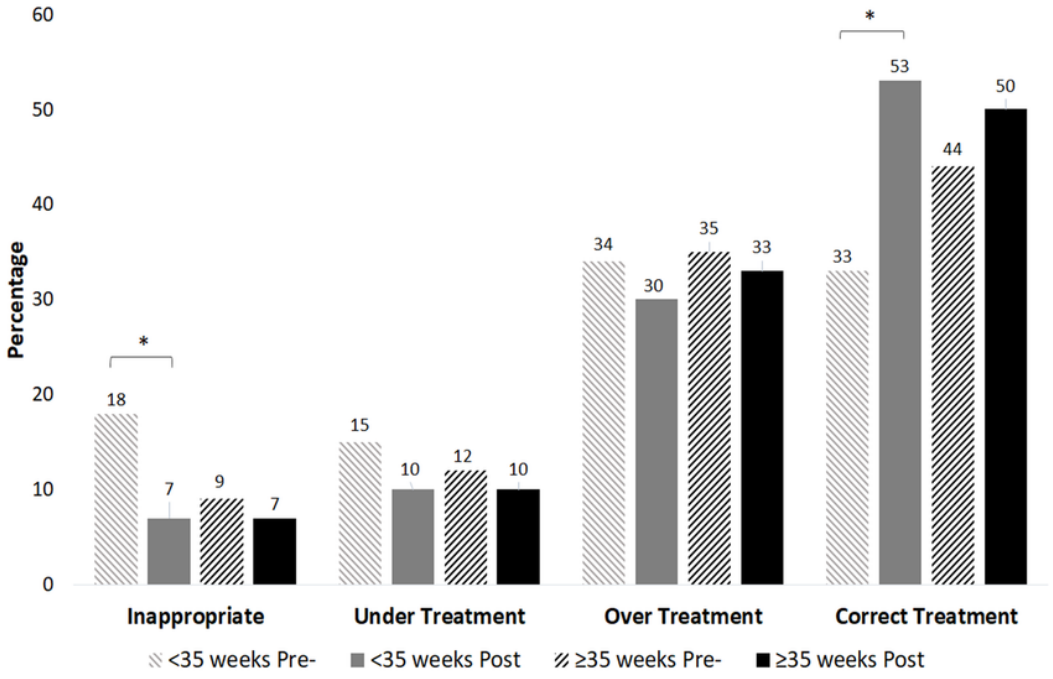



**Figure 1**

BiliNorm screenshots The screenshots show the data fields that must be completed on the input screen (A) and the results and advice given on the output screen (B) of the BiliNorm. Used with the permission of

Sampurna and Kurniwan, 2019 (https://bilinorm.babyhealthsby.org/) [7].




## Figure 2

Treatment classifications before and after the introduction of the BiliNorm based on gestational age The percentages of infants with a gestational age below (grey bars) or above (black bars) 35 weeks with inappropriate treatment, under-treatment, over-treatment and correct treatment before (hatched bars) versus after (solid bars) the introduction of the BiliNorm. *: $p < 0.05$ before versus after introduction.