Information system for diagnosing Neonatal Jaundice using rule-based algorithm

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Abstract. Neonatal jaundice often occurs in newborns characterized by a yellow discoloration of the sclera and baby's skin due to high levels of bilirubin in the blood. The occurrence of jaundice needs done identified to the development of hyperbilirubinemia which has the potential to become a toxic that can cause kernicterus. Detection of jaundice by manual (visual) is still often done by parents and health workers, so that the results of the diagnosis obtained are less accurate. This study proposes an innovative use of information systems in detecting jaundice using the SDLC (Systems Development Life Cycle) method with a waterfall model. Retrieval of data in this study with a quasi experiment using non-probability sampling with consecutive sampling on 48 newborn respondents. The result of this study indicate that the information system that has been built can detect jaundice faster as much as 2.1 minutes with an accuracy rate of 91.7%, can provide appropriate solutions and an effective level of use of information systems of 90.5% which can be used as an innovation in helping overcome jaundice problems.

1. Introduction

In 2017, globally, the neonatal mortality rate in the first 28 days of life was estimated at 18 per 1.000 live births the most occurring in Sub-Saharan Africa, namely 27 deaths per 1.000 live births and followed by South Asia with 26 deaths per 1.000 live births [1]. The main causes of neonatal mortality, as much as 93%, were attributable to asphyxia, infection and prematurity [2]. Incidence of preterm 80% have jaundice problems in the first week of life while about 60% of term babies have the incidence jaundice [3]. Jaundice is a problem associated with infant mortality rate where as much as 24% of neonatal deaths are caused by kernicterus [4].

The problem of jaundice can be overcome by using an information technology system that can detect, diagnose, treat, educate effectively, easily and quickly [5]. Advances in information technology play a very important role in the field of health services which includes telemedicine, biological signal processing (medical image processing), security of health information and health information systems [6]. The use of information systems in health services can shorten the process of care, improve quality of service, maximize efficiency of time, medical devices, workforce in doing preventive and curative [7].
The information system aims to improve the ability to collect, store, and analyze health data accurately, effectively in intervening, providing services efficiently, increasing data accuracy, learning about trends and increasing accountability [8]. Improving the quality of health services has now been carried out by developing and developed countries by using information systems to address emergencies in obstetrics [9]. Application of information systems in improving the effectiveness of health services can process data properly in public health management [10].

Overcoming problems using information systems is needed as a breakthrough that can motivate, provide convenience, connect, teach, understand, and empower individuals [11]. The success of an information system in patient care consists of six dimensions including system quality, usage, information quality, user satisfaction, organizational impact and individual impact, while the quality of information systems can be seen from response time, ease of access, ease of use, system integration, level system accuracy and flexibility [12].

Building a rule-based system is needed in conducting specific assessment of all possibilities that occur in the field [13]. Automatic system development can support and analyze in making a decision [14]. The use of the system as a non-invasive method based on image processing can measure the level of bilirubin levels in a person's body by looking at the degree of jaundice in the sclera [15]. The use of a non-invasive system is more appropriate in the assessment of jaundice because invasive methods can cause pain and risk of infection [16].

The development of science and technology systems that are increasingly rapid has a very large contribution in the health sector by using information systems. The use of information systems can diagnose the incidence of jaundice in newborns. The occurrence of jaundice must be detected and diagnosed quickly so as not to experience delays in getting medical treatment. Delay in taking action can adversely affect the health of the baby. This study discusses an information system to diagnose neonatal jaundice using a rule-based algorithm.

2. Methods
The data retrieval of this study was a quasi experiment using non-propability sampling with consecutive sampling on 48 newborns aged 0-15 days with two measurements, namely manual (visually) and using an information system. The information system framework that has been built in this study is shown in Figure 1.

![Figure 1. Information systems framework](image-url)

The design of the information system in the detection of neonatal jaundice using the System Development Life Cycle (SDLC) model with the waterfall method which consists of several stages is shown in figure 2 [17].
The stages of making the information system include:
1. Analysis, This stage identifies user needs in developing information systems.
2. Design, The system design in this study is in the form of making a framework according to the needs of users in the field to facilitate the system creation.
3. Implementation, The implementation stage is in the form of making the system according to the design that has been made.
4. Testing, Tests are carried out to determine whether the system that has been made is in accordance with expectations.
5. Evaluation, After conducting field testing, then evaluate to find out if there is an error in a system. Application-based and website-based information systems used in jaundice detection have several steps that can be taken to produce diagnoses and provide solutions. The steps for detecting jaundice are shown in figure 3.

![Figure 2. System Development Life Cycle (SDLC) waterfall model](image)

Diagnosis in this study uses rule-based reference to the Kramer parameter to see the yellow color changes that occur in newborn skin ranging from grade I to V. The rule-based architecture is shown in figure 4.

![Figure 3. Steps to detect jaundice](image)
3. Results and discussion
The results of this study have been validated by expert systems, namely midwives to see the speed, level of accuracy, accuracy and effectiveness of using information systems. The speed of early detection in diagnosing neonatal jaundice is done manually and using an information system, the difference in mean time is shown in Table 1.

Table 1. The results of the diagnostic speed

| Variable | Method                | Average time (minutes) | p value |
|----------|-----------------------|------------------------|---------|
| Speed    | Manual (visual)       | 7.8                    | 0.001   |
|          | Information System    | 5.7                    |         |

The average speed of time in determining the diagnosis of jaundice using the information system is 7.8 minutes while manually is 5.7 minutes, so it can be concluded that the use of information systems is 2.1 minutes faster in determining the diagnosis of jaundice than visually. Medical image analysis can achieve higher diagnostic speed and expert accuracy parallelism that can influence medical practice by applying natural language processing to read the growing scientific literature and compile electronic medical records, a machine that runs from medical data can prevent clinical errors due to bias human cognitive abilities that can positively affect patient care [18]. Artificial Intelligence application in biomedicine can efficiently use large data and provide fast access to data to solve health-related problems [19]. Prompt treatment or timely prevention of jaundice can save costs due to reduced hospitalization of newborns, so that evaluating the incidence of neonatal jaundice in jaundice services should be considered a fundamental policy [20]. The use of web-based computers to help carry out instructions that have fast characteristics, high capacity, makes the dissemination of knowledge without the limitations of time and space, and can be accurate [21]. In addition, the use of the system can make time, cost and energy more efficient for doctors and patients [22]. The diagnosis of jaundice detection that has been carried out is shown in Figure 5.
The jaundice detection assessment was carried out twice manually and using an information system. The diagnostic results obtained in this study were validated by an expert system, namely the midwife. Enforcement of jaundice diagnosis is done by comparing manual methods with expert systems, information systems with expert systems and manual methods with information systems that will be tested using statistics to see if there are differences in diagnosing enforcement. The results of different tests for the diagnosis of jaundice are shown in Table 2.

### Table 2 The results of different tests of diagnosis on the detection of jaundice

| Variable                                           | p value |
|----------------------------------------------------|---------|
| Manual diagnosis with an expert (midwife)          | 0.002   |
| Enforcement of the diagnosis using an information system with experts (Midwives) | 1.000   |
| Manually-enforced diagnosis-information systems    | 0.002   |

The results of the different test of manual diagnosis with experts (midwives) were different with a p value of 0.002 and diagnosis using an information system with an expert (midwife) had no difference with a p value of 1.000, while manual diagnosis with an information system was different. P value 0.002, it can be concluded that the use of information systems is better for conducting diagnoses on the detection of jaundice because there is no significant difference between jaundice detection using an information system and an expert system, whereas there is a difference in jaundice detection done manually with an expert system.

The detection of jaundice is done manually and uses an information system validated by an expert system to see the accuracy of the diagnosis in newborns. The level of accuracy is shown in Table 3.

### Table 3 The results of the frequency of accuracy in early detection of jaundice diagnosis

| Variable     | N  | Method               | Manual | Information system |
|--------------|----|----------------------|--------|--------------------|
| Level of accuracy | 48 | Manual               | 72.9%  | 91.7%              |

Based on the results of the accuracy that has been done manually, namely 72.9% and using an information system of 91.7% in enforcing the diagnosis, it can be concluded that early detection of neonatal jaundice to find jaundice diagnosis is more accurate using an information system so that it can be used as a tool for parents, at home in monitoring. Accurate diagnosis is very important in treatment...
problems, so clinical decision support systems such as applications have experienced improvement in recent years [23]. Image processing in the diagnostic method has a higher level of accuracy. Image possessing or image processing is widely used to assist experts in diagnosing diseases and choosing the right treatment [24].

Providing solutions to neonatal icterus events can be done by using an information system that can be used to make decisions to prevent adverse effects that can harm the baby. Providing solutions using an information system is shown in figure 6.

Figure 6. Administration of jaundice solutions

Accuracy in providing solutions to the problem of jaundice is very important because if the solution is not given the right one, the action taken will be wrong which can endanger the baby's health condition. The accuracy of providing solutions is in accordance with the diagnostic results obtained in the detection of jaundice. Providing the right solution can make it easier to treat jaundice problems.

Measurement of the effectiveness of the information systems aims to see the extent to which the application can be accepted among the public and can be effective in early detection of neonatal jaundice in newborns. The effectiveness of the information systems is shown in table 4.

| Variable    | N  | Effectiveness (%) |
|-------------|----|-------------------|
| Uses        | 48 | 91.0              |
| Convenience | 48 | 90.7              |
| Attitude    | 48 | 90.3              |
| Behaviors   | 48 | 90.2              |
| Actual      | 48 | 90.2              |
| **Total Average** |   | **90.5%**         |

Table 4. Effectiveness of information systems

The results of the effectiveness of the information systems carried out by parents using the TAM (Technology Acceptance Model) score based on the aspects of uses, convenience, attitude, behavior and actual aspects are 90.5% which states that the information system is very effective in early detection of jaundice neonatal. The Technology Acceptance Model (TAM) has been widely used to explain user behavior and assist in understanding an information system such as the convenience factor and perceived usefulness factors in computer use are the main factors based on the technology acceptance model [25]. Technology Acceptance Model in each individual is influenced directly or indirectly by behavioral intentions, attitudes, perceptions of the ease and usefulness of the technology system [26]. A person's behavioral intention to use technology and interest in behavior can be seen from the predictable level of
technology use from motivation, attitude and attention to keep using technology such as desire to motivate other users [27].

4. Conclusion
Information systems with rule-based algorithms can be used to detect and diagnose jaundice problems that occur in newborns. This research can prove that the information system has an accuracy rate of 91.7% which has a difference in time speed of 2.1 minutes manually, besides that the information system provides more precise solutions and information systems when viewed from the usefulness, convenience, attitude, behavior and actual. Effective 90.5% to be used as an innovation in helping to overcome the problem of jaundice. Recommendations for further research can develop the use of technology in overcoming problems that occur in newborns.

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