

The Use of Forward Chaining for Early Detection of Hepatitis B Risk Among Pregnant Women at Beber Community Health Center, Cirebon RegencyYanto Haryanto¹, Maula Ismail¹¹Poltekkes Kemenkes Tasikmalaya, Indonesia**ABSTRACT**

Hepatitis B virus (HBV) infection remains a major public health problem in Indonesia, particularly among pregnant women, where delayed detection may increase the risk of mother-to-child transmission as well as serious complications such as cirrhosis and hepatocellular carcinoma. The high cost of laboratory testing may contribute to delays in diagnosis and treatment. This study aimed to design a web-based early detection system for hepatitis B in pregnant women using the Forward Chaining method. A mixed-methods approach with a Research and Development (R&D) design was employed to develop and evaluate the system. The developed system was tested on 30 respondents and achieved a 100% success rate in black-box testing. Validation results showed a sensitivity of 100%, specificity of 90%, positive predictive value (PPV) of 82%, negative predictive value (NPV) of 100%, and an accuracy of 93%, indicating good diagnostic performance. The developed system can assist in the early detection of hepatitis B among pregnant women and may support earlier identification of the risk of mother-to-child transmission in primary healthcare settings.

Keywords: early detection, forward chaining, hepatitis B, pregnant women, web-based system

Correspondence:
Yanto Haryanto
Poltekkes Kemenkes Tasikmalaya
Email address yantohyt@gmail.com

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INTRODUCTION

Regulation of the Minister of Health of the Republic of Indonesia No. 53 of 2015 on the Control of Viral Hepatitis states that viral hepatitis control prioritizes promotive and preventive measures to reduce morbidity, disability, and mortality, as well as to interrupt disease transmission. One of the key preventive strategies is early detection.

Among the various types of viral hepatitis, hepatitis B virus (HBV) infection remains a major public health problem worldwide, particularly in Indonesia. The high cost of laboratory testing often leads to delayed detection and treatment, increasing the risk of progression to serious complications such as cirrhosis and hepatocellular carcinoma. In developing countries, including Indonesia, the prevalence of HBV infection ranges from 5% to 10%. Globally, an estimated 350–400 million people are living with chronic hepatitis B, while the prevalence among the general healthy population is estimated to range from 4.0% to 20.3%. According to the 2013 Basic Health Research (Riskesdas), the proportion of HBsAg-positive individuals in Indonesia was 7.1%.

To strengthen prevention efforts, the Indonesian government has implemented an early detection program for hepatitis B among pregnant women using the hepatitis B surface antigen (HBsAg) Rapid Diagnostic Test (RDT). According to the Cirebon Regency Health Office (2022), hepatitis B was detected in 460 (1.3%) of the 36,572 pregnant women who underwent screening in 2022.

As primary healthcare facilities, community health centers (Puskesmas) play an important role in implementing government health programs. Beber Community Health Center in Cirebon Regency is one of the health centers responsible for implementing the hepatitis B early detection program for pregnant women within its service area.

This study developed a Hepatitis B Early Detection System using the Forward Chaining method to assist in the early identification of pregnant women at risk of hepatitis B. The system was designed as a decision-support tool to facilitate early risk detection, enabling timely prevention and appropriate follow-up. Compared with laboratory screening using the Rapid Diagnostic Test (RDT), the proposed web-based application offers a more cost-effective approach for preliminary risk assessment. It is expected that the system will support the early identification of pregnant women at risk of mother-to-child transmission of hepatitis B and contribute to improving early prevention efforts in primary healthcare settings.

METHODS

This study employed the Expert System Development Life Cycle (ESDLC) using the Forward Chaining method as the inference engine for decision-making in the Hepatitis B Early Detection System. The study was conducted at Beber Community Health Center, Cirebon Regency. The inference engine was validated by a midwife from Beber Community Health Center who was responsible for hepatitis B screening among pregnant women.

The performance of the application was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. The evaluation sample consisted of 30 medical record documents selected using a purposive sampling method. The inclusion criteria were medical records of pregnant women who underwent a series of prenatal checkups at Beber Community Health Center in April 2024.

The variables in this study consisted of input variables (the assessment stage and the knowledge acquisition stage), process variables (the design stage and the testing stage), and output variables (the documentation stage). The instrument used in this study was a system testing checklist to evaluate the system's content and functionality.

RESULTS

Assessment Phase

An assessment of the problem was conducted through a literature review of published journals and authoritative sources, including the World Health Organization (WHO), regarding the risk of hepatitis B among pregnant women. The review identified low levels of public awareness, the impact of high testing costs, and the high risk of mother-to-child transmission of hepatitis B. The system was developed to meet the needs of Beber Community Health Center and the supervising faculty member. The Hepatitis B Early Detection System includes several menus to support the detection process, namely the detection menu, patient data menu, disease data menu, symptom data menu, and information menu.

Knowledge Acquisition Stage

The data and information used to develop the inference engine (Table 1) were collected through a literature review. These data were then formulated into IF–THEN rules, which were implemented as the system's inference engine (Table 2). This study focused on hepatitis B, with detection results categorized as "At Risk for Hepatitis B" or "Not at Risk for Hepatitis B."

Table 1. Basic symptoms of hepatitis B used for the inference engine

Symptoms of Hepatitis B	At Risk for Hepatitis B	Not at Risk for Hepatitis B
Weakness		√
Fever		√
Nausea and vomiting		√
Loss of appetite	√	
Pale stools	√	
Yellowing of the skin and eyes	√	
Weight loss	√	
Dark red urine, like tea	√	
Pain in the left side of the abdomen		√
Joint pain		√
Rash		√
Itching		√
Muscle pain/aches		√
Injection drug use	√	
Changing sexual partners	√	
Receiving an unsterile blood transfusion	√	
Undergoing dialysis (hemodialysis)	√	

Tabel 2. Rules implemented as the system's inference engine

Rule	IF	THEN
1	G04, G05, G06, G07, G08, G14, G15, G16	P01
2	G01, G02, G03, G09, G10, G11, G12, G13	P02

The system provides comprehensive information on hepatitis B, including its etiology, mode of transmission, prevention, recommendations, and management. Hepatitis B is an inflammation of the liver caused by the hepatitis B virus (HBV). The infection may become chronic if the virus remains in the bloodstream for more than six months and can progress to cirrhosis (liver scarring) or hepatocellular carcinoma (Kemenkes, 2020).

Hepatitis B can be transmitted through contact with the bodily fluids of an infected individual, including blood, saliva, vaginal secretions, and other body fluids. Transmission may also occur from an infected mother to her newborn during childbirth or through the use of unsterilized needles, such as those used for tattooing or injection drug use (Kemenkes, 2020).

Hepatitis B infection can be prevented by minimizing exposure to risk factors and adopting clean and healthy lifestyle practices. These include washing hands regularly with soap before and after activities, avoiding the sharing of personal items such as toothbrushes, razors, and nail clippers, and covering open wounds to prevent blood-to-blood contact (Pemerintah Kota Tasikmalaya, 2022).

Pregnant women are advised to consult a midwife or physician at the nearest community health center (Puskesmas) or hospital for anti-HBs testing and hepatitis B vaccination. Early consultation also enables pregnant women to obtain appropriate health information and timely medical intervention (Kemenkes RI, 2015).

If a pregnant woman tests positive for HBsAg and presents with clinical symptoms or indications for hepatitis B therapy, she should be referred to and managed at a hospital or community health center with appropriate infection-control measures. Infants born to HBsAg-positive mothers should receive the HB-0 vaccine and hepatitis B immunoglobulin (HBIG) within 24 hours after birth, followed by the HB-1, HB-2, and HB-3 vaccine doses according to the national immunization schedule (Kemenkes, 2019).

Design Phase

In this phase, Unified Modeling Language (UML) was used to visualize the system through four diagrams: the Activity Diagram, Use Case Diagram, Class Diagram, and Sequence Diagram. The system was developed using the PHP programming language and the MySQL database management system (Hasanah, 2020).

Testing Phase

A checklist was used to evaluate the Hepatitis B Early Detection System (SIDIHEP-B). The checklist assessed the system's features and content, including the user interface, ease of access, user-friendliness of the features and menus, clarity of the symptom-related questions, the system's ability to provide knowledge and information about hepatitis B, the occurrence of system errors during use, and user feedback regarding features or information requiring further improvement.

The hepatitis B detection results generated by SIDIHEP-B were compared with the HBsAg test results obtained from the medical record documents. The comparison is presented as a cross-tabulation in Table 3.

Table 3. Cross-tabulation of SIDIHEP-B results and HBsAg test results from medical record documents

Test Results SIDIHEP-B	HbsAg result from Medical Record Document		Total
	Reactive (+)	Non Reactive (-)	
<i>At Risk For Hepatitis B</i>	9	2	11
<i>Not At Risk For Hepatitis B</i>	0	19	19
<i>Total</i>	9	21	30

Based on the cross-tabulation results (Table 3), validity measures were calculated. As presented in Table 4, the proposed system demonstrated excellent performance. The sensitivity (Sn) and negative predictive value (NPV) both reached 100%, indicating that the system correctly identified all positive cases without producing any false-negative results. Furthermore, the specificity (Sp) was 90%, and the positive predictive value (PPV) was 82%. Overall, the system achieved an accuracy of 93%, indicating good reliability and effectiveness for the early detection of hepatitis B.

Table 4. Validity test results

Validity Test Result	Result (%)
Sensitivity (Sn)	100%
Specificity (Sp)	90%
Positive Predictive Value (PPV)	82%
Negative Predictive Value (NPV)	100%
Accuracy	93%

Documentation Phase

This phase describes how to use the developed Hepatitis B Early Detection System for pregnant women. The following instructions are provided for users:

First, users should prepare a device connected to the internet, such as a smartphone, laptop, or computer. Users can then access the system through their preferred web browser by entering the following address: <http://103.184.53.115:8023/sidihep-b/>.



Figure 1. System Home Page

Second, the Home Page is the initial screen displayed after users access the Hepatitis B Early Detection System website. This page provides an overview of the system and explains its workflow.



Figure 2. Main Page Display (System Workflow)

Third, the Registration Page is displayed for users who do not yet have an account. Users are required to complete the registration form before accessing the system.

The image shows a registration form titled "Daftar yuk, ke SIDIHE-P". It contains several input fields: "Nama Lengkap", "Nomor HP", "Password", "Alamat", "Ibu Hamil" (with a dropdown arrow), "Usia Kehamilan", and "dd/mm/yyyy" (with a calendar icon). Below the fields is a blue button labeled "Daftar Sekarang". At the bottom, there is a link that says "Sudah punya akun? Masuk Sekarang".

Figure 3. Registration Page Display

Fourth, the Login Page is displayed after users complete the registration process. Users can log in using the username and password they created during registration.

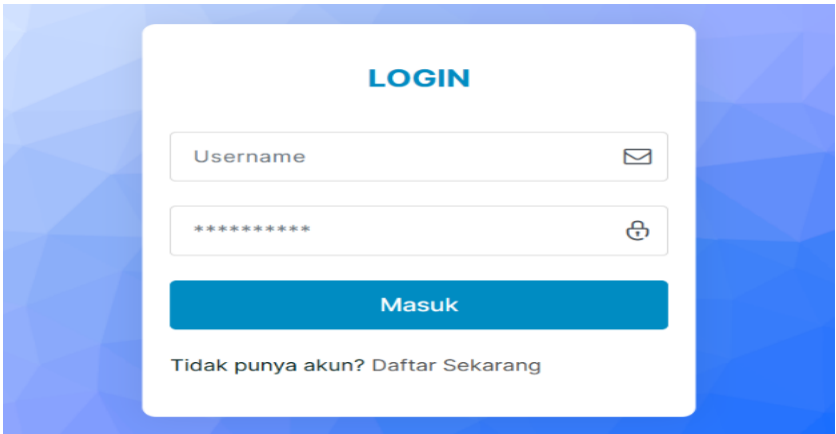
The image shows a login form titled "LOGIN". It has two input fields: "Username" with an envelope icon and a password field with asterisks and a lock icon. Below these is a blue button labeled "Masuk". At the bottom, there is a link that says "Tidak punya akun? Daftar Sekarang".

Figure 4. Login Page Display

Fifth, the Screening Page is displayed after users successfully log in. The system presents a series of questions to screen for hepatitis B. Users answer each question by selecting "Yes" or "No" according to the symptoms they are experiencing.



Figure 5. Screening Page Display

Sixth, the Screening Results Page is displayed after users complete the screening questions. The system presents the screening results based on the user's responses and provides information related to hepatitis B. If the result indicates "At Risk for Hepatitis B," the system provides recommendations for further action. If users are not satisfied with the screening results, they may repeat the screening process.

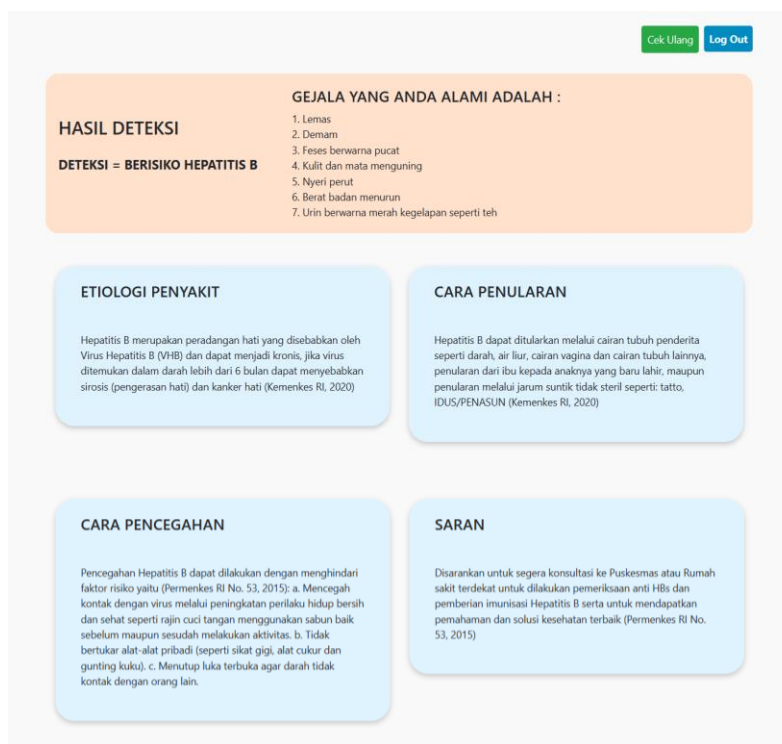


Figure 6. Detection Results Page

DISCUSSION

The system was developed using the Forward Chaining method as the inference engine, with the Expert System Development Life Cycle (ESDLC) serving as the development framework and providing guidance for each stage of the system development process. The ESDLC stages applied in this study included the assessment, knowledge acquisition, design, testing, and documentation stages. Although this study generally followed the ESDLC framework described in the literature, the maintenance stage was not included because it was beyond the scope of this study (Rosdianty *et al.*, 2023)

Assessment Stage

This system was developed to support the early detection of hepatitis B risk among pregnant women and to assist the government's hepatitis B screening program for pregnant women. The system was designed as a web-based platform, consistent with previous studies indicating that web-based systems can facilitate early disease detection through computers and mobile internet devices. This stage corresponds to the assessment phase of ESDLC, which focuses on identifying problems and determining appropriate solutions (Aprianto *et al.*, 2023; Syahputra & Syafindy, 2022).

Knowledge Acquisition Stage

The knowledge base was developed through a literature review. The system focuses on hepatitis B risk in pregnant women and incorporates 16 symptoms adapted from previous studies and validated by midwives responsible for hepatitis B screening among pregnant women (Hajjah *et al.*, 2023; Herlambang *et al.*, 2021; Hidayat & Ramsari, 2023). This stage involves collecting information, identifying relevant knowledge sources, and defining the system requirements needed for system development (Aprianto *et al.*, 2023; Syahputra & Syafindy, 2022).

Design Phase

The system was developed as a web-based application using PHP as the programming language and MySQL as the database management system (DBMS). System modeling was performed using four Unified Modeling Language (UML) diagrams: Activity Diagram, Use Case Diagram, Class Diagram, and Sequence Diagram. The design phase aimed to develop the system architecture and user interface based on the requirements identified during the assessment stage. The UML diagrams used in this study were adapted to the requirements of the developed system and therefore focused only on the interactions between users and administrators rather than implementing all UML components described in previous studies (Aprianto *et al.*, 2023; Hendra & Riti, 2023; Tabrani *et al.*, 2021).

During system development, the researcher encountered several challenges, including limited experience with PHP programming and temporary server failures. These issues were addressed by learning PHP through books, journals, websites, YouTube resources, and consultation with programming experts. While the primary server was unavailable, system development continued using an alternative server (Yansyah & Sumijan, 2020).

Testing Phase

Black-box testing was used to evaluate the system's functionality and achieved a 100% success rate, indicating that all functions operated as intended. Compared with previous studies,

black-box testing in this study was more comprehensive because it evaluated the system from both user and administrator perspectives (Herlambang *et al.*, 2021; Wicaksono, 2022).

The system's detection results were compared with HBsAg test results from pregnant women as the reference standard. Diagnostic validity testing demonstrated good system performance, with a sensitivity of 100%, specificity of 90%, positive predictive value of 82%, negative predictive value of 100%, and an overall accuracy of 93%. In addition, reliability testing produced a Cronbach's alpha coefficient of 0.790, indicating good reliability. The system also demonstrated a false-positive rate of 6.7%. These findings indicate that the developed system performed in accordance with the design objectives and implementation methods established during the previous development stages (Aprianto *et al.*, 2023).

Documentation Phase

The final phase of this research was the preparation of a user guide for the developed system. This user guide contains information on the system's menus, features, and operating procedures, complete with interface images to help users operate the system. The purpose of this documentation was to systematically and clearly document all stages of system development so that it can serve as a guide for both the operation and future development of the system (Aprianto *et al.*, 2023).

CONCLUSION

Based on the research conducted, the following conclusions were drawn according to each stage of the study.

The Assessment Stage resulted in a system suitable for the early detection of hepatitis B risk among pregnant women at Beber Community Health Center, Cirebon Regency, with features and menus tailored to the access rights of both administrators and users.

The Knowledge Acquisition Stage identified 16 signs, symptoms, and risk factors through a literature review using journals, books, and authoritative websites, including those of the World Health Organization (WHO). The knowledge base was further validated by the midwife responsible for hepatitis B screening among pregnant women at Beber Community Health Center.

The Design Phase involved designing and developing the system using the PHP programming language and a MySQL database. The system design was represented using four Unified Modeling Language (UML) diagrams: Activity Diagram, Use Case Diagram, Class Diagram, and Sequence Diagram.

The Testing Phase demonstrated that the system achieved a 100% success rate in black-box testing, indicating that all system functions operated as intended. The validity test showed a sensitivity (S_n) of 100%, specificity (S_p) of 90%, positive predictive value (PPV) of 82%, negative predictive value (NPV) of 100%, and an overall accuracy of 93%, indicating good system validity. In addition, the reliability test produced a Cronbach's alpha coefficient of 0.790, indicating that the system has acceptable reliability.

The Documentation Phase resulted in the development of an operation manual to support the implementation of the Hepatitis B Early Detection System (SIDIHEP-B). The manual is intended for both users and system administrators to facilitate system operation.

To further improve early detection, future development should incorporate more comprehensive hepatitis B laboratory parameters to enhance detection accuracy. In addition, the system's functionality can be expanded by improving its menus and features. Further pilot testing involving a broader population is also recommended to comprehensively evaluate the feasibility and applicability of the Hepatitis B Early Detection System.

RECOMMENDATION

Based on the findings of this study, future research is recommended to integrate more comprehensive hepatitis B laboratory examination data into the system to improve the accuracy of early detection. In addition, the system should be further enhanced by developing more interactive, user-friendly, and comprehensive menus and features to improve its usability and user experience.

Future studies are also encouraged to involve larger and more diverse populations to comprehensively evaluate the feasibility, effectiveness, and generalizability of the Hepatitis B Early Detection System (SIDIHEP-B). Furthermore, collaboration with healthcare providers and public health institutions is recommended to support the implementation and wider adoption of the system as a complementary tool for the early detection of hepatitis B among pregnant women.

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