Indonesian Journal of Global Health Research
Volume 6 Number 5, October 2024
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

EXPERT SYSTEM TECHNOLOGY USING FORWARD CHAINING METHOD TO ASSESS THE RISK LEVEL OF DIABETIC FOOT INFECTION: ORIGINAL RESEARCH

Kharisma Pratama[1]*, Jaka Pradika[2], Syahid Amrullah[1], Suriadi Jais[3]
[1]Program Studi Ners, Institut Teknologi dan Kesehatan Muhammadiyah Kalimantan Barat, Jl. Sungai Raya Dalam, Gg. Ceria V, No. 10, Kubu Raya, Kalimantan Barat, Indonesia
[2]Program Studi D3 Keperawatan, Institut Teknologi dan Kesehatan Muhammadiyah Kalimantan Barat, Jl. Sungai Raya Dalam, Gg. Ceria V, No. 10, Kubu Raya, Kalimantan Barat, Indonesia
[3]Program Studi S2 Keperawatan, Institut Teknologi dan Kesehatan Muhammadiyah Kalimantan Barat, Jl. Sungai Raya Dalam, Gg. Ceria V, No. 10, Kubu Raya, Kalimantan Barat, Indonesia
*kharisma@stikmuhptk.ac.id

ABSTRACT
Assessment and care of diabetic feet should always be provided to patients periodically to optimally prevent complications. This necessitates a practical guide that nurses can use to evaluate the risk of wounds in diabetic patients. Previous research has developed protocols for assessing the risk of diabetic foot ulcers; however, these protocols are manual, requiring nurses to spend time determining the risk level of wounds. The aim of this study is to develop a Web-Based Diabetic Foot Infection Risk Scale Application using the Forward Chaining Method. This research utilizes the Stetler model for evidence-based application development. The development process involves three stages: preparation, validation, and analysis. In the first stage, researchers conduct a literature review using literature review protocols and source scientific articles and books, followed by the development of a web-based application using the forward chaining method. There were 19 research articles recruited from three data base scientific (PubMed, Scopus, and Wiley online Library) from 2014-2024. In the second stage, experts will evaluate the content of the application concerning infection risk assessment. Finally, the application is tested. The results of this study have shown that, after testing, the Web-Based Expert System for Diabetic Foot Infection Risk Determination using the forward chaining method can be used and implemented directly by nurses working in diabetic foot care specialty clinics. This research represents an initial stage focusing on assessing infection risk levels, and it is hoped that future research will build upon this study, not only assessing infection risk but also evaluating the potential for diabetic foot ulcers based on assessed risk factors.

Keywords: diabetes mellitus; diabetic foot infection; diabetic foot care; expert system technology; forward chaining

First Received	Revised	Accepted
28 March 2024	28 April 2024	30 April 2024
Final Proof Received		**Published**
17 September 2024		01 October 2024

How to cite (in APA style)
Pratama, K., Pradika, J., Amrullah, S., & Jais, S. (2024). Expert System Technology Using Forward Chaining Method to Assess the Risk Level of Diabetic Foot Infection: Original Research. Indonesian Journal of Global Health Research, 6(5), 3051-3060. https://doi.org/10.37287/ijghr.v6i5.4275.

INTRODUCTION

Regional Health Research indicates that the prevalence of diabetes mellitus among individuals aged ≥15 years has increased from 6.9% to 10.9% (Kemenkes, 2018). In West Kalimantan in 2018, the prevalence of diabetes mellitus diagnosed by doctors across all age groups amounted to 28,343 cases. The city with the highest prevalence in West Kalimantan is Pontianak, with 3,611 cases, followed by Kubu Raya Regency with 3,235 cases, and Sambas Regency with 3,025 cases (Kemenkes RI, 2018; Riskesdas, 2018). The high number of diabetes cases is also accompanied by an increased risk of complications. Diabetic ulcers are a

common complication in individuals with diabetes mellitus (Jais & Pratama, 2023; Pratama, Putra, et al., 2020). The loss of sensation in the distal foot due to peripheral neuropathy is one of the symptoms leading to ulcer formation (Bondar & Popa, 2018). If untreated, these ulcers can develop into severe infections and may lead to amputation (Soelistijo et al., 2015). This situation requires nurses to be vigilant in monitoring for signs indicative of ulcer formation.

Assessment and care are crucial for individuals with diabetes mellitus to prevent complications (Jais et al., 2023; Suriadi et al., 2023). Foot assessment provides patients with information about the health status of their feet, while diabetic foot care involves measures patients can take to maintain the health of their feet (Pratama, Suriadi, et al., 2020). Regular diabetic foot assessment and care must be provided to patients to prevent complications optimally(Jais et al., 2023). This necessity calls for a practical guide that nurses can use to assess the risk of foot ulcers in individuals with diabetes mellitus.

Guidelines on diabetic foot assessment and care have been extensively developed by previous researchers (Pratama & Phuttikhamin, 2017). Earlier research developed a manual protocol for assessing the risk of diabetic foot ulcers, which required nurses to take time to determine the risk level (Pratama et al., 2018). Other researchers have developed educational videos aimed at preventing diabetic foot ulcers, showing that video-based education on foot examination for preventing diabetic foot complications is effective in enhancing family support (Wicahyani et al., 2021). Previous studies have developed protocols for assessing the risk of diabetic foot ulcers in individuals with diabetes mellitus (Rohmatulloh et al., 2024), However, these protocols were designed for patients' families rather than nurses, and the studies found that some patients and their families were able to conduct foot examinations independently. Although prior research has shared the same goal of preventing foot ulcer complications in individuals with diabetes mellitus, no study in Indonesia has developed a guideline for determining the scale of diabetic foot infection risk using a web-based application. The development of an application-based guideline is highly needed by nurses. An application-based guide will improve the efficiency of nurses in assessing risk and enable quick and accurate action to manage the risk of complications. Previous studies have revealed that diagnosing diseases or health disorders using a web-based application can increase diagnostic efficiency by 72% compared to manual methods (Maulinda, 2017). Therefore, the aim of this study is to develop a Web-Based Application for Determining the Infection Risk Scale of Diabetic Foot Ulcers using the Forward Chaining Method.

METHOD

This study employs the Stetler model (Stetler, 2003) for the development of evidence-based applications. The process of application development in this research is divided into three stages:

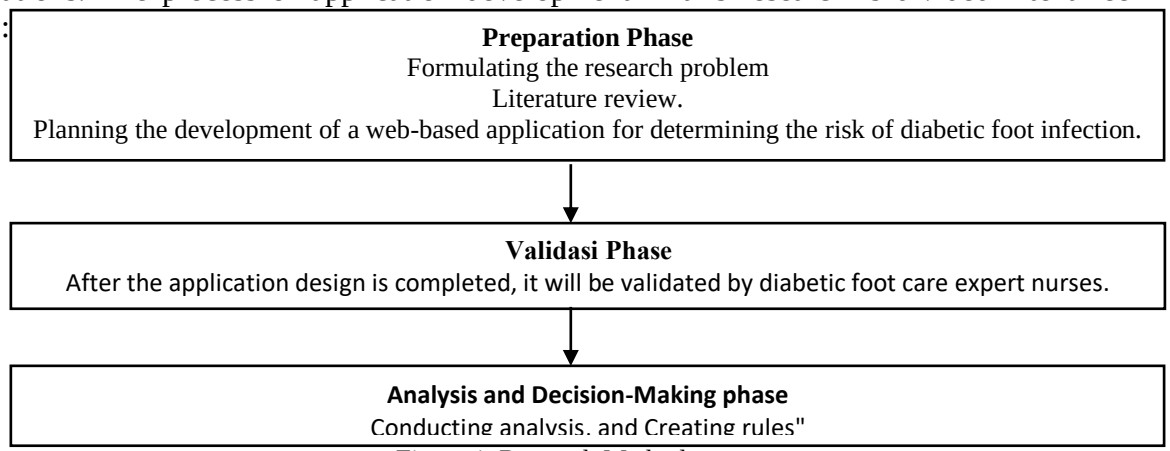

Figure 1. Research Methods

Preparation Phase
In developing the application, the researcher conducted a literature study using a literature review protocol and sourced references from scientific articles and books. After gathering the literature, the researcher proceeded to develop a web-based application using the forward chaining method.

Application for Diabetic Foot Ulcer Infection Risk Assessment
The web-based application for assessing the risk of diabetic foot ulcer infection consists of three components to be developed. The first component is the infection risk assessment, followed by the infection risk evaluation, and lastly, recommendations for diabetic foot care actions. The content of the assessment component to be included in the application involves aspects related to integument (skin and nails), foot vascularization, foot shape, neuropathy, callus, and fissures. The infection risk evaluation component displayed in the application consists of low and high-risk categories. The foot care action component within the application includes foot care measures that nurses should provide according to the risk level experienced by the patient with diabetes mellitus, such as providing education, foot care, and consultations.

Forward Chaining
Forward chaining is a method used by inference engines to start reasoning or tracking data from existing facts towards a conclusion (Christy & Syafrinal, 2019). In this study, reasoning and tracking involve assessing symptoms that indicate the risk of diabetic foot infection. The assessment results are forwarded to determine the level of infection risk experienced. The final conclusion from the assessment and risk evaluation results is in the form of recommended actions that nurses should take.

Validation phase
The second stage involves a Delphi Study conducted by three experts in diabetic foot care and wound management. The Delphi study method is also used when available knowledge is incomplete, and no other method can provide a higher level of evidence (Hosseinzadeh et al., 2019). The Delphi study will be conducted in two rounds. The experts involved are nurses who have completed diabetic foot care training and run wound and diabetic foot care clinics. The three expert nurses also hold doctoral degrees in diabetic wound care. In the first round of the Delphi study, the experts will evaluate the content of the application regarding infection risk assessment.

Analysis/Decision-Making Phase
After the evaluation, the researcher will make revisions based on the feedback provided. The system will then be further refined. At this stage, rules will be created, and the system will be re-tested.

RESULTS
The results obtained from the research methods can be described as follows:
Preparation Phas
There were 19 research articles recruited from three data base scientific (PubMed, Scopus, and Wiley online Library) from 2014-2024.

Application for Diabetic Foot Ulcer Infection Risk Assessment

User Interface

The main interface of the application contains a login page for the user. After logging in, the user fills out a questionnaire related to the client's identity. The user then begins the assessment on the next page, containing questions about risk factors causing diabetic foot infection. After assessing the risk factors, the system interprets the client's risk level. The interpretation page displays the risk level, causes, and recommended solutions provided by the nurse to the patient. The layout can be seen in the following images:

Figure 1. Form Example for a Question.

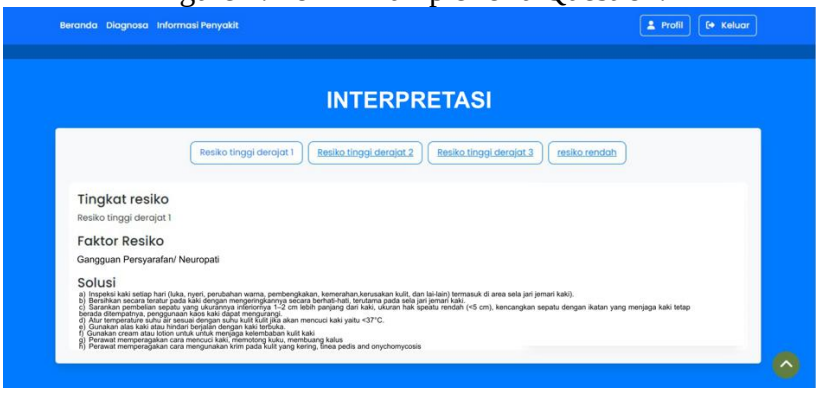

Figure 5. Risk Level Interpretation Page with Solutions.

System Testing

System testing is conducted by answering Yes or No to questions posed by the system through an interface form based on risk factors causing diabetic foot infection, as shown in the table below.

Table 1.
High-Risk Grade 1 Testing.

Risk Factor Assessment	Answers
Do you have a history of Diabetes Mellitus (Diabetes)?	Yes
Do you have Diabetic Neuropathy?	Yes
Is there a fissure on the client's foot?	Yes
Is there a callus on the client's foot?	Yes
Is there an ingrown toenail on the client's foot?	Yes
Interpretation: High Risk Grade 1	

System Architecture

The components required in the system are presented in the following figure:

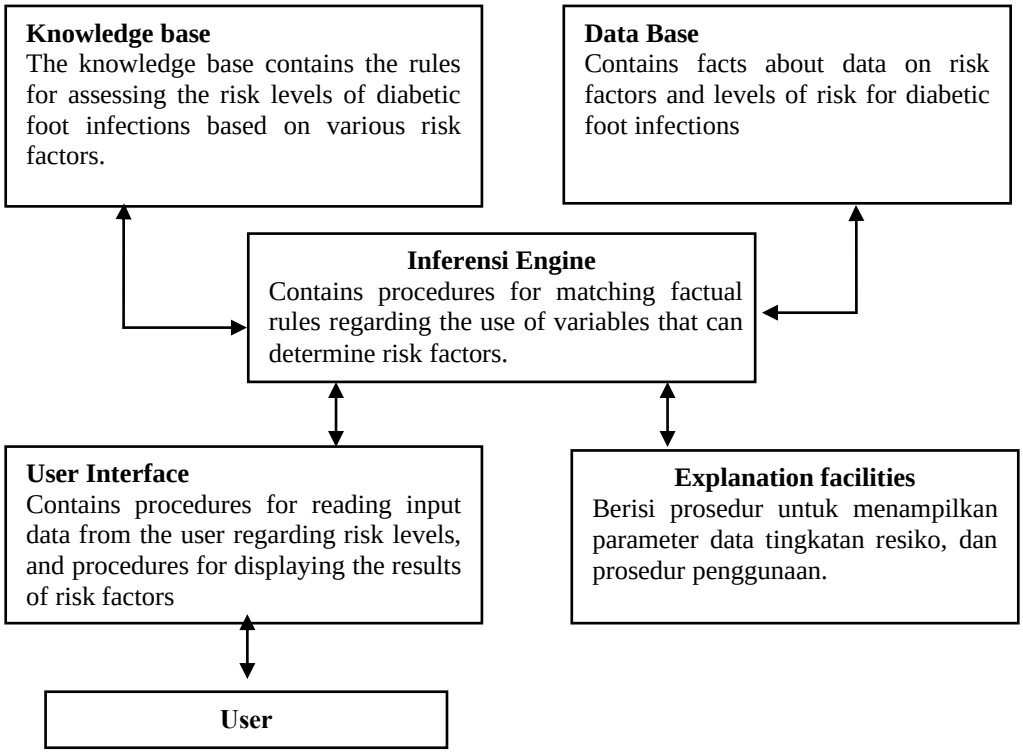

Figure 2. Expert System Architecture for Assessing the Risk Level of Diabetic Foot Infection

Knowledge Base

Based on the system analysis, an overview of the problem analysis and the software requirements for the expert system application will be developed to assess the risk level of diabetic foot infection based on risk factors identified from the nurse/user assessment. The expert system uses a forward chaining inference method, selected because it is suitable for assessing or determining the risk level of foot infection in diabetic patients. The risk factors and risk levels for diabetic foot infection are shown in the following tables:

Table 1.
Risk Factors Codes

F1	History of DM
F2	Not wearing footwear outside
F3	Wearing tight shoes
F4	Diabetic Neuropathy
F5	Fissure
F6	Callus
F7	Ingrown toenail
F8	Foot Deformity
F9	PAD/PVD
F10	History of wounds
F11	History of Amputation

Table 2.
Risk Level Codes

RR0	Low Risk
RT01	High Risk Grade 1
RT02	High Risk Grade 2
RT03	High Risk Grade 3

Method Application

The method used in this research is Forward Chaining. Forward chaining is a search technique that begins with known facts and then matches those facts with the IF part of IF-THEN rules. If the facts match the IF part, the rule is executed. When a rule is executed, a new fact (the THEN part) is added to the database. The matching process starts from the top rule, and each rule can only be executed once. The matching process stops when no more rules can be executed. This approach starts from input information and attempts to draw conclusions, where forward chaining searches for facts that match the IF part of IF-THEN rules. Using forward chaining, the approach and rules generated can be reviewed by experts for refinement or modification to achieve better results (Verina, 2015). The forward chaining technique is implemented by arranging the IF part rules toward the THEN part (Puspaningrum et al., 2020). Based on the risk levels and risk factors, the forward chaining rules used are shown in Figure 3.

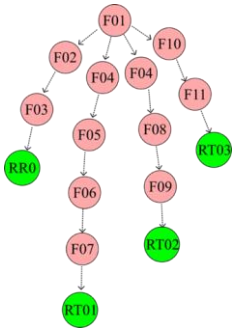

Figure 3. Decision Tree of Diabetic Foot Infection Risk Levels

Fact Presentation

Table 3 is a sample of fact presentation data for risk levels based on existing risk factors. The table explains the knowledge needed to identify risk factors causing diabetic foot infection.

Table 3.
Sample Fact Presentation Data

No.	Risk Level	Risk Factors
1	Low Risk	History of DM Not wearing footwear outside Wearing tight shoes
2	High Risk Grade 1	History of DM Diabetic Neuropathy Fissure Callus Ingrown toenail
3	High Risk Grade 2	History of DM Diabetic Neuropathy Foot Deformity PAD/PVD
4	High Risk Grade 3	History of DM History of wounds History of Amputation

Table 4.
Rule Presentation

No.	Rule
1	IF F01 AND F02 AND F03 THEN RR0
2	IF F01 AND F04 AND F05 AND F06 AND F07 THEN RT01
3	IF F01 AND F04 AND F08 AND F09 THEN RT02
4	IF F01 AND F10 AND F11 THEN RT03

Sample Testing

The following is a sample of forward chaining tracing for low-risk levels, where risk factors are questioned, and the system provides a diagnosis based on the assessment.

Table 5.
Sample Tracing of Low-Risk Level

Risk Level	Risk Factors
Low Risk	IF History of DM: True AND Not wearing footwear outside: True AND Wearing tight shoes: True THEN Low Risk

Forward Chaining Tracing Process:

1. IF F01 AND
2. F02 AND
3. F03 THEN RR0 → Goal

The low-risk level is achieved through Rule 3, where the first tracing is executed if the facts match the IF part of the IF-THEN rule. The new fact produced in the THEN part is saved in the database. The tracing process starts from the first rule, and no rule is executed more than once. The execution process stops when no data matches the rule, and a conclusion is drawn based on the fact matching.

DISCUSSION

Preparation Phase

This study showed that in preparation phase, there is a significant need of the web based application for assessing risk of Diabetic Foot infection. This study also showed that sufficiency findings of research studies related Assessment risk of diabetic Foot infection. Moran & Burson (2017) suggest that phenomenon identification stems from real-world practice scenarios. A notable concern is the high incidence of diabetic foot infection among patients with diabetes mellitus (DM), yet there are no established a special web-based application for detecting risk of diabetic foot complication. This issue has persisted over the years, prompting nurses to recognize the need for addressing it to avoid complications. Despite their awareness of the diabetic foot infection problem, no preventive measures or interventions have been implemented. A significant barrier identified is the lack of time for nurses to seek evidence on diabetic foot infection prevention. According to Pitsillidou et al., (2021), time constraints, insufficient resources, and difficulties in interpreting statistical analyses are key challenges to adopting evidence-based practice (EBP). Many nurses have minimal exposure to the nursing research process, even though it offers significant benefits (Swenson-Britt & Berndt, 2013). Several factors make it difficult for nurses to integrate EBP into their practice, and obstacles to utilizing current research evidence remain widespread. In most cases, nurses lack an understanding of what EBP entails or how to implement it in a clinical setting (Schaefer & Welton, 2018). Professionals often find it challenging to apply new, abstract, and explicit knowledge in their daily practice (Kristensen et al., 2016; Melnyk et al., 2017). Instead, nurses tend to rely on established routines, even when alternative methods are available (Kristensen et al., 2015).

Validation and Decision Making Phase

The Application for Diabetic Foot Ulcer Infection Risk Assessment has undergone validation testing by IT experts and diabetic foot care specialist nurses. Validation is essential for assessing the tool's ability to achieve the desired outcomes (Suyono & Hambali, 2020). The validity of this application is primarily based on its ability to identify risk factors contributing to diabetic foot infections, with high levels of sensitivity and specificity. Research has shown that the application can accurately assess infection risk based on various clinical parameters,

including skin condition, blood flow, and signs of infection. The application was verified through testing involving a sample of patients with a history of type 2 diabetes who were at high risk for diabetic foot infection. The study findings revealed that the application successfully predicted the risk of diabetic foot infection based on embedded risk factors, achieving an overall accuracy that surpasses the traditional manual methods used in clinics. Additionally, it was found that the application reduces clinical workloads by simplifying the risk assessment process and increasing efficiency in the early detection of DFU infection risks. This study aligns with research conducted by Zaki et al., (2023), which explored an Expert System using the Forward Chaining Method to detect internet network damage. Their research demonstrated that the Expert System using the forward chaining method achieved 100% accuracy with 29 test data points. Similarly, Susilo et al., (2022) developed a web-based Expert System for diagnosing chronic diseases using the Forward Chaining Method. The study showed tha after testing with several test data sets, the designed expert system was able to diagnose chronic diseases based on input symptoms and provided results consistent with expert conclusions. Researchers argue that the success of this application is evident from its implementation in various clinical settings, where it has consistently demonstrated positive outcomes in preventing diabetic complications through early identification. Further external validation will also be conducted in several hospitals and specialist diabetic foot care clinics, ensuring that the application will eventually provide results comparable to expert-based assessments, making it a reliable and trustworthy tool in evidence-based nursing practice.

CONCLUSION

This research has shown that after testing, the Web-Based Expert System for Assessing Diabetic Foot Infection Risk using the forward chaining method can be used and implemented by nurses working in diabetic foot care specialist clinics. This study is an initial stage research focusing on assessing the risk of infection. Therefore, the researcher hopes that further studies will develop this research not only to assess the risk of infection in diabetic feet but also to assess the potential for diabetic foot ulcers based on the evaluated risk factors.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the Ministry of Education, Culture, Research, and Technology for funding this research activity. The researchers also extend their thanks to ITEKES Muhammadiyah West Kalimantan for providing both moral and material support

REFERENCES

Bondar, A. C., & Popa, A. R. (2018). Diabetic Neuropathy Prevalence And Its Associated Risk Factors In Two Representative Groups Of Type 1 And Type 2 Diabetes Mellitus Patients From Bihor County. *Maedica*, *13*(3), 229.

Christy, T., & Syafrinal, I. (2019). Sistem Pakar Diagnosa Kerusakan Pada Alat Berat Menggunakan Metode Forward Chaining. *JURTEKSI (Jurnal Teknologi Dan Sistem Informasi)*, *6*(1), 93–100.

Hosseinzadeh, T., Ghanbari, A., Paryad, E., Maghsoudi, S., & Alizadeh, M. P. (2019). Research Priorities In Evidence-Based Nursing Cares: A Delphi Survey. *Journal Of Health Sciences*, *9*(1), 9–16.

Jais, S., & Pratama, K. (2023). A Diabetic Foot Wound Healing Assessment Tool: A Scoping Review. *Heliyon*, *9*(5), E15736. Https://Doi.Org/10.1016/J.Heliyon.2023.E15736

Jais, S., Pratama, K., Pradika, J., & Haryanto, H. (2023). The Validity And Efficacy Of A Preventative Intervention Model For Reducing Ulcer Recurrence In Diabetic Patients In Indonesia. *SAGE Open Nursing*, *9*, 23779608231179548. Https://Doi.Org/10.1177/23779608231179549

Kemenkes, R. I. (2018). Hasil Riset Kesehatan Dasar Tahun 2018. *Kementrian Kesehatan RI*, *53*(9), 1689–1699.

Kemenkes RI. (2018). *Laporan Provinsi Kalimantan Barat Riskesdas 2018*. Riskesdas.

Kristensen, N., Nymann, C., & Konradsen, H. (2016). Implementing Research Results In Clinical Practice- The Experiences Of Healthcare Professionals. *BMC Health Services Research*, *16*(1), 48. Https://Doi.Org/10.1186/S12913-016-1292-Y

Maulinda, H. (2017). *Rancang Bangun Sistem Pakar Diagnosa Penyakit Gigi Dan Mulut Menggunakan Metode Forward Chaining Dan Naive Bayes Berbasis Web*. UNIVERSITAS NEGERI JAKARTA.

Melnyk, B. M., Gallagher-Ford, L., & Fineout-Overholt, E. (2017). No Title. In *Implementing The Evidence-Based Practice (EBP) Competencies In Healthcare : A Practical Guide For Improving Quality, Safety, And Outcomes*. Sigma Theta Tau International. Http://Apn.Mhmedical.Com/Content.Aspx?Aid=1189766720

Moran, K. J., & Burson, R. (2017). Assessment Of Glycemic Control. *Home Healthcare Now*, *35*(10), 567.

Pitsillidou, M., Roupa, Z., Farmakas, A., & Noula, M. (2021). Factors Affecting The Application And Implementation Of Evidence-Based Practice In Nursing. *Acta Informatica Medica*, *29*(4), 281.

Pratama, K., Jiu, C. K., Amrullah, S., & Pradika, J. (2018). *How To Assess And Prevent The Risk Of Diabetic Foot Ulcer*.

Pratama, K., & Phuttikhamin, N. (2017). Diabetic Foot Ulcer Prevention: An Evidence Based Practice. *Jurnal Keperawatan Dan Kesehatan*, *8*(2), 79–84.

Pratama, K., Putra, G. J., Setiawan, D., Djalil, A. D., Jiu, C. K., & Gusmiah, T. (2020). Nursing Technology In Vibration Perception Threshold Testing In Diabetic Peripheral Neuropathy Patients. *1st International Conference On Science, Health, Economics, Education And Technology (Icosheet 2019)*, 322–325.

Pratama, K., Suriadi, Putra, G. J., Setiawan, D., Djalil, A. D., Jiu, C. K., Usman, & Gusmiah, T. (2020). *Nursing Technology In Vibration Perception Threshold Testing In Diabetic Peripheral Neuropathy Patients BT - Proceedings Of The 1st International Conference On Science, Health, Economics, Education And Technology (Icosheet 2019)*. 322–325. Https://Doi.Org/Https://Doi.Org/10.2991/Ahsr.K.200723.081

Puspaningrum, A. S., Susanto, E. R., & Sucipto, A. (2020). Penerapan Metode Forward Chaining Untuk Mendiagnosa Penyakit Tanaman Sawi. *INFORMAL: Informatics Journal*, *5*(3), 113–120.

Riskesdas. (2018). Laporan. *Dinas Kesehatan Kalimantan Barat*, 1–493. Https://Dinkes.Kalbarprov.Go.Id/Wp-Content/Uploads/2019/05/Laporan-RKD-2018-Kalbar.Pdf

Rohmatulloh, M. S., Mulyadi, E., & Alamsyah, M. S. (2024). Pengaruh Video Health Education Terhadap Pengetahuan Perawatan Kaki Penderita Diabetes Mellitus Di Desa Cibolang Puskesmas Cibolangkidul. *Quantum Wellness: Jurnal Ilmu Kesehatan*, *1*(1), 21–34.

Schaefer, J. D., & Welton, J. M. (2018). Evidence Based Practice Readiness: A Concept Analysis. *Journal Of Nursing Management*, *26*(6), 621–629. Https://Doi.Org/10.1111/Jonm.12599

Soelistijo, S. A., Novida, H., Rudijanto, A., Soewondo, P., Suastika, K., Manaf, A., Sanusi, H., Lindarto, D., Shahab, A., Pramono, B., Langi, Y. A., Purnamasari, D., Soetedjo, N. N., Saraswati, M. R., Dwipayana, M. P., Yuwono, A., Sasiarini, L., Sugiarto, Sucipto, K. W., & Zufry, H. (2015). *Pengelolaan Dan Pencegahan Diabetes Melitus Tipe 2 Di Indonesia 2015*. PB. PERKENI.

Stetler, C. B. (2003). Role Of The Organization In Translating Research Into Evidence-Based Practice. *Outcomes Management*, *7*(3), 97–103.

Suriadi, Pratama, K., Fahrain, J., Junaidi, Herman, Pradika, J., Kardiatun, T., Bhakti, W. K., Haryanto, & Suyasa, P. D. (2023). Prevention Strategy For Ulcer Recurrence In Patients With Type II Diabetes Mellitus: A Quasi-Experimental Study. *Iranian Journal Of Nursing And Midwifery Research*, *28*(2), 139–143. Https://Doi.Org/10.4103/Ijnmr.Ijnmr_432_21

Susilo, H., Ihksan, M., Abdillah, N., & Darma, I. Y. (2022). Implementasi Metode Forward Chaining Pada Sistem Pakar Berbasis Web Untuk Mendiagnosa Penyakit Kronis. *Jurnal Kesehatan Medika Saintika*, *13*(2), 292–300.

Suyono, H., & Hambali, H. (2020). Perancangan Alat Pengukur Kadar Gula Dalam Darah Menggunakan Teknik Non-Invasive Berbasis Mikrokontroler Arduino Uno. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *6*(1), 69–76.

Swenson-Britt, E., & Berndt, A. V. O.-21. (2013). Development And Psychometric Testing Of The Nursing Research Self-Efficacy Scale (NURSES). *J Nurs Meas*, *1*(1), 4–2013. Https://Doi.Org/10.1891/1061-3749.21.1.4

Verina, W. (2015). Penerapan Metode Forward Chaining Untuk Mendeteksi Penyakit THT. *JATISI (Jurnal Teknik Informatika Dan Sistem Informasi)*, *1*(2), 123–138.

Wicahyani, N. K. T., Purnamayanti, N. K. D., & Bukian, P. A. W. Y. (2021). Aplikasi Edukasi Berbasis Video Untuk Meningkatkan Dukungan Keluarga Mencegah Komplikasi Kaki Diabetes. *Jurnal Kesehatan*, *14*(1), 79–86.

Zaki, A., Defit, S., Sumijan, S., & Fauzana, R. (2023). Sistem Pakar Menggunakan Metode Forward Chaining Untuk Mendeteksi Kerusakan Jaringan Internet (Studi Kasus: Di Layanan Internet Diskominfotik Sumatera Barat). *Jurnal Nasional Teknologi Dan Sistem Informasi*, *9*(3), 227–236.