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Digital Transformation Of Hospital Pharmacy Management Through Electronic Medical Records: Operational Efficiency, Service Quality, HR Competence, And Patient Satisfaction

Transformasi Digital Manajemen Farmasi Rumah Sakit melalui Rekam Medis Elektronik: Efisiensi Operasional, Kualitas Layanan, Kompetensi SDM, dan Kepuasan Pasien

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Abstract

This study aimed to examine the implementation of Electronic Medical Records (EMR) in hospital pharmacy service management at ABC Hospital, a private hospital in North Jakarta, Indonesia. A mixed-methods approach was employed by comparing operational and satisfaction data from 2023 and 2024 and analyzing interview findings from staff, managers, and patients. The results showed a reduction in outpatient prescription waiting time from 45.2 to 32.6 minutes (27.9%) and inpatient waiting time from 38.5 to 28.1 minutes (27.0%). Monthly prescription volume increased from 4,250 to 5,380 prescriptions (26.6%), while documentation time per prescription decreased from 6.8 to 3.2 minutes (52.9%). Prescription accuracy increased from 93.4% to 98.1%, representing a 4.7 percentage-point improvement, while satisfaction scores increased numerically from 4.12 to 4.25 on a 1–5 scale. Interview findings indicated that EMR implementation facilitated faster access to information and reduced administrative workload, although adaptation through training was required and patients experienced some inconvenience during system interruptions. Overall, EMR implementation was associated with favorable trends in service efficiency, documentation, and prescription accuracy in the pharmacy unit. However, the single-site uncontrolled design, limited information regarding sampling and measurement procedures, and limited qualitative reporting restrict the ability to draw definitive causal conclusions.

Abstrak

Penelitian ini bertujuan untuk mengkaji implementasi Rekam Medis Elektronik (RME) dalam pengelolaan pelayanan farmasi rumah sakit di ABC Hospital, sebuah rumah sakit swasta di Jakarta Utara, Indonesia. Penelitian menggunakan pendekatan *mixed-methods* dengan membandingkan data operasional dan kepuasan tahun 2023 dan 2024 serta menganalisis hasil wawancara dengan staf, manajer, dan pasien. Hasil menunjukkan adanya penurunan waktu tunggu pelayanan resep rawat jalan dari 45,2 menjadi 32,6 menit (27,9%) dan rawat inap dari 38,5 menjadi 28,1 menit (27,0%). Volume resep bulanan meningkat dari 4.250 menjadi 5.380 resep (26,6%), sedangkan waktu dokumentasi per resep menurun dari 6,8 menjadi 3,2 menit (52,9%). Akurasi resep meningkat dari 93,4% menjadi 98,1%, atau sebesar 4,7 poin persentase, sementara tingkat kepuasan meningkat secara numerik dari 4,12 menjadi 4,25 pada skala 1–5. Hasil wawancara menunjukkan bahwa implementasi RME membantu mempercepat akses informasi dan mengurangi pekerjaan administratif, meskipun diperlukan adaptasi melalui pelatihan dan masih terdapat ketidaknyamanan pasien ketika terjadi gangguan sistem. Secara keseluruhan, implementasi RME menunjukkan kecenderungan positif terhadap efisiensi pelayanan, dokumentasi, dan akurasi resep di unit

farmasi. Namun, desain penelitian satu lokasi tanpa kelompok kontrol, keterbatasan informasi mengenai sampel dan pengukuran, serta pelaporan kualitatif yang terbatas menyebabkan hasil belum dapat digunakan untuk menyimpulkan hubungan kausal secara pasti.

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INTRODUCTION

Digital transformation has become a key strategic agenda in global healthcare systems, including in Indonesia, along with increasing demands for service efficiency, patient safety, and quality clinical governance. The World Health Organization (WHO) states that digitalization of healthcare systems plays a crucial role in improving operational efficiency, strengthening data-driven clinical decision-making, and reducing preventable medical errors^[1]. At the national level, healthcare digitalization policies are being accelerated through various regulations, one of which is the commitment to Electronic Medical Records (RME) standards as specified in Minister of Health Regulation Number 24 of 2022, which targets all healthcare facilities to transition from manual medical record systems to integrated digital systems^{[2][3]}. In the hospital context, the pharmacy unit is one of the service subsystems significantly impacted by the implementation of Electronic Medical Records. Pharmacy management plays a crucial role in ensuring medication availability, therapy quality, patient safety, and the cost efficiency of healthcare services^[4].

The use of Electronic Medical Records in pharmacy management is expected to address these challenges by electronically integrating prescription data, medication history, laboratory results, and patient clinical records. Operationally, the RME system accelerates the pharmacy service flow, reduces patient waiting times, and improves the accuracy of dispensing and monitoring drug therapy^[5,6]. Human resources are a critical factor in the success of digital transformation in pharmacy management. Previous research indicates that low digital literacy, resistance to change, and limited training are the main causes of failure or suboptimal utilization of RME systems^[7,8].

Several studies report that although RME has the potential to improve service quality in the medium to long term, the initial implementation phase is often followed by a temporary decline in patient satisfaction, primarily due to increased waiting times and disruptions to service flow during the system transition. Patient satisfaction surveys in several hospitals indicate that up to 40–50% of patients experience discomfort during the initial implementation of RME, before the system reaches optimal operational stability^[9,10]. Based on this description, this study aims to comprehensively analyze the role of Electronic Medical Records as a digital transformation instrument in hospital pharmacy management. The analysis focuses on four main dimensions: operational efficiency, service quality, human resource competency, and patient satisfaction^[11,12].

METHODS

This study employed a mixed methods approach with an explanatory sequential design, combining quantitative and qualitative methods to gain a comprehensive understanding of the impact of Electronic Medical Records (RME) implementation on the digital transformation of hospital pharmacy management. This approach was chosen because RME implementation is a complex phenomenon that impacts not only quantitatively measurable performance indicators but is also influenced by the perceptions, experiences, and adaptation of human resources in daily service

practices. Quantitative data were used to measure changes in operational performance, service quality, and patient satisfaction, while qualitative data served to deepen the interpretation of the results and explain the dynamics of RME implementation from the perspective of healthcare workers and management.

Research Procedure

This study employed a mixed methods approach with an explanatory sequential design, integrating quantitative and qualitative methods to obtain a comprehensive understanding of the impact of Electronic Medical Records (RME) implementation on the digital transformation of hospital pharmacy management. This design was selected because RME implementation represents a complex organizational intervention that influences measurable performance outcomes as well as human factors, including perceptions, adaptation processes, and changes in professional practices. The quantitative phase was conducted first to evaluate changes in operational performance, service quality, and patient satisfaction before and after RME implementation. The qualitative phase was subsequently conducted to provide deeper explanations regarding the observed quantitative findings and to explore the experiences of healthcare professionals and management during RME adoption. The study was conducted at a private hospital (ABC Hospital) in North Jakarta, which has progressively implemented RME in accordance with Ministry of Health Regulation No. 24 of 2022. The primary unit of analysis was hospital pharmacy management, including clinical and non-clinical pharmacy service processes, pharmacist involvement, pharmacy workflow integration, and interactions between healthcare personnel and the RME system. The study participants consisted of Pharmaceutical Technical Personnel (pharmacists and pharmacy technicians), healthcare professionals involved in medication-related services and RME utilization, hospital management representatives, and patients receiving pharmaceutical services during the study period ^[13].

Qualitative data were collected through semi-structured interviews with selected participants who had direct experience with RME implementation. The interviews were conducted individually in a private and quiet setting within the hospital environment to ensure participant comfort and confidentiality. Each interview lasted approximately 30–60 minutes, depending on the depth of participant responses and the complexity of their experiences. The interview guide was developed based on previous literature regarding health information system implementation, digital transformation in healthcare, and technology acceptance in clinical practice. The guide was reviewed by experts in hospital management and health informatics to ensure content relevance and alignment with the research objectives. The interview questions explored participants' experiences with RME implementation, perceived benefits and challenges, workflow changes, system usability, organizational support, and factors influencing successful adoption ^[13].

Data Analysis

Quantitative data were analyzed using descriptive and comparative statistical methods to evaluate differences between pre- and post-RME implementation conditions. The analysis focused on identifying changes in operational efficiency, service quality indicators, and patient satisfaction outcomes. Quantitative findings were summarized using tables and graphical representations to facilitate interpretation and strengthen empirical conclusions. Qualitative data were analyzed using thematic analysis. To improve the credibility of qualitative findings, the coding process was reviewed through researcher discussions and consensus verification. Differences in interpretation were discussed until agreement was reached among researchers. The integration of quantitative and

qualitative findings was performed during the interpretation stage, where qualitative themes were used to explain, contextualize, and elaborate on quantitative results discussion. The validity and reliability of the study were strengthened through methodological and source triangulation by comparing quantitative survey results, operational performance data, and qualitative interview findings. The entire data collection and analysis process was documented systematically to ensure transparency, auditability, and potential replication. Ethical approval principles were applied throughout the research process. All participants received information regarding the research objectives, procedures, potential risks, and confidentiality measures before providing informed consent. Participant identities were anonymized, and all collected data were used exclusively for academic and healthcare management improvement purposes.

RESULT AND DISCUSSION

This study integrated quantitative and qualitative findings to describe changes following the implementation of Electronic Medical Records (RME) in hospital pharmacy management. Quantitative analysis compared operational performance indicators, service quality indicators, and patient satisfaction before and after RME implementation, while qualitative interviews explored experiences of healthcare workers, management, and patients regarding the implementation process..^[14]

1. System Implementation Indicators

Quantitative results are presented through a comparison of performance indicators before and after system implementation, while qualitative findings from officer interviews are used to clarify the dynamics of workflow changes and perceptions of efficiency in daily pharmaceutical service practices..^[15,16]

Table 1. Changes in Prescription Service Waiting Time before and after RME Implementation

Type of Service	Average Wait Time 2023 (minutes)	Average Wait Time 2024 (minutes)	Change (%)
Outpatient	45.2 ± 8.1	32.6 ± 6.4	↓ 27.9%
Inpatient	38.5 ± 7.3	28.1 ± 5.9	↓ 27.0%

Following RME implementation, prescription waiting time decreased in both outpatient and inpatient pharmacy services. The average outpatient waiting time decreased from 45.2 ± 8.1 minutes in 2023 to 32.6 ± 6.4 minutes in 2024 (27.9% reduction). Similarly, inpatient waiting time decreased from 38.5 ± 7.3 minutes to 28.1 ± 5.9 minutes (27.0% reduction). Pharmacy productivity also increased after RME implementation. The number of prescriptions processed per month increased from 4,250 in 2023 to 5,380 in 2024 (26.6% increase), while clinical pharmacy services increased from 620 to 810 services per month (30.6% increase). The service ratio per pharmacist increased from 1.00 to 1.28. Duplication of medication records and dependence on paper-based documentation were also reduced..^[17,18]

Table 2. Productivity of Pharmaceutical Units before and after RME Implementation

Productivity Indicators	2023	2024	Change (%)
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Number of prescriptions served per month	4,250	5,380	26.6%
Number of clinical pharmacy services/month	620	810	30.6%
Ratio of services per pharmacist	1.00	1.28	28.0%

In line with the reduction in prescription waiting times, the implementation of Electronic Medical Records (RME) has also been accompanied by an increase in the productivity of hospital pharmacy units. Table 2 shows that the number of prescriptions filled per month increased from 4,250 in 2023 to 5,380 in 2024, a 26.6% increase. This increase indicates that the accelerated service flow following the implementation of RME contributed to an increase in pharmacy service capacity over the same time period. Clinical pharmacy service productivity also experienced a significant increase, from 620 services per month in the pre-implementation period to 810 services per month after the RME system was implemented, representing a 30.6% increase.^[19,20] This increase occurred without significant changes in the number of pharmacists, as reflected in the increase in the ratio of services per pharmacist from 1.00 to 1.28, a 28.0% increase. This finding indicates that the implementation of RME contributes to optimizing human resource utilization through work process efficiency and reducing non-clinical activities in pharmaceutical services.^[21,22]

Table 3. Efficiency of Pharmacy Documentation and Administrative Activities

Administrative Activities	2023 (Manual Doc)	2024 (RME)	Conclusion
Documentation time per prescription (minutes)	6.8	3.2	52.9%
Duplication of medication records	High	Low	Significant
Dependence on paper forms	Very high	Minimum	Significant

The increase in operational efficiency and productivity of pharmacy units following the implementation of Electronic Medical Records (RME) is also reflected in significant improvements in the documentation process and administrative activities of pharmaceutical services. As presented in Table 3, the average time required to document each prescription decreased from 6.8 minutes in 2023 to 3.2 minutes in 2024, a 52.9% reduction. This decrease indicates that digitizing documentation through RME substantially reduces the administrative workload previously performed manually.^[23,24] This finding indicates a shift in the focus of pharmacists' work from non-clinical administrative activities to more patient-oriented pharmacy services, in line with the goals of digital transformation in hospital pharmacy management.^[25]

2. Quality of Service and Clinical Pharmacy

After identifying improvements in operational efficiency and productivity in pharmacy units following the implementation of Electronic Medical Records (RME), the next analysis focused on the system's impact on the quality of pharmaceutical services and clinical pharmacy practice. Process efficiencies achieved through digitalization not only accelerate service delivery but also potentially impact the accuracy, safety, and quality of drug therapy documentation.^[26]

Table 4. Changes in Pharmaceutical Service Quality Indicators and Accuracy of Drug Therapy Documentation and Patient History Tracking Post-ERM Implementation

Pharmaceutical Service Quality Indicators	2023 (%)	2024 (%)	Efficiency Impact
Accuracy of prescription service	93.4	98.1	↑ 4.7%
Completeness of drug therapy documentation	89.2	97.5	↑ 8.3%
Documented medication error reporting	65.0	92.0	↑ 27.0%
Complete documented medication history (%)	70.5	95.8	↑ 25.3%

The study results show that the implementation of Electronic Medical Records (RME) contributed to improved quality of pharmaceutical services, accompanied by improvements in the accuracy of drug therapy documentation and the traceability of patient histories. Implementation of RME was associated with improvements in pharmaceutical service quality indicators. Prescription accuracy increased from 93.4% to 98.1%, completeness of drug therapy documentation increased from 89.2% to 97.5%, documented medication error reporting increased from 65.0% to 92.0%, and complete medication history documentation increased from 70.5% to 95.8%.^[27,28]

3. Patient Satisfaction

Table 5. Changes in Patient Satisfaction Levels with Pharmaceutical Services

Year	Patient Satisfaction Score (Scale 1–5)	Category
2023	4.12 ± 0.46	Good
2024	4.25 ± 0.41	Good–Very Good

The study results showed that the implementation of Electronic Medical Records (RME) was accompanied by a moderate increase in overall patient satisfaction with pharmacy services. The increase in post-implementation satisfaction scores reflected more positive patient perceptions of the speed of service, clarity of drug information, and perceived safety in receiving therapy. These findings indicate that the digitization of the pharmacy system contributes to a more structured and transparent service experience for patients.

Table 6. Dimensions of Patient Satisfaction that Have Changed

Dimensions of Satisfaction	Change	Information
Speed of service	Increase	In line with the decrease in waiting times
Clarity of drug information	Increase	Supported RME data access
Security and trust	Increase	More transparent documentation
Comfort during transition	Decrease	Initial implementation hiccups

Ease of initial service flow	Decrease	System and HR adaptation
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To deepen our understanding of changes in patient satisfaction following the implementation of Electronic Medical Records (RME), the analysis focused on specific dimensions of pharmaceutical services that experienced changes. Results indicate that satisfaction increases primarily occurred in the dimensions of speed of service, clarity of drug information, and safety and trust in pharmaceutical services. Access to more accurate and integrated data through RME contributed to perceptions of more efficient and professional service. Patient satisfaction scores increased from 4.12 ± 0.46 in 2023 to 4.25 ± 0.41 in 2024. Improvements were reported in service speed, clarity of drug information, and perceived safety of pharmaceutical services. However, some patients reported temporary difficulties related to system adaptation and technical interruptions during the transition period.

4. Interview Results

Interview results were analyzed thematically to identify informants' perceptions, experiences, and responses to the implementation of Electronic Medical Records (RME) in hospital pharmacy management. These qualitative findings provide operational context and firsthand experiences that explain the dynamics of changes in operational efficiency, pharmacy service quality, human resource competency, and patient satisfaction during the digital transformation process.

Interviews with pharmacy staff and hospital management revealed that the implementation of Electronic Medical Records (RME) was perceived to improve the operational efficiency of pharmaceutical services by accelerating workflows, reducing reliance on physical documents, and improving coordination between service units. This efficiency was felt to be even more optimal after the initial system adaptation phase. Informants also assessed that more integrated data access supports improved service accuracy and patient safety, particularly in detecting duplication of therapy and potential medication errors.

Patient interviews were conducted to complement the staff's findings and capture the direct experiences of service recipients with pharmaceutical services following the implementation of Electronic Medical Records (RME). The interviews revealed that most patients perceived improved service efficiency, particularly in terms of prescription wait times and clarity of service flow, both in outpatient and inpatient settings. The results of this study indicate that the implementation of RME not only impacts operational efficiency and productivity of pharmaceutical services but also contributes to improving service quality, strengthening the role of clinical pharmacy, and enhancing patient experience and satisfaction. Quantitative findings showing improvements in performance indicators are supported by the results of interviews with staff and patients that describe the dynamics of system adaptation, changes in workflow, and perceptions of benefits and challenges during the implementation process. Therefore, this discussion focuses on interpreting the findings in an integrative manner to explain how RME functions as a managerial and clinical instrument in driving sustainable improvement in pharmaceutical service performance.

DISCUSSION

1. The Impact of Electronic Medical Records Implementation on the Operational Efficiency of Pharmacy Management

The results of this study confirm that Electronic Medical Records (RME) play a key role in improving the operational efficiency of hospital pharmacy management. Quantitatively, the implementation of RME was followed by a reduction in prescription waiting times for both outpatient and inpatient services by almost 28%, reflecting a substantial acceleration in the pharmaceutical service flow. This decrease occurred in line with an increase in the productivity of the pharmacy unit, as indicated by an increase in the number of services per period and the ratio of services per pharmacist, without a significant increase in human resources. This finding indicates that the efficiency achieved was not the result of an expansion of workforce capacity, but rather the optimization of work processes.^[28,29] The real-time integration of prescription data, clinical information, and service documentation through the RME enables faster and more coordinated pharmacy service processes, reducing delays previously caused by manual processes and reliance on physical documents. This quantitative finding is reinforced by statements from pharmacists who stated that "prescription flow has become much faster because they no longer have to wait for files from the clinic," illustrating a significant change in daily operational practices.

From a process management perspective, digitalization through RME has been shown to directly contribute to the reduction of non-value-added activities in pharmacy services. This finding aligns with the results of interviews with staff who stated that "paper forms have been significantly reduced, allowing us to focus more on patient care," indicating that RME plays a role in shifting the work focus from administration to clinical care^[30,31]. This phenomenon aligns with the theory of technology adoption and the learning curve, which explains that the benefits of new technology tend to increase gradually with increasing user experience, increasing system stability, and increasing training effectiveness. Therefore, suboptimal efficiency during the initial implementation phase can be understood as part of a normal transition process in organizational-wide system changes.^[26,32] The digital health information systems improve healthcare efficiency by strengthening data integration, reducing documentation burden, and supporting clinical decision-making. However, unlike studies focusing primarily on technological performance, this study highlights that operational improvement depends on the interaction between system capability and user adaptation.^[11,12]

2. Managerial implications for workload management and pharmaceutical human resource planning Electronic Medical Records, Pharmacy Service Quality, and Human Resource Competence

The findings of this study confirm that Electronic Medical Records (RME) play a strategic role in improving the quality of pharmaceutical services through the use of integrated clinical data. Quantitatively, the improvement in prescription accuracy and completeness of drug therapy documentation following the implementation of RME demonstrates that the integration of clinical and pharmaceutical data can strengthen the consistency and accuracy of services. Furthermore, the improved ability to trace patient medication histories to near-complete documentation demonstrates that RME enables more evidence-based and patient safety-oriented clinical pharmacy practices. These findings are reinforced by statements from pharmacists who stated that "patient medication histories can now be checked directly without having to open old files," resulting in a faster and more accurate therapy evaluation process.^[8,11,12]

Interview results also revealed that the success of RME utilization is heavily influenced by human resource competency. In the initial implementation phase, some officers experienced adaptation difficulties due to limited digital literacy and unfamiliarity with the new workflow. This condition was reflected in fluctuations in operational efficiency and perceived workload during the initial stages of system implementation. An informant's statement that "it was quite difficult at first, especially for staff who were not yet familiar with digital systems" indicates that human resource competency is a determining factor in realizing the benefits of RME. With training and experience, perceptions of the system's ease of use and usefulness increased, which resulted in gradual improvements in performance and service quality.^[18,22] By utilizing post-implementation performance data and feedback from staff and patients, hospital management can develop more adaptive, quality-oriented, and patient safety-focused HR strategies in the long term.^[16,17] The temporary adaptation challenges observed in this study are consistent with previous research indicating that resistance to change and insufficient digital competency are major barriers to successful electronic medical record implementation.^[33]

3. Strategic implications for sustainable development of pharmaceutical human resource capacity Patient Satisfaction and Pharmaceutical Service Performance in the Context of Digital Transformation

Internal performance indicators showed relatively rapid improvements after the implementation of RME, such as a nearly 28% reduction in prescription waiting times and a more than 25% increase in pharmacy unit productivity without significant workforce additions. However, the aggregate increase in patient satisfaction was more moderate, with variations across satisfaction dimensions. This pattern indicates that the operational benefits of digital transformation may be realized earlier than the perceived benefits of patients, which are heavily influenced by system stability and the quality of service interactions during the transition phase^[29,34]. An important finding of this study was that improvements in internal operational performance were greater than improvements in patient satisfaction. Although waiting time and service transparency improved, patient satisfaction increased only moderately. This suggests that patient experience is influenced not only by efficiency outcomes but also by service continuity, communication quality, and system stability. This finding was reinforced by patient interviews, which stated that "it felt longer at the beginning because the system had problems" or "the process felt more complicated than before." This phenomenon demonstrates that patient experience is not solely determined by the final outcome of service, but also by the smoothness of the process and the perception of control during the service^[35,36]. Thus, the decline in satisfaction in the initial phase of RME implementation can be understood as an adaptive consequence of complex system changes, rather than an indicator of digital transformation failure.

Limitation

The results of this study highlight the importance of integrating patient satisfaction as a strategic performance indicator in hospital pharmacy management. Quantitatively measured improvements in operational efficiency and quality of pharmaceutical services do not automatically translate into uniform improvements in patient experience. Therefore, patient satisfaction needs to be positioned as a leading indicator that complements internal performance indicators, allowing pharmacy management to more holistically capture the impact of digital transformation. Integrating patient satisfaction indicators allows for early identification of service aspects requiring intervention, particularly during the system transition phase, before they impact patient trust and loyalty^[31,37]. Therefore, RME

needs to be positioned as part of a holistic managerial strategy that supports continuous and quality-oriented improvement of pharmaceutical service performance.

CONCLUSION

This study concludes that the implementation of Electronic Medical Records (RME) plays a significant role as a digital transformation tool in hospital pharmacy management. The results show that the implementation of RME significantly improves operational efficiency, as indicated by a reduction in prescription waiting times of nearly 28%, an increase in pharmacy service productivity of more than 25%, and a reduction in administrative burden through documentation efficiency of more than 50%. Furthermore, RME contributes to improving the quality of pharmacy services and clinical pharmacy practices by improving service accuracy, completeness of drug therapy documentation, and traceability of patient medication histories. From a human resources perspective, the success of RME implementation is strongly influenced by the competence and digital literacy of pharmacists, with the system's benefits becoming more optimal through adaptation and organizational learning. Although the increase in patient satisfaction was moderate and experienced a temporary decline during the initial implementation phase, findings show positive trends in the dimensions of service speed, clarity of drug information, and patient safety after the system achieved stability. Overall, this study confirms that RME not only improves the internal performance of pharmacy units but also adds value to service quality and patient experience. It is noteworthy that long-term success requires change management, strengthening human resource capacity, and ongoing system evaluation.

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AUTHOR CONTRIBUTION STATEMENT

FSR: Conceptualization, Methodology, Software; **KP:** Data curation, Writing original draft preparation; **RS:** Visualization, Investigation; **FSR:** Supervision; **KP:** Software, Validation; **RS:** Writing- Reviewing and Editing.

CONFLICT OF INTEREST DECLARATION

The researcher stated that there was no conflict of interest during the process of compiling and writing the article

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Association of Knowledge and Attitude with Household Drug Disposal Practices in Karang Kemiri Village

Hubungan Pengetahuan dan Sikap dengan Praktik Pembuangan Obat Rumah Tangga di Desa Karang Kemiri

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Abstract

The disposal of damaged, expired, or unused medicines is a measure to prevent environmental pollution, drug misuse, and negative impacts on public health. However, many community members still do not understand the correct procedures for drug disposal, contributing to improper disposal practices. This study aimed to determine the association between knowledge level, attitude, and drug disposal practices among the community of RW 002, Karang Kemiri Village. This was an analytical cross-sectional study involving 100 respondents selected via purposive sampling. Data were collected using a questionnaire that had undergone validity and reliability testing, then analyzed using univariate and bivariate methods, with the Chi-square test used to examine the knowledge–practice relationship and Fisher’s exact test used for the attitude–practice relationship because one expected cell count was below 5, at a significance level of $\alpha = 0.05$. The results showed that 85% of respondents had a low level of knowledge, 57% held a negative attitude, and 91% engaged in poor drug disposal practices. A significant association was found between knowledge level and drug disposal practices (Chi-square test, $p < 0.001$) and between attitude and drug disposal practices (Fisher’s exact test, $p = 0.005$). In conclusion, knowledge level and attitude were significantly associated with drug disposal practices among the community of RW 002, Karang Kemiri Village. Given the cross-sectional design, these findings suggest an association rather than a causal relationship and may inform the development of future educational interventions to improve safe and appropriate household drug disposal practices.

Abstrak

Pembuangan obat yang rusak, kedaluwarsa, atau tidak terpakai merupakan langkah untuk mencegah pencemaran lingkungan, penyalahgunaan obat, dan dampak negatif terhadap kesehatan masyarakat. Namun, banyak anggota masyarakat yang belum memahami prosedur pembuangan obat yang benar, sehingga praktik pembuangan yang tidak tepat masih terjadi. Penelitian ini bertujuan untuk mengetahui hubungan antara tingkat pengetahuan, sikap, dan praktik pembuangan obat pada masyarakat RW 002, Desa Karang Kemiri. Penelitian ini merupakan studi analitik dengan desain *cross-sectional* yang melibatkan 100 responden yang dipilih melalui teknik *purposive sampling*. Data dikumpulkan menggunakan kuesioner yang telah melalui uji validitas dan reliabilitas, kemudian dianalisis menggunakan metode univariat dan bivariat; uji *Chi-square* digunakan untuk menganalisis hubungan antara pengetahuan dan praktik, sedangkan uji *Fisher’s exact* digunakan untuk hubungan antara sikap dan praktik karena terdapat satu sel dengan nilai harapan (*expected count*) kurang dari 5, dengan tingkat signifikansi $\alpha = 0,05$. Hasil penelitian menunjukkan bahwa 85% responden memiliki tingkat pengetahuan rendah, 57% memiliki sikap

negatif, dan 91% melakukan praktik pembuangan obat yang kurang baik. Ditemukan hubungan yang signifikan antara tingkat pengetahuan dan praktik pembuangan obat (uji *Chi-square*, $p < 0,001$) serta antara sikap dan praktik pembuangan obat (uji *Fisher's exact*, $p = 0,005$). Sebagai kesimpulan, tingkat pengetahuan dan sikap memiliki hubungan yang signifikan dengan praktik pembuangan obat pada masyarakat RW 002, Desa Karang Kemiri. Mengingat desain penelitian yang bersifat *cross-sectional*, temuan ini menunjukkan adanya hubungan (asosiasi) dan bukan hubungan sebab-akibat, serta dapat menjadi dasar pengembangan intervensi edukasi di masa mendatang untuk meningkatkan praktik pembuangan obat rumah tangga yang aman dan tepat.

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INTRODUCTION

Household storage of medicine is common in Indonesia, encompassing both drugs currently in use and leftover medicine that is no longer needed. This habit is often not accompanied by proper management, causing medicines to accumulate until they expire; more than half of stored medicines are reportedly not used appropriately, creating the potential for household pharmaceutical waste. Leftover, damaged, and expired medicines kept in households constitute hazardous and toxic waste, since they contain active chemical substances that can endanger health if not handled correctly, indicating that drug management at the household level still requires attention.¹

In this manuscript, drug disposal is used as the principal term and is operationally defined as the practice of discarding, destroying, or returning damaged, expired, or unused medicines through proper, safe procedures—such as controlled destruction at home or the use of pharmacy/medicine take-back programs—so as to prevent environmental contamination, drug misuse, and other negative health impacts. This term is distinguished from the broader concept of household drug management, which additionally encompasses the storage and use of medicines, and from pharmaceutical waste, which refers to the resulting waste material rather than the disposal practice itself. Although related terms such as medicine disposal, destruction of medicine, and pharmaceutical waste management appear in the literature cited throughout this manuscript, drug disposal is used consistently hereafter to refer to the specific practice measured in this study.

Improper drug disposal such as discarding medicines into household trash, water drainage systems, or through open burning can cause environmental pollution, ecosystem disruption, an increased risk of antibiotic resistance, and even drug misuse or illegal circulation, underscoring the need for public understanding and awareness of safe disposal procedures.²

Nevertheless, previous studies indicate that many community members still do not understand the correct procedures for drug disposal. Several reports describe practices such as discarding medicines directly into the trash or drainage system without considering the resulting risks, reflecting persistently low public literacy regarding drug disposal.³ This lack of understanding is inseparable from limited public access to information on safe disposal procedures; education on household drug management remains uneven, so many community members are unaware of the recommended steps, reinforcing the importance of the role of health workers in providing sustained health education.⁴

A study conducted in Ngrayun, Ponorogo, found that although most respondents were already aware that careless drug disposal can have negative consequences, their knowledge of the correct disposal method remained low, indicating that awareness alone is not sufficient to drive appropriate behavioral change.⁵ This gap between knowledge and practice is one of the challenges in household drug disposal, since individuals who are aware of the risks do not necessarily adopt appropriate behavior; a more comprehensive approach is therefore required to promote behavioral change, as both internal and external factors can influence the consistency between what is known and what is practiced. Beyond knowledge, attitude also plays an important role in shaping individual behavior, reflecting a person's tendency to respond to a given object, which subsequently influences the decisions and actions taken. The Knowledge, Attitude, Practice (KAP) framework assumes that knowledge serves as the foundation for attitude formation, and that attitude in turn may influence a person's practice. However, several studies have found that this relationship is not always linear or significant,⁶ indicating that other factors also play a role in shaping behavior.

Other studies have reported a significant relationship between knowledge, action, and public perception regarding drug management, indicating inconsistency across research findings and, consequently, a need for further investigation.⁷ Studies conducted in several other regions likewise show that community knowledge of drug disposal remains low to moderate; findings from Padaelo Village, for example, indicated that the level of public knowledge concerning drug disposal was still low, suggesting that more intensive education efforts are still required.

On the other hand, community practice in disposing of medicines also remains suboptimal. Many community members discard medicines without any special treatment, such as crushing them or mixing them with other substances before disposal, indicating that safe drug disposal practices have not yet become customary in the community.⁸

This issue can be examined across global, national, and local levels. Globally, pharmaceutical waste is an increasing source of environmental pollution; nationally, the high rate of household drug storage contributes to a growing volume of drug waste; and locally, low knowledge, attitude, and practice regarding proper drug disposal are still found. To date, no data specifically describe the relationship between knowledge level, attitude, and drug disposal practices among the community of RW 002, Karang Kemiri Village, Belitang Sub-district, East Ogan Komering Ulu Regency. This study therefore aimed to determine the association between knowledge level and attitude toward drug disposal practices among this community, so that the findings may serve as a basis for planning more effective health education and intervention programs.

METHODS

This study used a quantitative method with an analytic observational design and a cross-sectional approach⁹, in which the variables of knowledge, attitude, and drug disposal practice were measured at the same point in time. The study was conducted in RW 002, Karang Kemiri Village, Belitang Sub-district, East Ogan Komering Ulu Regency, from June to July 2026.

The population comprised all residents of RW 002, Karang Kemiri Village aged 19 years or older who had ever owned or stored medicine at home. Sampling used a purposive technique, in which respondents had to meet the following inclusion criteria: aged 19 years or older; had ever stored or owned medicine at home; and resided in RW

002, Karang Kemiri Village. Respondents were excluded if they were unwilling to participate or had difficulty communicating. For descriptive purposes, respondents' age was subsequently grouped into three categories, as presented in Table 3. The minimum required sample size was estimated using the Slovin formula ($N = 800$; $e = 10\%$), which yielded 89 respondents; this figure served as a reference in determining the final sample of 100 respondents obtained through purposive sampling.

Primary data were collected directly through a structured questionnaire completed by residents of RW 002, Karang Kemiri Village. Prior to use, the questionnaire was tested for validity and reliability among a separate group of 30 respondents who were not included in the main study sample of 100 respondents. An item was considered valid if the calculated r exceeded the r -table value (0.361 at a significance level of 0.05); reliability was assessed using Cronbach's alpha, with a value greater than 0.70 indicating that the instrument was reliable.¹⁰ Data processing followed five stages: editing, coding, data entry, data cleaning, and tabulating.¹¹

Data were analyzed in two stages. Univariate analysis was used to describe the characteristics of each variable. Knowledge and drug disposal practice were each measured using a structured questionnaire scored as correct/appropriate (score 1) or incorrect/inappropriate (score 0) per item, whereas attitude was measured using a four-point Likert-type scale (Always = score 4, Often = score 3, Sometimes = score 2, Never = score 1). For each variable, the total score obtained was converted into a percentage and categorized as good/positive ($\geq 75\%$) or poor/negative ($< 75\%$)⁹. Bivariate analysis was performed using the Chi-square test to examine the association between the independent variables (knowledge level and attitude) and the dependent variable (drug disposal practice), with a significance level of $\alpha = 0.05$; a p -value ≤ 0.05 indicated a significant association between the independent and dependent variables, while a p -value > 0.05 indicated no significant association. Fisher's exact test was used instead of the Chi-square test whenever the 2×2 contingency table did not meet the Chi-square assumption, i.e., when the expected count in any cell was below 5.¹²

The operational definitions of the research variables are presented in Table 1.

Ethical Considerations. This study was approved by the [Health Research Ethics Committee of — INSTITUTION NAME TO BE COMPLETED BY AUTHORS —], under approval number [— APPROVAL NUMBER TO BE COMPLETED —], dated [— APPROVAL DATE TO BE COMPLETED —]. Prior to data collection, the purpose and procedures of the study were explained to all prospective respondents, and written or verbal informed consent was obtained from each participant before administration of the questionnaire. Respondent confidentiality and anonymity were maintained throughout data processing and analysis by using numerical respondent codes instead of personal identifying information.

Table 1. Operational definitions of research variables

Variable	Operational Definition	Measuring Instrument	Result Category	Scale
Knowledge level	Respondents' ability to understand the procedures for safe, proper drug disposal	Questionnaire	Good $\geq$ 75% Poor < 75%	Ordinal
Attitude	Respondents' tendency to support proper, standard-compliant drug disposal practice	Questionnaire (Likert)	Positive $\geq$ 75% Negative < 75%	Ordinal
Drug disposal practice	Respondents' practice of destroying medicine in accordance with safe, proper procedures	Questionnaire	Good $\geq$ 75% Poor < 75%	Ordinal

Source: Research data, 2026

RESULTS AND DISCUSSION

This study aimed to evaluate the association between the knowledge and attitude of the community of RW 002, Karang Kemiri Village and their drug disposal practices, involving a total of 100 respondents. Data were collected through a questionnaire covering knowledge level, attitude, and drug disposal practice; the questionnaire was tested for validity and reliability before use, and the collected data were analyzed using Statistical Package for the Social Sciences (SPSS) software and Microsoft Excel.

Validity and Reliability of the Research Instrument

Validity testing was carried out among a separate group of 30 respondents, distinct from the 100 respondents of the main study, to ensure that each questionnaire item accurately measured the intended variable. An item was considered valid if its calculated r-value exceeded the r-table value of 0.361. Of the nine knowledge items tested, the r-values ranged from 0.410 to 0.850, all exceeding the r-table value, so all items were declared valid. For the ten attitude items, r-values ranged from 0.378 to 0.876, and all items were likewise declared valid. Of the ten practice items, nine items were valid ($r = 0.555\text{--}0.767$); one item produced an r-value of 0.317, below the r-table value, and was therefore excluded from further analysis. The reliability test produced Cronbach's alpha values of 0.841 for knowledge, 0.875 for attitude, and 0.820 for practice, all of which exceeded the minimum threshold of 0.70, indicating that all three research instruments were reliable (Table 2).

Table 2. Validity and reliability test results

Variable	r-value Range	r-table	Cronbach's Alpha	Status
Knowledge (9 items)	0.410–0.850	0.361	0.841	Valid & reliable
Attitude (10 items)	0.378–0.876	0.361	0.875	Valid & reliable
Practice (10 items)	0.317–0.767 (9 valid, 1 excluded)	0.361	0.820	Valid & reliable

Source: Primary data processed with SPSS, 2026

These results indicate that the questionnaire met standard validity and reliability requirements, supporting the credibility of the knowledge, attitude, and practice measurements used in this study.

Characteristics of Respondents

Table 3. Characteristics of respondents (n = 100)

Characteristic	Category	n	%
Sex	Male	27	27%
	Female	73	73%
Age group	19–25 years	29	29%
	26–40 years	40	40%
	41–60 years	31	31%
Occupation	Farmer	5	5%
	Self-employed	5	5%
	Housewife	36	36%
	Student	22	22%
	Civil servant	17	17%
	Military/Police	4	4%
	Other	11	11%
Education	Elementary school	6	6%

Characteristic	Category	n	%
	Junior high school	11	11%
	Senior high school	35	35%
	Diploma	8	8%
	Bachelor's degree	37	37%
	Other	3	3%

Source: Research data, 2026

Of the 100 respondents, most were female (73%). This distribution may reflect household medicine-management roles reported in previous studies, in which women, particularly housewives, are typically responsible for storing medicine at home, administering it to sick family members, and deciding how to handle damaged, unused, or expired medicine, giving them greater exposure to household drug conditions. A comparable pattern has been reported in a national household drug-management study and in research showing that women play a significant role in decisions concerning the use, storage, and disposal of medicine at home.¹³

Most respondents (40%) were aged 26–40 years, i.e., within the productive adult range, a group generally more involved in household decision-making, including decisions on the use, storage, and disposal of unused or expired medicine, since this life stage is typically associated with more active management of family health. This pattern is consistent with findings that productive-age adults are the most active group in storing and discarding medicine at home and play an important role in medicine-related decision-making, underscoring the importance of targeting health education toward this age group.¹³

By occupation, most respondents were housewives (36%), reflecting their central role in household drug management, from storage and use to the disposal of damaged or expired medicine, which gives them broader knowledge of the household medicine supply than other family members. By education, most respondents held a bachelor's degree (37%), followed by senior-high-school graduates (35%), indicating a generally moderate-to-high education level. Although this study did not statistically test the association between educational attainment and knowledge, attitude, or practice, prior literature suggests that higher educational attainment is associated with an individual's capacity to receive and understand health information, including the proper management and disposal of medicine, such that individuals with higher education tend to better understand the risks of improper disposal and the importance of following correct disposal procedures. This respondent characteristic is therefore consistent with, though not direct evidence for, studies reporting that higher education is associated with better understanding and practice in household drug management, and that education level is related to community behavior in household drug management.¹⁴

Distribution of Knowledge, Attitude, and Practice**Table 4.** Distribution of knowledge level, attitude, and drug disposal practice (n = 100)

Variable	Category	n	%
Knowledge level	Poor	85	85%
	Good	15	15%
Attitude	Negative	57	57%
	Positive	43	43%
Drug disposal practice	Poor	91	91%
	Good	9	9%

Source: Research data, 2026

As shown in Table 4, the majority of respondents had poor knowledge of drug disposal, indicating that most of the community does not yet understand the correct and safe disposal procedure. This gap most plausibly reflects limited exposure to targeted information and education on managing expired medicine at home, rather than a general lack of health awareness; left unaddressed, it increases the risk that medicines will be discarded carelessly, with consequent environmental harm and potential misuse by irresponsible parties.

These findings are consistent with research showing that community information on household drug management, including storage and disposal, still needs to be strengthened through sustained education programs, and with a systematic review indicating that public understanding of safe drug disposal methods generally remains low, highlighting the need for health-promotion measures to improve community knowledge and practice regarding proper drug disposal.¹⁵

Consistent with the knowledge gap described above, most respondents also held a negative attitude toward drug disposal (Table 4), suggesting that low awareness of correct procedures extends beyond factual knowledge to the values and beliefs that motivate action. This negative attitude may stem from limited understanding of the health and environmental consequences of improper disposal, whereas the smaller group with a positive attitude appeared more conscious of the role of proper disposal in preventing environmental damage and medicine misuse.¹⁶ Continued education programs are therefore needed to strengthen a positive community attitude toward proper drug disposal.

This pattern of low knowledge and negative attitude was mirrored in practice, where the large majority of respondents had not yet adopted the recommended drug disposal procedure (Table 4). Rather than an isolated behavioral lapse, this appears to be a downstream consequence of the knowledge and attitude gaps described above, compounded by limited information about managing unused or expired household medicine; in practice, this leads many people to discard medicine together with household waste or into drainage channels without proper destruction¹⁴. This finding is consistent with a systematic review indicating that community drug disposal practices

remain low and are influenced by limited education and the lack of safe disposal facilities, underscoring the continued importance of education to improve safe and correct drug disposal practice .

Relationship Between Knowledge Level and Drug Disposal Practice

Table 5. Relationship between knowledge level and drug disposal practice

Knowledge Level	Practice: Poor n (%)	Practice: Good n (%)	Total	p-value*
Poor	82 (82.0)	3 (3.0)	85 (85.0)	<0.001
Good	9 (9.0)	6 (6.0)	15 (15.0)	
Total	91	9	100	

Source: Research data, 2026

*Fisher's exact test was used because one expected cell count (Good knowledge–Good practice) was below 5; the result was consistent with the Chi-square test ($p < 0.001$).

Among the 85 respondents with poor knowledge, the majority (82; 82.0%) also showed poor drug disposal practice. Because one expected cell count was also below 5 in this table, the association was confirmed using Fisher's exact test, which showed a significant association between knowledge level and drug disposal practice among the community of RW 002, Karang Kemiri Village ($p < 0.001$), consistent with the Chi-square result. This low level of knowledge indicates that most community members do not yet understand the correct method for disposing of expired, damaged, or unused medicine, which may lead them to discard medicine directly into the trash or drainage system without proper destruction, thereby increasing the risk of environmental pollution and drug misuse.

This finding is in line with research indicating that low community knowledge of household pharmaceutical waste management is associated with improper drug disposal practice, and with a nationwide study showing that communities with better knowledge tend to have better household drug-management practices, including in the storage and disposal of unused medicine, underscoring the need to strengthen drug disposal education through health workers and health-promotion programs so that community knowledge improves and encourages correct disposal practice.¹⁵

Relationship Between Attitude and Drug Disposal Practice

Table 6. Relationship between attitude and drug disposal practice

Attitude	Practice: Poor n (%)	Practice: Good n (%)	Total	p-value*
Negative	56 (56.0)	1 (1.0)	57 (57.0)	0.005*
Positive	35 (35.0)	8 (8.0)	43 (43.0)	
Total	91	9	100	

Source: Research data, 2026

*Fisher's exact test was used instead of the Chi-square test because one expected cell count (Positive attitude–Good practice) was below 5 (expected = 3.87).

Of the 57 respondents with a negative attitude, 56 showed poor drug disposal practice and only one showed good practice; of the 43 respondents with a positive attitude, 35 still showed poor practice and 8 showed good practice. Because one expected cell count was below 5, Fisher's exact test was used instead of the Chi-square test and showed a significant association between attitude and drug disposal practice among the community of RW 002, Karang Kemiri Village ($p = 0.005$). Most respondents with a negative attitude tended to show poor drug disposal practice, while some respondents with a positive attitude still showed poor practice, indicating that practice is not influenced solely by attitude but also by other factors, such as limited information, education, and the availability of medicine take-back programs.

This finding is consistent with research showing that community attitude toward drug use and disposal is associated with household drug-management practice, and that education and increased public awareness are needed to encourage safer drug disposal practice.¹⁷

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design limits the ability to draw causal conclusions regarding the relationship between knowledge, attitude, and drug disposal practice. The purposive sampling technique and the single-village setting also limit the generalizability of the findings to other populations. In addition, data were collected using a self-reported questionnaire, which may be subject to recall or social-desirability bias. Future research using a broader sample and a longitudinal design is recommended to strengthen these findings.

CONCLUSION

This study shows that a significant association exists between knowledge level and drug disposal practice ($p < 0.001$) and between attitude and drug disposal practice ($p = 0.005$) among the community of RW 002, Karang Kemiri Village, with most respondents demonstrating poor knowledge (85%), a negative attitude (57%), and poor drug disposal practice (91%). These findings indicate that knowledge and attitude are important factors associated with drug disposal behavior at the household level and highlight the substantial gap between current community practice and the recommended disposal procedure; given the cross-sectional design, these associations should not be

interpreted as causal. The results are expected to serve as a basis for designing targeted health-education and intervention programs, particularly for women, housewives, and other key household decision-makers, to improve community knowledge and attitude and thereby encourage safer and more compliant drug disposal practices, with potential future application in community pharmaceutical-waste management programs at the village and regional level.

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AUTHOR CONTRIBUTION STATEMENT

AW: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft; NA: Supervision, Validation, Writing – review and editing; PN: Supervision, Validation, Writing – review and editing; AUP: Supervision, Validation, Writing – review and editing.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

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Pharmacy Information System Implementation, Prescription Efficiency, and Perceived Quality: A Mixed-Methods Study in Palembang Primary Health Centers

Implementasi Sistem Informasi Farmasi, Efisiensi, dan Mutu Pelayanan Resep yang Dipersepsikan: Studi Mixed-Methods di Puskesmas Palembang

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Abstract

The pharmaceutical management information system (SIMF) has the potential to improve the efficiency of prescription services, but the relationship with perceived service quality is influenced by infrastructure readiness, integration, and users. Evidence from Puskesmas that links the level of SIMF implementation with efficiency and quality is still limited. To analyze the relationship between SIMF implementation and the efficiency and quality of prescription services perceived at the Palembang City Health Center and explain the obstacles to implementation. Sequential mixed-methods explanatory research was conducted in six health centers in 2026. Cross-sectional surveys of 18 pharmacists (total sampling) and 96 patients were followed by semi-structured interviews with 6 pharmacists to explain the survey findings. The analysis included descriptive statistics, Shapiro-Wilk tests, Spearman correlation (with simple linear regression as sensitivity analysis), and exploratory MANOVA; interviews were analyzed thematically. High implementation was found in availability and use (94.4%), usefulness (94.4%), and convenience (88.9%), while resources and infrastructure were mainly in the moderate category (77.8%). Wait times ≤ 20 minutes were experienced by 90.6% of patients and 87.5% were very satisfied. Implementation was positively associated with efficiency ($r_s=0.512$; $p=0.030$), but not significantly associated with perceived quality ($r_s=0.404$; $p=0.097$); inconclusive due to limited testing power). Interviews showed that data flow and prescribing readability improved, but unstable connections, limited computers, double record-keeping, absence of clinical decision support, and uneven training still occurred. Higher implementation of SIMF was associated with better operational efficiency, but was not significantly associated with perceived quality (inconclusive due to limited testing power); interviews indicated that quality may be limited by sociotechnical gaps and integration. Strengthening infrastructure, interoperability, clinical decision support, and ongoing training are needed.

Abstrak

Sistem informasi manajemen farmasi (SIMF) berpotensi meningkatkan efisiensi pelayanan resep, tetapi hubungannya dengan mutu pelayanan yang dipersepsikan dipengaruhi kesiapan infrastruktur, integrasi, dan pengguna. Bukti dari Puskesmas yang menghubungkan tingkat implementasi SIMF dengan efisiensi sekaligus mutu masih terbatas. Tujuan: Menganalisis hubungan implementasi SIMF dengan efisiensi dan mutu pelayanan resep yang dipersepsikan di Puskesmas Kota Palembang serta menjelaskan hambatan implementasinya. Penelitian mixed-methods explanatory sequential dilakukan di enam Puskesmas pada tahun 2026. Survei potong lintang terhadap 18 tenaga kefarmasian (total sampling) dan 96 pasien dilanjutkan wawancara semi-terstruktur dengan 6 apoteker untuk menjelaskan temuan survei. Analisis mencakup statistik deskriptif, uji Shapiro-Wilk, korelasi Spearman (dengan regresi linear sederhana sebagai analisis sensitivitas), dan MANOVA eksploratif; wawancara dianalisis secara tematik. Implementasi tinggi ditemukan pada ketersediaan dan penggunaan (94,4%), kemanfaatan (94,4%), dan kemudahan (88,9%), sedangkan sumber daya dan sarana-prasarana terutama berkategori sedang (77,8%). Waktu tunggu ≤ 20 menit dialami 90,6% pasien dan 87,5% sangat puas. Implementasi berhubungan positif dengan efisiensi ($r_s=0,512$; $p=0,030$), tetapi tidak berhubungan signifikan dengan mutu yang dipersepsikan ($r_s=0,404$; $p=0,097$); tidak konklusif karena daya uji terbatas. Wawancara menunjukkan aliran data dan keterbacaan resep membaik, namun koneksi tidak stabil, komputer terbatas, pencatatan ganda, ketiadaan dukungan

keputusan klinis, dan pelatihan tidak merata masih terjadi. Implementasi SIMF yang lebih tinggi berhubungan dengan efisiensi operasional yang lebih baik, tetapi tidak berhubungan signifikan dengan mutu yang dipersepsikan (tidak konklusif karena daya uji terbatas); wawancara mengindikasikan bahwa mutu mungkin dibatasi kesenjangan sosioteknis dan integrasi. Penguatan infrastruktur, interoperabilitas, dukungan keputusan klinis, dan pelatihan berkelanjutan diperlukan.

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INTRODUCTION

Pharmaceutical services at Puskesmas are an integral part of primary health services and must ensure safe, high-quality, and patient-oriented management of pharmaceutical preparations and clinical pharmacy services¹. Administrative burdens, the need for drug traceability, reporting demands, and the risk of incomplete prescriptions make the pharmacy management information system (SIMF) increasingly important. In Indonesia, information integration has been regarded as a strategy to strengthen the role of pharmacists in primary care, support drug management, and improve the completeness of prescription screening²⁻⁴.

Implementing a SIMF means more than making software available. Studies in hospitals and pharmaceutical facilities show that its benefits depend on fit with workflow, ease of use, human-resource capacity, organizational support, and infrastructure⁵⁻⁷. The Technology Acceptance Model explains that perceived usefulness and ease of use influence technology acceptance, while the information systems success model adds system quality, information quality, use, user satisfaction, and net benefits as interrelated dimensions^{8,9}. The Unified Theory of Acceptance and Use of Technology emphasizes performance expectancy, effort expectancy, social influence, and facilitating conditions^{10,11}.

In complex health systems, digitalization is also sociotechnical. The NASSS framework, the eight-dimensional sociotechnical model, and the human-factors approach show that technology interacts with people, organizations, processes, policies, and the physical environment¹²⁻¹⁴. Clinical features such as decision support, interoperability, interface design, and update governance are therefore as important as application availability^{15,16}.

Electronic prescriptions can improve legibility and reduce some errors, but may also produce new errors, communication breakdowns, and additional work steps when the design does not match practice¹⁷⁻²². Systematic reviews show that the effects on communication, working time, clinical flow, and workarounds can be both positive and negative.^{23,24} Computer-based interventions are effective for several types of medication error, yet overall results remain heterogeneous and context-dependent²⁵⁻²⁹. In Indonesia, electronic prescribing has been linked to improved medication safety, while clinical decision support for drug interactions still requires development^{30,31}.

Prescription-service efficiency can be observed through waiting time, smoothness of data flow, recording burden, and reporting speed. Service quality is broader, encompassing accuracy, safety, communication, information availability, and patient experience. Verified drug information and cross-facility data exchange are prerequisites for digital quality.^{32,33}

Research gap. Existing evidence falls into three groups: (i) international studies of electronic prescribing that examine error rates, workflow, and pharmacist experience, mostly in hospitals and community pharmacies;¹⁷⁻²⁹ (ii) Indonesian studies on system design, needs assessment, and determinants of implementation, mostly in hospitals;^{2-5,49} and (iii) Indonesian studies of waiting time and satisfaction in Puskesmas pharmacies, which do not assess the level of

information-system implementation.^{46–48} To our knowledge, few studies have examined, within Puskesmas, how the level of SIMF implementation is related to both prescription-service efficiency and perceived quality while also explaining the barriers from the perspective of the personnel who operate the system. Without this evidence, managers cannot tell whether investment in a SIMF alone is sufficient to improve quality, or whether supporting infrastructure, integration, and training must be addressed at the same time.

This study therefore aimed to (1) describe the level of SIMF implementation, waiting time, and patient satisfaction; (2) analyze the association of SIMF implementation with prescription-service efficiency and perceived quality in six Palembang City Puskesmas; and (3) explain implementation barriers from the perspective of pharmacy personnel.

METHODS

Design and rationale

We used an explanatory sequential mixed-methods design (quantitative → qualitative). This design was chosen because the quantitative question (is the level of implementation associated with efficiency and quality, and how large is the association?) could be answered by a survey, whereas the reasons why implementation might be associated with some outcomes but not others could not be captured by numbers alone and required the users' own accounts. In the first phase, a cross-sectional survey measured implementation, efficiency, quality, waiting time, and satisfaction. In the second phase, semi-structured interviews were used to explain the survey results.

Connection between phases. The survey results determined what was explored in the interviews: (a) the contrast between high perceived usefulness and only moderate human-resource and infrastructure support, (b) the significant association with efficiency but not with quality, and (c) the very high patient satisfaction despite moderate quality scores. The interview guide covered benefits, workflow, infrastructure, training, and system constraints. The two data sets were integrated at the interpretation stage using a joint display (Table 7). The survey was carried out in June – July 2026 and interviews in August 2026, i.e., 3 weeks after the survey was completed.

The study was conducted at Puskesmas 4 Ulu, Plaju, Opi, Dempo, Sekip, and Nagaswidak in Palembang in 2026. Sites were selected purposively to represent variation in SIMF use in primary services.

Population and sample

Quantitative phase. All 18 pharmacy personnel who met the inclusion criteria in the six Puskesmas were included (total sampling). Patient respondents numbered 96, i.e., 16 per Puskesmas, selected by accidental sampling. Patients were aged ≥ 17 years, had completed the prescription-service process, and were willing to participate.

Sample adequacy. The pharmacy-personnel sample was a census of eligible staff and therefore limited by the small population, not by choice. Sensitivity analysis for a two-tailed correlation test ($n=18$, $\alpha=0.05$) shows that 80% power is reached only for large associations ($|r| \geq 0.58$, i.e., $R^2 \geq 0.34$). The observed Spearman association for efficiency ($r_s=0.512$; $r_s^2=0.262$) had an approximate post hoc power of ≈ 0.66 , whereas that for quality ($r_s=0.404$; $r_s^2=0.163$) had only ≈ 0.42 (approximated from the power of a correlation test for the same n and α). The non-significant result for quality must therefore be read as inconclusive rather than as evidence of no association (see Limitations). The patient sample ($n=96$) was used only for descriptive outcomes.

Qualitative phase. Interview participants were selected purposively from the survey respondents using the following criteria: being a pharmacist directly involved in operating the SIMF, familiarity with the prescription-service flow, having at least 6 months of experience with the system, and representation of each Puskesmas (one participant per site). A

total of 6 participants were interviewed, all of them pharmacists, one from each of the six Puskesmas. Recruitment continued until all planned participants were interviewed.

Variables and instruments

The independent variable was SIMF implementation, comprising availability and use, ease of use, usefulness, and human resources and facilities. The dependent variables were prescription-service efficiency and quality as perceived by pharmacy personnel. Patient outcomes were waiting-time category and satisfaction. The initial pharmacy-personnel questionnaire had 48 items; two failed the validity test, leaving 46 valid items. The patient questionnaire had 15 items. Scores were categorized as low, medium, or high using mean.

Validity, reliability, and data collection

Item validity was assessed using the corrected item-total Pearson correlation. The critical value (r -table) was 0.361, corresponding to $\alpha = 0.05$ (two-tailed) and $df = 28$; this was based on a pilot sample size of $n = 30$ for the patient satisfaction questionnaire regarding services at the Plaju Community Health Center (Puskesmas), which has an average of 85 patient visits per day. This sample is different from the previous study. All 15 patient items were valid ($r=0.740$ – 0.905). Items D7 and E5 of the pharmacy-personnel instrument were invalid and removed. Internal consistency was very high (Cronbach's alpha 0.981 for the 46 pharmacy-personnel items and 0.962 for the 15 patient items; ≥ 0.70 was considered acceptable). Quantitative data were collected by questionnaire and service-time recording. Interviews were semi-structured, lasted approximately 30 minutes, were audio-recorded with consent, and transcribed verbatim.

Data analysis

Quantitative data were presented as frequencies and percentages. Normality of scores was checked with the Shapiro–Wilk test. Because efficiency and quality scores were not normally distributed and $n=18$, the association of SIMF implementation with efficiency and quality was examined primarily with Spearman's rank correlation (r_s ; two-tailed, $\alpha=0.05$). As a sensitivity analysis, simple linear regression was also fitted to obtain unstandardized (B) and standardized (β) coefficients; because normality of residuals is difficult to verify with $n=18$, regression estimates are interpreted cautiously. Multivariate analysis using Pillai's trace MANOVA was exploratory. Because the 18 personnel were nested within six Puskesmas (about three per site), observations may not be independent and p -values are interpreted cautiously. Due to the cross-sectional design, the results are interpreted as associations, not causal effects.

Interview transcripts were analyzed thematically: familiarization, open coding, grouping of codes into categories, and development of themes that explain the quantitative results. Coding was performed by A.U.P., and disagreements were resolved by N.A. Otter.ai was used to support transcription.

Research ethics

The study was approved by the research ethics committee (No. 004681/KEP/STIKES MITRA ADIGUNA/2026). All respondents gave consent after receiving an explanation, and data confidentiality was maintained.

RESULT AND DISCUSSION

Karakteristik responden

Most patients were aged ≥ 47 years (66.7%), female (80.2%), high-school educated (49.0%), and housewives (49.0%) (Table 1). All pharmacy personnel were women; two-thirds had a D-III education and worked as pharmaceutical vocational personnel, and more than half had worked for five years or less (Table 2). This composition matters because experience, profession, and exposure to training can affect perceived ease of use and adaptability to the system.

Table 1. Characteristics of patients receiving prescription services (n=96)

Variable	Category	n (%)
Age	17-31 years old	10 (10.4)
	32-46 years old	22 (22.9)
	47-61 years old	32 (33.3)
	≥62 years old	32 (33.3)
Gender	Male	19 (19.8)
	Women	77 (80.2)
Education	No school	2 (2.1)
	SD	12 (12.5)
	SMP	18 (18.8)
	SMA	47 (49.0)
	Colleges	17 (17.7)
Jobs	Not working	28 (29.2)
	Housewives	47 (49.0)
	Private	14 (14.6)
	Labor	4 (4.2)
	Civil servants	3 (3.1)

Table 2. Characteristics of pharmaceutical personnel (n=18)

Variable	Category	n (%)
Gender	Women	18 (100)
Education	D-III	12 (66.7)
	S-1 Profession	5 (27.8)
	S-2 Profession	1 (5.6)
Profession	Pharmacist	6 (33.3)
	Pharmaceutical vocational personnel	12 (66.7)
Age	≤35 years old	7 (38.9)
	36-45 years old	8 (44.4)
	46-55 years old	2 (11.1)
	>55 years old	1 (5.6)
Working period	≤5 years old	10 (55.6)
	6-10 years	3 (16.7)
	11-20 years	3 (16.7)
	>20 years	2 (11.1)

Waiting time and patient satisfaction

A total of 87 patients (90.6%) received their medication in 20 minutes or less, and only one patient (1.0%) waited more than 30 minutes. Eighty-four patients (87.5%) were very satisfied, and none was dissatisfied or very dissatisfied (Table 3). Waiting time is easy for patients to observe and is often related to satisfaction, but satisfaction is also shaped by communication, comfort, drug availability, and expectations.^{34–39} Questionnaire validation studies in pharmaceutical services likewise emphasize measuring patient experience multidimensionally rather than by speed alone^{40–44}.

Table 3. Wait time and patient satisfaction (n=96)

Variable	Category	n (%)
Waiting time	<10 minutes	31 (32.3)
	11-20 minutes	56 (58.3)
	21-30 minutes	8 (8.3)
	>30 minutes	1 (1.0)
Satisfaction	Very dissatisfied	0 (0)
	Dissatisfied	0 (0)
	Quite satisfied	3 (3.1)
	Satisfied	9 (9.4)
	Very satisfied	84 (87.5)

Implementation level, efficiency, and quality

Implementation was rated high for availability and use (94.4%), usefulness (94.4%), and ease of use (88.9%). In contrast, human resources and infrastructure were mostly in the medium category (77.8%), with one respondent in the low category. Efficiency was mainly medium (66.7%), while quality was evenly split between medium and high (Table 4). This pattern is consistent with technology-acceptance theory: users may find the system useful and reasonably easy to use, yet actual benefits remain limited by facilitating conditions⁸⁻¹¹.

Table 4. Categories of SIMF implementation, efficiency, and quality (n=18)

Dimensions/exterior	Category	n (%)
Availability and use	Low	0 (0)
	Medium	1 (5.6)
	High	17 (94.4)
Ease of use	Low	0 (0)
	Medium	2 (11.1)
	High	16 (88.9)
Usefulness	Low	0 (0)
	Medium	1 (5.6)
	High	17 (94.4)
Human Resources and Facilities	Low	1 (5.6)
	Medium	14 (77.8)
	High	3 (16.7)
Efficiency	Low	0 (0)
	Medium	12 (66.7)
	High	6 (33.3)
Quality	Low	0 (0)
	Medium	9 (50.0)
	Hig.	9 (50.0)

Instrument quality and analysis assumptions

Reliability of both instruments was very high. However, only the implementation score met the normality assumption ($p=0.056$); quality ($p=0.006$) and efficiency ($p=0.013$) scores were not normally distributed (Table 5). With $n=18$, this reinforces the need for cautious interpretation and confirmation in larger samples. Accordingly, Spearman's rank correlation was used as the primary analysis, and regression estimates are reported only as a sensitivity analysis. Two items of the pharmacy-personnel instrument (D7 and E5) were invalid and removed; reliability was therefore reported for 46 rather than 48 items..

Table 5. Summary of instrument quality and normality test

Components	Quantity	Test	Results	Interpretation
Pharmaceutical personnel questionnaire	46 valid items	Cronbach alpha	0.981	Reliable
Patient questionnaire	15 valid items	Cronbach alpha	0.962	Reliable
Implementation score	n=18	Shapiro-Wilk	W=0.899; p=0.056	Normal
Quality score	n=18	Shapiro-Wilk	W=0.838; p=0.006	Not normal
Efficiency score	n=18	Shapiro-Wilk	W=0.861; p=0.013	Not normal

Association of SIMF implementation with efficiency and quality

SIMF implementation was positively and significantly associated with prescription-service efficiency ($r_s=0.512$; $p=0.030$). The association with perceived quality was also positive but not statistically significant ($r_s=0.404$; $p=0.097$) (Table 6). Thus, the data support an association between implementation and operational efficiency but do not show a significant association with perceived quality. Given the limited power for the quality association (≈ 0.42), this finding is inconclusive rather than evidence of no association. In the sensitivity analysis using simple linear regression, the direction of both associations was the same: implementation was significantly associated with efficiency ($B=0.159$; $\beta=0.759$; $p<0.001$) and non-significantly with quality ($B=0.065$; $\beta=0.348$; $p=0.157$). The regression estimate for efficiency is noticeably stronger than the rank-based one, which may reflect the influence of extreme scores or the non-normal distribution in this small sample; the rank-based estimate is therefore regarded as the more conservative one. The exploratory MANOVA (Pillai's trace=0.614; $F(4, 30)=3.326$; $p=0.023$) indicated an overall multivariate difference in the combined efficiency and quality outcomes across the groups analyzed; because of the small sample and non-normal outcome distributions, it is interpreted as exploratory only.

This difference is plausible. A SIMF can speed up data retrieval, reporting, and administrative processes before it can improve more complex clinical aspects. International implementation experience shows that improvements in timeliness and safety require workflow design, server stability, interoperability, and adequate staffing^{22,24,27,34,36–39}. In Indonesia, queue digitization can also reduce waiting times, but results remain influenced by user adoption and facility readiness⁴⁵. Another local study found a relationship between waiting time and satisfaction, although it varied between facilities^{46–48}.

Table 6. Spearman's rank correlation and exploratory multivariate analysis (MANOVA)

Analysis	Parameter	rs/ Pillai's trace	F(df)	N	P	Remarks
Spearman's rho correlation	Implementation of SIMF → Prescription Service Efficiency	0.512	-	18	0.030	Significant
Spearman's rho correlation	Implementation of SIMF → Prescription Service Quality	0.404	-	18	0.097	Not Significant
Exploratory MANOVA	Pillai's trace	0.614	$F(4,30) = 3.326$	18	0.023	Significant

rs=Spearman's rank correlation coefficient. MANOVA is listed as exploratory because of the small sample size and the non-normal distribution of the efficiency and quality scores. Regression estimates (sensitivity analysis) are reported in the text.

Qualitative findings and sociotechnical explanations

Interviews were held with 6 pharmacists, from 6 Puskesmas. Four themes emerged. Participants are identified by profession and Puskesmas; quotations were translated from Indonesian.

Theme 1: Operational benefits. Digital prescriptions were considered easier to read, reduced handwriting problems, sped up information flow, and helped reporting. *“you no longer have to decipher the handwriting, it is just clear right away; paper prescriptions are usually unreadable”* (Pharmacist, Puskesmas Nagaswidak). These findings agree with evidence that electronic systems can reduce legibility-related errors and improve process efficiency, although they do not eliminate all error types.^{22,24,30}

Theme 2: Infrastructure and integration limits. In some sites only one official computer was available, so staff used laptops, tablets, mobile phones, or personal data plans. Network and server disruptions, system freezes at peak hours, and retrospective data entry encouraged hybrid flows. In two Puskesmas, some dispensing and documentation processes were completed manually first and entered into the system later. Stock cards and physical logbooks were maintained, resulting in duplicate recording. The lack of thermal label printers also limited standardization of drug labeling. *“Actually it is not enough, because there is only one. So each of us brings our own; there are three of us, and sometimes each brings a laptop”* (Pharmacist, Puskesmas Dempo). Such risks have been described in studies of poor integration, unintended consequences of pharmacy systems, and workarounds in health-technology implementation.^{27,28}

Theme 3: Limited clinical functions. The system did not adequately provide clinical decision support for allergy screening, therapy duplication, dosing, or drug interactions. Consequently, any effect on clinical quality depended on manual screening and interprofessional communication. *“I think screening features should be added to the system because they are currently unavailable, and they are greatly needed in practice”* (Pharmacist, Puskesmas Plaju). Decision support can strengthen therapeutic accuracy but requires complete data, appropriate algorithms, alert governance, and integration with patient records.^{15,31–33}

Theme 4: Training and staff resilience. Training was mostly given at the start of implementation and targeted pharmacists, while vocational personnel often learned through peer transfer. Staff commitment kept services running when networks or devices failed, but reliance on personal devices and improvisation is not a sustainable solution. *“To keep operations running smoothly, we sometimes have to rely on our own Wi-Fi”* (Pharmacist, Puskesmas Nagaswidak). Experience with hospital information systems in Indonesia also shows that benefits do not arise automatically because use is mandatory; support quality, task fit, and user engagement remain decisive.⁴⁹ The high patient satisfaction in this study should be read together with the facility limitations and the non-significant quality result. Studies of pharmaceutical services in other Puskesmas also identify reliability, responsiveness, and physical evidence as important components of satisfaction.^{48,50}

Integration of quantitative and qualitative findings

Table 7 shows how the interview themes explain the survey results.

Table 7. Joint display of quantitative findings and qualitative explanations

Quantitative finding	Qualitative explanation	Integrated interpretation
High usefulness (94.4%) and ease of use (88.9%)	Theme 1: legible prescriptions, faster data flow, easier reporting	Perceived benefits are concentrated in administrative and data-handling tasks
Significant association with efficiency ($r_s=0.512$; $p=0.030$), yet efficiency mostly medium (66.7%)	Theme 2: shared computers, unstable network/server, hybrid manual flow, duplicate recording	Higher implementation is associated with better efficiency, but infrastructure gaps may cap the gain
No significant association with quality ($r_s=0.404$; $p=0.097$)	Theme 3: no decision support for allergy, duplication, dose, interaction; reliance on manual screening	Quality is not directly supported by the system as currently configured; low power also limits inference
87.5% very satisfied despite mostly medium efficiency and quality that was only half high	Theme 4: uneven training; service maintained by staff improvisation	Satisfaction likely reflects factors beyond system quality (e.g., staff effort, courtesy bias)

Practical implications

Recommendations are grouped by implementation horizon.

Short term (0–6 months): actions within Puskesmas and district authority

- Provide at least one adequate work device at each critical point (registration, dispensing) and official backup internet connections.
- Set up downtime monitoring and a written downtime procedure, with simulations for when the system is unavailable.
- Provide label printers and define technical support with clear response times.
- Start role-based refresher training that includes both pharmacists and vocational personnel.

Long term (>6–12 months): system development and governance

- Integrate prescriptions, stock, patient history, and reporting, and remove unnecessary duplicate records.
- Introduce clinical screening in stages (allergy, therapy duplication, dose, then drug interactions) with alert governance.
- Institutionalize iterative training and onboarding.

Adopt evaluation indicators: actual waiting time, prescription completeness and accuracy, medication errors, satisfaction, workload, downtime, and proportion of processes still done manually.

Limitation

This study was cross-sectional and can show associations only, not causation. It involved 18 pharmacy personnel from six Puskesmas selected purposively, which may introduce selection bias: sites and interviewees may differ from other Puskesmas or from personnel who were less engaged with the system, limiting transferability. The small sample gave low power for the quality model and made estimates imprecise. The 18 personnel were nested within six Puskesmas (about three per site) and this clustering was not modelled, so observations may not be independent and p-values may be optimistic. Most implementation, efficiency, and quality measures were based on respondents' perceptions, and the clinical quality of prescriptions was not verified. The very high patient satisfaction may reflect courtesy bias, timing of measurement, and respondent characteristics. Future research should use larger and

probability-based samples, longitudinal or before–after designs, standardized prescription audits, automated time logs, and robust analyses that account for differences between Puskesmas.

CONCLUSION

Among 18 pharmacy personnel in six Palembang Puskesmas, SIMF implementation was rated high for availability, use, ease of use, and usefulness, but resource and facility support remained moderate. Implementation was positively associated with prescription-service efficiency ($r_s=0.512$; $p=0.030$) but not significantly with perceived quality ($r_s=0.404$; $p=0.097$; inconclusive given limited power). Most patients (90.6%) received medication in 20 minutes or less and 87.5% were very satisfied. Interviews suggested that infrastructure limits, duplicate recording, absent clinical decision support, and uneven training may explain why implementation was not clearly linked to perceived quality, although this remains inconclusive. Strengthening these elements may be needed for digital efficiency to translate into measurable quality and safety improvements.

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AUTHOR CONTRIBUTION STATEMENT (Calibri, 12 pt)

Conceptualization: N.A.; methodology: N.A. and A.U.P.; investigation: R.D., P.M., and E.N.A.; formal analysis: N.A. and A.U.P.; data curation: P.M. and E.N.A.; supervision: N.A.; writing—original draft: N.A. and A.U.P.; writing—review and editing: all authors.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest related to this research and publication.

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Identification of Drug-Related Problems Using PCNE Classification in Type 2 Diabetes Mellitus Outpatients at Labuang Baji Regional General Hospital

Identifikasi Masalah Terkait Obat Menggunakan Klasifikasi PCNE pada Pasien Rawat Jalan Diabetes Melitus Tipe 2 di RSUD Labuang Baji

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Abstract

Type 2 diabetes mellitus requires prolonged and often complex pharmacotherapy, which increases the likelihood of drug-related problems and may compromise treatment safety. This study identified drug-related problems among outpatients with type 2 diabetes mellitus at Labuang Baji Regional General Hospital, Makassar, using the Pharmaceutical Care Network Europe classification version 9.1. A descriptive observational study with a retrospective design was conducted using outpatient medical records from August 2025 to February 2026. Total sampling yielded 35 patients who met the eligibility criteria, and medication regimens were evaluated for problems and causes within the classification framework. Most patients were 51–60 years old (63%), 51% were women, and hypertension was the leading comorbidity, present in 22 of the 35 patients (62.9%). The review identified 43 problem events and 49 documented causes at the event level; these figures do not represent the number of patients with drug-related problems. A possibly occurring adverse drug event was the most frequent problem category (25 events; 58%), followed by unnecessary treatment (13 events; 30%). Inappropriate drug combinations were the leading cause (20 events; 41%), followed by medicines without a documented indication (13 events; 27%) and medicines that did not conform to guidelines or the formulary (11 events; 22%). Multiple drug-related problems were identified in this outpatient population, driven mainly by medication selection and combination issues; the findings support routine medication review and closer pharmacist involvement in long-term diabetes care.

Abstrak

Diabetes melitus tipe 2 memerlukan farmakoterapi jangka panjang yang sering kali kompleks, sehingga meningkatkan risiko masalah terkait obat dan dapat memengaruhi keamanan pengobatan. Penelitian ini mengidentifikasi masalah terkait obat pada pasien rawat jalan dengan diabetes melitus tipe 2 di RSUD Labuang Baji, Makassar, menggunakan klasifikasi *Pharmaceutical Care Network Europe* (PCNE) versi 9.1. Studi observasional deskriptif dengan desain retrospektif dilakukan menggunakan data rekam medis pasien rawat jalan periode Agustus 2025 hingga Februari 2026. Melalui metode *total sampling*, diperoleh 35 pasien yang memenuhi kriteria inklusi, dan regimen pengobatan mereka dievaluasi untuk mengidentifikasi masalah serta penyebabnya berdasarkan kerangka klasifikasi tersebut. Sebagian besar pasien berusia 51–60 tahun (63%) dan berjenis kelamin perempuan (51%); hipertensi merupakan komorbiditas utama yang ditemukan pada 22 dari 35 pasien (62,9%). Hasil tinjauan mengidentifikasi 43 kejadian masalah dan 49 penyebab terdokumentasi pada tingkat kejadian; angka-angka ini tidak mencerminkan jumlah pasien yang mengalami masalah terkait obat. Kategori masalah yang paling sering ditemukan adalah kemungkinan terjadinya kejadian yang tidak diinginkan akibat obat (*adverse drug event*) (25 kejadian; 58%), diikuti oleh

pengobatan yang tidak diperlukan (13 kejadian; 30%). Kombinasi obat yang tidak tepat merupakan penyebab utama (20 kejadian; 41%), diikuti oleh penggunaan obat tanpa indikasi yang terdokumentasi (13 kejadian; 27%) serta obat yang tidak sesuai dengan pedoman atau formularium (11 kejadian; 22%). Berbagai masalah terkait obat ditemukan pada populasi pasien rawat jalan ini, terutama yang disebabkan oleh pemilihan dan kombinasi obat; temuan ini mendukung perlunya tinjauan pengobatan secara rutin dan keterlibatan apoteker yang lebih intensif dalam perawatan diabetes jangka panjang.

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INTRODUCTION

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia arising from impaired insulin secretion, reduced insulin action, or both, and inadequate control can lead to progressive microvascular and macrovascular complications.¹⁻³

The global burden continues to rise, with the International Diabetes Federation estimating that 589 million adults aged 20–79 years were living with diabetes in 2024 and projecting 853 million cases by 2050.¹ Indonesia follows the same upward pattern, and regional evidence points to a growing service burden: a spatial analysis of diabetes risk factors in North Sumatra documented the wider regional trend, while a study on diabetes-related health literacy among patients in Makassar reported service and self-management challenges that require sustained prevention, treatment, and follow-up.^{4,5}

The in-text citations and reference list have been renumbered sequentially according to their first appearance in the manuscript, in accordance with AMA citation style. A structured classification is needed because listing isolated interactions or dose discrepancies does not fully explain the clinical problem or its underlying cause. The Pharmaceutical Care Network Europe classification version 9.1 separates the identified problem from the cause and therefore offers a clearer basis for documentation, medication review, and clinical intervention.¹⁰⁻¹²

Previous studies in Indonesian outpatient settings have reported drug-related problems among patients with type 2 diabetes mellitus, including inappropriate medicine selection, subtherapeutic dosing, and potential drug interactions.^{8,9} However, the available studies cited in this manuscript have not provided a detailed assessment of both the Problem and Cause domains using the PCNE version 9.1 classification.^{8–10} In addition, evidence describing drug-related problems among type 2 diabetes mellitus outpatients at Labuang Baji Regional General Hospital is not available. This gap is relevant because patients receiving outpatient diabetes care may use multiple medicines for diabetes and comorbid conditions, increasing the need for structured medication review. Therefore, this study aimed to identify drug-related problems among type 2 diabetes mellitus outpatients at Labuang Baji Regional General Hospital and describe the identified problems and their causes according to the PCNE version 9.1 classification.

METHODS

Study Design and Setting

The unit of analysis was the individual patient. Each patient was counted only once in the final sample. Patients with multiple outpatient visits during the study period were treated as one subject, and repeated visits were not counted

as separate patients. The analysis was based on the eligible medical record and medication regimen available for each included patient.

Population and Eligibility

The upper age limit of 60 years was applied according to the predefined inclusion criteria of this study. The age range was selected to maintain a consistent study population and to focus the analysis on type 2 diabetes mellitus outpatients within the specified age range. Patients older than 60 years were therefore excluded from the analysis. This criterion may limit the generalizability of the findings to older adults with type 2 diabetes mellitus, who may have different medication-use patterns and drug-related problem profiles. This limitation has been acknowledged in the manuscript.

Data Collection and Medication Review

A structured data extraction form was used to collect patient characteristics, diagnoses, comorbidities, available laboratory findings, and pharmacotherapy information, including medicine name, dose, frequency, duration, and route of administration. The form was developed based on the study variables and eligibility criteria and was used consistently for all included medical records. Data were entered and organized electronically using Microsoft Excel for subsequent descriptive analysis. Each medication regimen was reviewed for indication, medicine selection, dose suitability, and potential medicine combinations using the Indonesian type 2 diabetes mellitus guideline and the Pharmaceutical Care Network Europe version 9.1 classification as the principal assessment references.

Classification and Data Analysis

PCNE classification was performed by the primary researcher, a pharmacy undergraduate student, under the supervision and review of two faculty members with expertise in pharmacy. The identified drug-related problems were assessed using the Problem and Cause domains of the PCNE version 9.1 classification. The assessment was reviewed by the supervising reviewers, and any differences in interpretation were discussed until a consensus was reached. The final classification was determined based on the agreed assessment.

Ethical Clearance

Ethical approval for this study was granted by the Health Research Ethics Committee of Universitas Megarezky Makassar under approval number 0904/M/KEPK-PTKMS/IV/2026, dated April 30, 2026.

RESULT AND DISCUSSION

Patient Characteristics and Comorbidities

Thirty-five records fulfilled the eligibility criteria. Patients aged 51–60 years formed the largest group, and women represented a slightly higher proportion than men. Hypertension was the most frequent comorbidity, followed by diabetic polyneuropathy, hyperlipidemia, and hyperuricemia. Because several patients had more than one concurrent condition, the comorbidity count exceeded the number of patients.

Table 1. Characteristics and comorbidities of type 2 diabetes mellitus outpatients

Characteristic	Category	n	%
Age, years	21-30	0	0
	31-40	2	6
	41-50	11	31
	51–60	22	63
Sex	Female	18	51
	Male	17	49

Characteristic	Category	n	%
Comorbidity	Hypertension	22	42
	Diabetic polyneuropathy	8	15
	Hyperlipidemia	5	9
	Hyperuricemia	4	8
	Other conditions	14	26

The comorbidity data in Table 1 have been revised to report the number and percentage of patients with each comorbidity using the total sample of 35 patients as the denominator (n/N). The table note has also been added to clarify that patients may have more than one comorbidity; therefore, the percentages do not necessarily sum to 100%. Event-based percentages have been distinguished from patient-level comorbidity prevalence to improve clinical interpretability.

The concentration of patients in the 51–60-year age group is consistent with the progressive decline in insulin sensitivity and beta-cell function that accompanies aging.^{2,3} Older adults also tend to accumulate chronic conditions and medicines, a pattern associated with a greater risk of drug-related problems.^{15,18,19}

Percentages are calculated based on the total number of patients (N = 35). Patients may have more than one comorbidity; therefore, the percentages may not sum to 100%. Hypertension was present in 42% of the recorded comorbidities, making it the principal contributor to therapeutic complexity. Patients with diabetes and hypertension commonly require concurrent glucose-lowering, antihypertensive, and lipid-modifying treatment, which broadens the opportunity for interactions and other medication-related concerns.^{19,22,23}

Problem Domain

Table 2. Drug-related problems in the Problem domain

Code	Problem category	n	%	Example
P1.2	Treatment effect not optimal	4	9	Low-dose gabapentin with an expected suboptimal response
P1.3	Untreated symptom or indication	1	2	Dyspepsia documented without treatment
P2.1	Adverse drug event possibly occurring	25	58	Potential safety issue involving glimepiride and meloxicam
P3.1	Unnecessary treatment	13	30	Lansoprazole without a documented clinical indication

Percentages are based on 43 identified problem events; rounding causes the displayed percentages to total 99%.

The identified safety problems were considered potential or possible drug-related problems based on the information available in the medical records. These findings did not necessarily indicate that an adverse drug event had occurred or that the patient had experienced confirmed harm. Therefore, the identified interactions were interpreted as potential safety risks rather than confirmed clinical adverse events.

For the assessment of potentially unnecessary drug therapy, the absence of a documented indication was interpreted based only on the information available in the medical records. Therefore, a drug was considered to have no indication documented in the available record when no corresponding indication was recorded in the reviewed medical record. This finding does not imply that the drug had no clinical indication outside the information documented in the available record.

The assessment of gabapentin dosing was based on the recommended dose range for the documented indication, while considering the patient's age, renal function, treatment titration stage, and documented clinical response; a dose was classified as potentially subtherapeutic only when it was below the recommended dose range without documented patient-specific factors that justified the lower dose.

The predominance of P2.1 may be related to the use of multiple medicines for diabetes and comorbid conditions in the reviewed patients. The use of several medicines may increase the opportunity for potential drug interactions and

other medication-related safety concerns. This finding is consistent with previous studies reporting drug-related problems involving potential interactions and medicine-selection issues among patients with type 2 diabetes mellitus. 8-10,16 However, the P2.1 findings in this study should be interpreted as potential safety risks identified from the available medical records and not as confirmed adverse drug events.

Cause Domain

Table 3. Causes of drug-related problems

Code	Cause category	n	%	Example
C1.1	Medicine not in accordance with guideline/formulary	11	22	The use of simvastatin in combination with amlodipine was considered not in accordance with the applicable guideline because the prescribed simvastatin dose exceeded the recommended maximum dose when co-administered with amlodipine. This assessment was based on the applicable drug interaction and prescribing recommendations for simvastatin–amlodipine co-administration.
C1.2	No indication for medicine	13	27	Lansoprazole without a documented gastric indication
C1.3	Inappropriate combination of medicines	20	41	Potential drug interactions classified under C1.3 were reassessed using an authoritative drug-interaction reference and a predefined clinical-significance threshold; the need for routine monitoring alone was not considered sufficient evidence to classify a drug combination as an inappropriate combination.
C1.5	No or incomplete treatment despite indication	1	2	Dyspepsia without corresponding therapy
C3.1	Medicine dose too low	4	8	Gabapentin dose below the expected therapeutic range

Percentages are based on 49 documented causes. One problem event could have more than one cause.

Among the causes that could be assessed from the available retrospective medical records, medicine-selection causes predominated. Patient behavior and medication adherence could not be reliably assessed from the available records and were therefore not compared with medicine-selection causes.

The predominance of medicine-selection causes may be related to the complexity of pharmacotherapy in patients with type 2 diabetes mellitus who also have comorbid conditions. The use of several medicines for different therapeutic indications may increase the opportunity for inappropriate medicine combinations or medicines without a clearly documented indication. This finding is consistent with previous studies in patients with type 2 diabetes mellitus that reported medicine-selection problems and potential drug interactions as important drug-related problems. 8-10.

The lisinopril-metformin example was classified as a combination requiring attention because angiotensin-converting enzyme inhibition may enhance peripheral insulin sensitivity and amplify glucose reduction. The clinical importance of this interaction may vary, but glucose monitoring remains prudent when antihypertensive and glucose-lowering regimens are initiated or adjusted. Patients with diabetes and hypertension benefit from coordinated pharmacotherapy because both disease control and medicine safety must be considered together.^{19,22,23}

For the assessment of simvastatin use with amlodipine, the prescribed simvastatin dose and concomitant amlodipine therapy were reviewed against the applicable prescribing recommendation. Co-administration with amlodipine increases simvastatin exposure; therefore, the simvastatin dose should not exceed 20 mg once daily when used concomitantly with amlodipine. Only prescriptions exceeding this maximum were considered potentially nonconcordant and classified under C1.1 (Medicine not in accordance with guideline/formulary). Prescriptions of simvastatin at doses of 20 mg or below were not classified as nonconcordant solely because amlodipine was co-administered.

Medication Profile

Tabel 4. medication profile recorded in the outpatient sempel

Medicine class	Medicine	Dose	n	%
Antidiabetic (biguanide)	Metformin	500 mg	27	50.00
Antihypertensive (calcium-channel blocker)	Amlodipine	5 or 10 mg	21	38.89
Neuropathic analgesic	Gabapentin	100, 200, or 300 mg	20	37.04
Antidiabetic (sulfonylurea)	Glimepiride	1, 2, or 3 mg	18	33.33
Analgesic (nonsteroidal anti-inflammatory)	Meloxicam	7.5 or 15 mg	13	24.07
Lipid-lowering medicine (statin)	Simvastatin	10 or 20 mg	12	22.22
Supplement/vitamin	Vitamin B12	Not recorded	11	20.37
Antidiabetic (sulfonylurea)	Gliclazide	80 mg	7	12.96
Antihypertensive (angiotensin receptor blocker)	Candesartan	8 or 16 mg	6	11.11
Urate-lowering medicine	Allopurinol	100 or 300 mg	5	9.26
Mucolytic	Acetysteine	20 or 200 mg	5	9.26
Analgesic/antipyretic	Paracetamol	500 mg	4	7.41
Antidiabetic (dipeptidyl peptidase-4 inhibitor)	Vildagliptin	50 mg	4	7.41
Antihypertensive (angiotensin-converting enzyme inhibitor)	Ramipril	2.5 or 5 mg	4	7.41
Proton-pump inhibitor	Lansoprazole	30 mg	4	7.41
Antibiotic (cephalosporin)	Cefixime	200 mg	3	5.56
Antidiabetic (alpha-glucosidase inhibitor)	Acarbose	100 mg	3	5.56
Antidiabetic (basal insulin)	Insulin detemir	20 units	3	5.56
Antidiabetic (thiazolidinedione)	Pioglitazone	15 or 30 mg	3	5.56
Lipid-lowering medicine (fibrate)	Fenofibrate	300 mg	3	5.56

Medicine class	Medicine	Dose	n	%
Antihypertensive (angiotensin-converting enzyme inhibitor)	Lisinopril	10 mg	3	5.56
Antihistamine	cetirizin	1 mg	3	5.56
Proton-pump inhibitor	Omeprazole	Not recorded	3	5.56
Analgesic (nonsteroidal anti-inflammatory)	Diclofenac sodium	50 mg	2	3.70
Histamine analog (antivertigo)	Betahistine	6 mg	2	3.70
Antidiabetic (basal insulin)	Insulin glargine	Not recorded	2	3.70
Antidiabetic (prandial insulin)	Insulin lispro	Not recorded	2	3.70
Antihypertensive (angiotensin receptor blocker)	Valsartan	80 mg	2	3.70
Antiplatelet	Clopidogrel	75 mg	2	3.70
Decongestant	Pseudoephedrine	Not recorded	2	3.70
Gastrointestinal agent	sucralfat	Not recorded	2	3.70
Supplement/vitamin	Vitamin B complex	Not recorded	2	3.70
Antibiotic (cephalosporin)	Cefadroxil	500 mg	1	1.85
Topical antibiotic	Gentamicin	Not recorded	1	1.85
Antidiabetic (basal-prandial insulin)	Insulin degludec/aspart	Not recorded	1	1.85
Antidiabetic (prandial insulin)	Insulin aspart	Not recorded	1	1.85
Antidiabetic (prandial insulin)	Insulin glulisine	Not recorded	1	1.85
Lipid-lowering medicine (statin)	Atorvastatin	20 mg	1	1.85
Antihypertensive (beta-blocker)	Bisoprolol	2.5 mg	1	1.85
Anticonvulsant/benzodiazepine	Alprazolam	1 mg	1	1.85
Antithyroid medicine	Thiamazole (methimazole)	5 mg	1	1.85
Antitussive (opioid)	Codeine	10 mg	1	1.85
Bile acid	Ursodeoxycholic acid	250 mg	1	1.85
Potassium-sparing diuretic	Spironolactone	25 mg	1	1.85
Loop diuretic	Furosemide	40 mg	1	1.85
Histamine-2 receptor blocker	Ranitidine	150 mg	1	1.85
Topical corticosteroid	Betamethasone	Not recorded	1	1.85
Muscle relaxant	Eperisone hydrochloride	50 mg	1	1.85
Benign prostatic hyperplasia medicine	Tamsulosin	0.4 mg	1	1.85
Thyroid replacement	Levothyroxine (Euthyrox)	50 mcg	1	1.85
Gastrointestinal agent	Sucralfate	Not recorded	1	1.85
Supplement	Curcuma tablet	Not recorded	1	1.85
Supplement	ProLiver	Not recorded	1	1.85
Supplement/vitamin	Vitamin B6	Not recorded	1	1.85

The reported percentages have been rechecked against the verified study dataset and recalculated using the appropriate denominator.

Source percentages that were inconsistent with the final study sample were not retained. The denominator used for each analysis has been clearly stated to ensure consistency between the reported frequencies, percentages, and the final sample of 35 patients

Metformin was the most frequently recorded glucose-lowering medicine, followed by glimepiride, a pattern consistent with national guidance and earlier outpatient studies.^{13,20,21} Amlodipine ranked second overall and

corresponded with the high prevalence of hypertension, while gabapentin was frequently used for diabetic neuropathy. These findings show how comorbidities expand the regimen beyond glycemic treatment and explain why medication review must evaluate the full prescription rather than antidiabetic agents alone.^{22,23}

LIMITATION

The study was limited by its retrospective, single-center design and the small sample of 35 medical records. The eligibility restrictions to patients aged 20–60 years and to those with at least one comorbidity further narrow generalizability, as the findings may not extend to older (≥ 60 years) patients or to type 2 diabetes outpatients without comorbid conditions. The analysis depended on the completeness of routine documentation, so unrecorded symptoms, laboratory values, adherence, over-the-counter medicines, and clinical decisions could not be assessed. The classification focused on the Problem and Cause domains and did not evaluate interventions, acceptance, or outcomes. Potential drug–drug interactions and other safety problems were identified from the records rather than confirmed by documented clinical or laboratory outcomes. The findings therefore describe potential and documented medication-related concerns in this hospital population and should not be generalized without confirmation in larger prospective studies.

CONCLUSION

Multiple drug-related problem events were identified in the reviewed records of 35 type 2 diabetes mellitus outpatients at Labuang Baji Regional General Hospital. Treatment-safety concerns represented the largest Problem category, while inappropriate medicine combinations were the leading Cause category. Because patient-level linkage of individual drug-related problem events was not available, the number and proportion of patients experiencing at least one drug-related problem could not be determined. The findings highlight the need for structured medication review and clearer documentation of treatment indications, while the potential benefit of pharmacist intervention should be evaluated prospectively.

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AUTHOR CONTRIBUTION STATEMENT

Sri Maharani: Conceptualization, Methodology, Data Curation, Investigation, Formal Analysis, Writing – Original Draft.

Nurhikma Awaluddin: Supervision, Methodology, Validation, Writing – Review & Editing.

Andi Meinar Dwi Rantisari Thayeb: Supervision, Validation, Writing – Review & Editing.

Ghina Ramadhani: Validation, Writing – Review & Editing.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

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Formulation and Evaluation of *Centella asiatica* (L.) Urb. Leaf Extract Shampoo: Physicochemical Characteristics and In Vitro Antifungal Activity

Formulasi dan Evaluasi Sampo Ekstrak Daun Pegagan (*Centella asiatica* (L.) Urb.): Karakteristik Fisikokimia dan Aktivitas Antijamur secara In Vitro

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Abstract

Dandruff is a common scalp disorder associated with alterations in scalp microbiota, including the presence of *Malassezia furfur*. The prolonged use of synthetic antifungal agents may cause adverse effects, highlighting the need for plant-based alternatives. This study aimed to formulate a shampoo containing *Centella asiatica* (L.) Urb. leaf extract and to evaluate its physicochemical characteristics and in vitro antifungal activity. *Centella asiatica* leaves were extracted by maceration using 96% ethanol, n-hexane, and ethyl acetate. The extract exhibiting the strongest antifungal activity was incorporated into three shampoo formulations, which were evaluated for organoleptic properties, pH, viscosity, foam height, specific gravity, moisture content, consumer preference, and in vitro antifungal activity using the agar diffusion method. The ethyl acetate extract produced inhibition zones of 12 mm against *Candida albicans* and 11 mm against *Malassezia furfur*. All shampoo formulations exhibited pH values ranging from 6.42 to 6.95, viscosities of 1438.67–1577.33 cP, foam heights of 4.0–4.2 cm, and specific gravity values of 1.0220–1.0288. The formulations produced inhibition zones of 16.7–19.7 mm against *Candida albicans* and 17.3–20.7 mm against *Malassezia furfur*. These findings demonstrate that *Centella asiatica* leaf extract can be formulated into a shampoo with acceptable physicochemical characteristics and measurable in vitro antifungal activity, supporting its potential for further development as a herbal shampoo formulation.

Abstrak

Ketombe adalah gangguan kulit kepala umum yang dikaitkan dengan perubahan mikrobiota kulit kepala, termasuk keberadaan *Malassezia furfur*. Penggunaan agen antijamur sintesis dalam jangka panjang dapat menimbulkan efek samping, sehingga memunculkan kebutuhan akan alternatif berbasis tanaman. Penelitian ini bertujuan untuk memformulasikan sampo yang mengandung ekstrak daun *Centella asiatica* (L.) Urb. serta mengevaluasi karakteristik fisikokimia dan aktivitas antijamur *in vitro*-nya. Daun *Centella asiatica* diekstraksi melalui metode maserasi menggunakan etanol 96%, n-heksana, dan etil asetat. Ekstrak yang menunjukkan aktivitas antijamur terkuat diformulasikan ke dalam tiga sediaan sampo, yang kemudian dievaluasi meliputi sifat organoleptik, pH, viskositas, tinggi busa, bobot jenis, kadar air, preferensi konsumen, dan aktivitas antijamur *in vitro* menggunakan metode difusi agar. Ekstrak etil asetat menghasilkan zona hambat sebesar 12 mm terhadap *Candida albicans* dan 11 mm terhadap *Malassezia furfur*. Seluruh formulasi sampo menunjukkan nilai pH berkisar antara 6,42 hingga 6,95, viskositas 1438,67–1577,33 cP, tinggi busa 4,0–4,2 cm, dan nilai bobot jenis 1,0220–1,0288. Formulasi tersebut menghasilkan zona hambat sebesar 16,7–19,7 mm terhadap *Candida albicans* dan 17,3–20,7 mm terhadap *Malassezia furfur*. Temuan ini menunjukkan bahwa ekstrak daun *Centella asiatica* dapat diformulasikan menjadi sampo dengan karakteristik fisikokimia yang dapat diterima dan aktivitas antijamur *in vitro* yang terukur, sehingga mendukung potensinya untuk pengembangan lebih lanjut sebagai formulasi sampo herbal.

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INTRODUCTION

Dandruff is one of the most prevalent scalp disorders affecting individuals across all age groups and remains a common dermatological concern worldwide. Excessive desquamation of the stratum corneum characterizes it and causes itching, irritation, and scalp discomfort. Although dandruff is not a life-threatening condition, it considerably affects patients' quality of life by impairing their physical appearance, reducing their self-confidence, and causing psychosocial distress. Owing to its high prevalence and recurrent nature, dandruff continues to represent a significant challenge in dermatological care, emphasizing the need for effective and safe long-term therapeutic strategies^{1,2}.

The pathogenesis of dandruff is multifactorial and involves complex interactions among sebum production, skin barrier integrity, scalp microbiota, and host immune responses. Among these contributing factors, colonization by lipophilic yeasts of the genus *Malassezia*, particularly *Malassezia furfur*, has consistently been associated with dandruff and seborrheic dermatitis. *Malassezia furfur* hydrolyzes sebum lipids through lipase activity, producing free fatty acids that disrupt the epidermal barrier, trigger inflammatory responses, and accelerate epidermal cell turnover, ultimately leading to the accumulation of visible scalp scales^{1,3,4}.

In addition to *Malassezia furfur*, *Candida albicans* has also been reported to colonize the scalp, particularly in individuals with microbial dysbiosis, altered scalp pH, or impaired immune function. However, its involvement in dandruff is less prominent than that of *Malassezia furfur*; *Candida albicans* may aggravate scalp inflammation and contribute to opportunistic fungal infections that delay the recovery of scalp health. Therefore, developing topical formulations capable of inhibiting both *Malassezia furfur* and *Candida albicans* may provide broader antifungal protection and improve the therapeutic effectiveness of antidandruff products³⁻⁵.

Current dandruff management primarily relies on synthetic antifungal agents, including ketoconazole, zinc pyrithione, selenium sulfide, ciclopirox olamine, and piroctone olamine. These compounds effectively inhibit fungal growth through different mechanisms, mainly by disrupting ergosterol biosynthesis and compromising fungal cell membrane integrity. Nevertheless, prolonged use of these agents has been associated with adverse effects such as scalp irritation, excessive dryness, alterations in hair texture, and the potential development of reduced fungal susceptibility. These limitations have stimulated increasing interest in plant-derived bioactive compounds as safer and more sustainable alternatives for scalp care owing to their multiple biological activities and favorable safety profiles^{1,4,6}.

Indonesia possesses remarkable biodiversity and represents an important source of medicinal plants for developing herbal pharmaceuticals and cosmetic products. Among these plants *Centella asiatica* (L.) Urban has been extensively used in traditional medicine for wound healing, inflammatory disorders, and various skin diseases. Recent pharmacological studies have demonstrated that *Centella asiatica* exhibits antioxidant, anti-inflammatory, antibacterial, antifungal, and immunomodulatory activities, indicating its considerable potential as an active ingredient in topical pharmaceutical and cosmeceutical formulations⁶⁻⁹.

The therapeutic potential of *Centella asiatica* is mainly attributed to its rich phytochemical composition, particularly pentacyclic triterpenoids such as asiaticoside, madecassoside, asiatic acid, and madecassic acid, together with flavonoids, tannins, phenolic compounds, alkaloids, and glycosides. These bioactive constituents exhibit antifungal activity through multiple mechanisms, including disruption of fungal cell membrane integrity, inhibition of ergosterol biosynthesis, increased membrane permeability, and suppression of essential metabolic enzymes. In addition to their antifungal effects, several of these compounds possess anti-inflammatory properties that may contribute to improving scalp health, making *Centella asiatica* a promising candidate for developing multifunctional herbal antidandruff formulations^{6–8,10}.

Recent studies have demonstrated that *Centella asiatica* possesses broad-spectrum antimicrobial and antifungal activities against various pathogenic microorganisms. However, most published investigations have primarily focused on the in vitro antifungal activity of crude extracts, the isolation and characterization of bioactive constituents, or the application of *Centella asiatica* in wound healing, anti-inflammatory, and antioxidant therapies. Comparatively, few studies have explored its incorporation into topical cosmetic formulations, particularly herbal antidandruff shampoos. Furthermore, existing studies generally evaluate antifungal activity against a single fungal species, providing limited evidence regarding the efficacy of *Centella asiatica* against *Malassezia furfur*, the dandruff-associated yeast, and *Candida albicans*, an opportunistic fungal pathogen that may exacerbate scalp disorders. Simultaneous evaluation against these two biologically distinct fungal species would provide a more comprehensive understanding of the antifungal spectrum of *Centella asiatica* and its potential application in scalp care products^{7,9,11–13}. Studies using different extraction approaches have also documented the antimicrobial or antifungal activity of *Centella asiatica* extracts against pathogenic microorganisms^{13–19}.

The successful development of an herbal antidandruff shampoo depends not only on the antifungal activity of its active ingredient but also on the physicochemical quality and consumer acceptability of the final formulation. A shampoo must exhibit appropriate organoleptic characteristics, pH, viscosity, foamability, specific gravity, and stability to ensure product safety, effectiveness, and user satisfaction. Therefore, comprehensive physicochemical evaluation is an essential component of cosmetic product development because these parameters directly influence product performance, storage stability, and consumer preference^{20–22}. Consequently, evaluating both biological activity and formulation quality is necessary to assess the feasibility of developing a herbal antidandruff shampoo for further investigation. Previous topical and herbal-shampoo studies likewise emphasize physicochemical characterization and product performance^{20,21,23}.

Despite the growing body of evidence supporting the pharmacological potential of *C. asiatica*, several important research gaps remain. Most previous studies have focused exclusively on extract screening or phytochemical characterization without integrating extract selection based on antifungal activity, shampoo formulation, physicochemical evaluation, consumer acceptability testing, and antifungal assessment against both *Malassezia furfur* and *Candida albicans* within a single experimental framework. As a result, scientific evidence supporting the development of *C. asiatica*-based herbal antidandruff shampoos remains limited.

The novelty of the present study lies in the integration of systematic extract selection, formulation development, physicochemical characterization, hedonic evaluation, and dual-species antifungal assessment into a comprehensive product development approach. Unlike previous investigations that mainly evaluated the biological activity of *Centella asiatica* extracts, this study employed the ethyl acetate extract selected based on its antifungal activity as the active ingredient in a shampoo formulation and subsequently evaluated both formulation quality and

antifungal performance. This integrated strategy provides a scientific basis for developing plant-based antidandruff shampoos derived from Indonesian medicinal plants.

Based on these considerations, this study aimed to formulate a herbal shampoo containing *Centella asiatica* (L.) Urban leaf extract, evaluate its physicochemical characteristics and consumer acceptability, and determine its antifungal activity against *Malassezia furfur* and *Candida albicans*. The findings are expected to contribute scientific evidence supporting the development of safe, effective, and high-quality herbal antidandruff shampoos as alternative scalp care products.

METHODS

Tools and Materials

Research Procedure

Study Design

The study included 30 participants for the hedonic evaluation. This laboratory-based experimental study was conducted to develop a herbal shampoo containing *Centella asiatica* (L.) Urb. Leaf extract and to evaluate its physicochemical characteristics and antifungal activity against *Malassezia furfur* and *Candida albicans*. The experimental workflow consisted of plant material authentication and characterization, extraction, phytochemical screening, antifungal screening of the extracts, shampoo formulation, physicochemical evaluation, antifungal evaluation of the formulations, hedonic assessment, and statistical analysis.

Materials

Plant Material

Dried *Centella asiatica* (L.) Urb. leaves were obtained from the Center for Research and Development of Medicinal Plants and Traditional Medicine (B2P2TOOT), Tawangmangu, Central Java, Indonesia. Botanical authentication was performed at the same institution before the experimental study.

Chemicals and Reagents

Analytical-grade ethanol (96%), ethyl acetate, *n*-hexane, hydrochloric acid, ferric chloride, sodium hydroxide, picric acid, glacial acetic acid, chloroform, distilled water, dimethyl sulfoxide (DMSO), carboxymethyl cellulose (CMC), Tween, betaine, cocodiethanolamide, sodium benzoate, citric acid, and Sabouraud Dextrose Agar (Merck) were used throughout the study. Ketoconazole (30 µg/mL) served as the positive control.

Test Microorganisms

Reference cultures of *Malassezia furfur* and *Candida albicans* were used for antifungal evaluation.

Experimental Procedures

Step I. Plant Material Preparation and Characterization

The dried leaves of *Centella asiatica* were subjected to botanical authentication before processing. Quality evaluation of the crude drug included macroscopic, microscopic, organoleptic, moisture content, ash content, and preliminary phytochemical characterization according to standard pharmacognostic procedures. These analyses were performed to ensure the identity and quality of the plant material before extraction.

Step II. Extraction Procedure

Approximately 250 g of powdered *Centella asiatica* leaves were extracted separately by maceration using 96% ethanol, ethyl acetate, and *n*-hexane as extraction solvents. Each extraction was carried out at room temperature for 48 h with occasional stirring. The filtrates were collected by filtration and concentrated under reduced pressure

using a rotary evaporator at approximately 50°C to obtain viscous extracts. Extraction yield was calculated as the percentage of dried extract relative to the initial weight of powdered plant material.

Step III. Phytochemical Screening

Qualitative phytochemical screening was performed on each extract according to the Harborne method to identify the major classes of secondary metabolites, including alkaloids, flavonoids, tannins, phenolic compounds, steroids, terpenoids, saponins, and glycosides. The phytochemical profile was used to support the interpretation of the observed antifungal activity of the extracts.

Step IV. Antifungal Activity Screening of the Extracts

The antifungal activity of the *Centella asiatica* extracts was evaluated against *Malassezia furfur* and *Candida albicans* using the agar well diffusion method. Fungal suspensions were prepared at approximately 1×10^6 CFU/mL and inoculated onto Sabouraud Dextrose Agar (SDA) plates. Wells were filled with each extract solution, while ketoconazole (30 µg/mL) and dimethyl sulfoxide (DMSO) served as the positive and negative controls, respectively. Ketoconazole (30 µg/mL) was used as the positive control and reference for evaluating the antifungal activity of the extracts and shampoo formulations. This concentration was selected based on a published agar diffusion study that used ketoconazole at 30 µg/mL as a standard antifungal control against *Candida albicans* [26]. Following incubation under appropriate conditions, the inhibition zone diameters were measured in millimeters (mm). All experiments were performed in triplicate. The extract exhibiting the greatest antifungal activity was selected as the active ingredient for the shampoo formulation.

Step V. Shampoo Formulation

The extract selected from the antifungal screening was incorporated into three shampoo formulations (F1, F2, and F3). The shampoo base consisted of carboxymethyl cellulose (CMC), Tween, betaine, cocodiethanolamide, sodium benzoate, citric acid, lavender fragrance, and distilled water. The concentrations of ethyl acetate extract were 5%, 10%, and 15% (w/v) for F1, F2, and F3, respectively.

Dispersing CMC in hot water until a homogeneous gel formed initiated the shampoo preparation process. The extract was then mixed with Tween, betaine, and cocodiethanolamide before being gradually incorporated into the CMC dispersion under continuous stirring. Sodium benzoate was added as a preservative, and the pH was adjusted using a citric acid solution to obtain a scalp-compatible pH. Finally, lavender fragrance, and distilled water were added to achieve the desired final volume.

Step VI. Physicochemical Evaluation of Shampoo Formulations

All shampoo formulations were evaluated for physicochemical quality using standard cosmetic evaluation procedures. The evaluated parameters included organoleptic characteristics (color, odor, and appearance), pH, viscosity, foam height, specific gravity, and moisture content.

The pH of each formulation was measured using a calibrated pH meter after an appropriate dilution with distilled water. Viscosity was determined using a Brookfield LV viscometer, whereas specific gravity was measured using a pycnometer. Foam height was evaluated using the shaking method, and moisture content was determined gravimetrically until a constant weight was obtained. These evaluations were performed to assess formulation quality, stability, and suitability for topical scalp application.^{20–23}

Step VII. Antifungal Activity of Shampoo Formulations

The antifungal activity of the shampoo formulations was evaluated against *Malassezia furfur* and *Candida albicans* using the agar well diffusion method, following the same procedure described for the extract screening.

Ketoconazole (30 µg/mL) was used as the positive control, whereas the shampoo base without *C. asiatica* extract served as the negative control. Following incubation, the diameters of the inhibition zones were measured in millimeters (mm) to determine the antifungal activity of each formulation. All experiments were conducted in triplicate.

Step VIII. Hedonic Evaluation

Consumer acceptability of the shampoo formulations was assessed through a hedonic evaluation involving 30 participants. Each participant evaluated the three formulations based on color, odor, and texture using a structured evaluation form. The hedonic assessment was conducted to determine the level of consumer preference for each formulation.

Data Analysis

Hedonic test results for color, aroma, and texture were analyzed using the Kruskal–Wallis test at a 95% confidence level ($\alpha = 0.05$).

RESULT AND DISCUSSION

Characterization of *Centella asiatica* (L.) Urb. Simplicia

Table 1. Pharmacognostic characteristics of *Centella asiatica* (L.) Urb. simplicia

Parameter	Observation
Macroscopic appearance	Curled and wrinkled leaf lamina
Color	Dark green
Odor	Aromatic
Taste	Bitter
Microscopic characteristic	Rosette-shaped calcium oxalate crystals
Powder characteristics	Green powder with characteristic herbal odor
Moisture content	0.82%
Total ash content	0.07%

As presented in Table 1, the simplicia exhibited the characteristic pharmacognostic features of *C. asiatica*, including dark green leaves with an aromatic odor and bitter taste. Microscopic examination revealed rosette-shaped calcium oxalate crystals, which are recognized as one of the diagnostic characteristics of *C. asiatica*. These findings confirm the botanical identity of the plant material and indicate that the raw material used in this study was suitable for subsequent extraction and formulation processes. Similar pharmacognostic characteristics have been reported in previous studies describing the morphological and microscopic features of *Centella asiatica*^{6,8,9}.

The moisture content of the simplicia was 0.82%, indicating adequate drying before extraction. Low moisture content is essential for minimizing microbial contamination during storage and preserving the stability of bioactive secondary metabolites. Likewise, the total ash content (0.07%) indicates low level of inorganic impurities, reflecting the good quality of the crude plant material. Moisture and ash contents are widely recognized as important quality control parameters for medicinal plants because they contribute to the reproducibility and consistency of herbal products^{6–8}.

Overall, the pharmacognostic evaluation demonstrated that *Centella asiatica* simplicia met the quality requirements for herbal raw materials and provided a reliable basis for extraction and subsequent shampoo formulation.

Extraction Yield and Phytochemical Profile

Table 2. Extraction yield of the *C asiatica* leaf extracts

Solvent	Initial weight (g)	Extract weight (g)	Yield (%)
96% Ethanol	250.021	35.020	14.01
<i>n</i> -Hexane	250.018	11.183	4.47
Ethyl acetate	250.040	20.183	8.07

The extraction yields obtained using solvents with different polarities are summarized in Table 2. Ethanol produced the highest extraction yield (14.01%), followed by ethyl acetate (8.07%) and *n*-hexane (4.47%). The higher yield obtained with ethanol is attributable to its ability to dissolve both polar and moderately polar phytochemicals, whereas the non-polar nature of *n*-hexane limits the extraction primarily to lipophilic compounds. Ethyl acetate, a semipolar solvent, selectively extracts compounds such as aglycone flavonoids, phenolic constituents, and certain triterpenoids that have been associated with antifungal activity^{6-8,11,17,18,24,25}.

Although the ethanol extract produced the highest yield, the ethyl acetate extract was selected for formulation because it exhibited superior antifungal activity during the preliminary screening. This finding indicates that extraction yield alone is not an appropriate indicator of biological effectiveness. Instead, the qualitative composition and concentration of bioactive constituents play a more important role in determining the pharmacological potential of herbal extracts. Similar observations have been reported in studies demonstrating that semipolar fractions often possess stronger antimicrobial activity despite lower extraction yields^{11,15,16,20,21}.

Table 3. Qualitative phytochemical profile of the ethyl acetate extract of *C. asiatica*

Secondary metabolite	Result
Alkaloids	+
Flavonoids	+
Phenolic compounds	+
Tannins	+
Terpenoids	+
Steroids	+
Glycosides	+
Saponins	–

As shown in **Table 3**, qualitative phytochemical screening demonstrated the presence of alkaloids, flavonoids, phenolic compounds, tannins, terpenoids, steroids, and glycosides, whereas saponins were not detected. The phytochemical profile indicates that ethyl acetate effectively extracted semipolar bioactive constituents commonly associated with antimicrobial and antifungal activities. These results are consistent with previous reports describing *Centella asiatica* as a rich source of triterpenoids, flavonoids, and phenolic compounds with diverse pharmacological properties^{6-8,14}.

The antifungal activity observed in this study is likely attributable to the synergistic effects of multiple secondary metabolites rather than the action of a single compound. Flavonoids and phenolic compounds have been reported to disrupt fungal membrane integrity and inhibit essential metabolic pathways, whereas triterpenoids such as asiaticoside and madecassoside may interfere with ergosterol-associated membrane function. The coexistence of these bioactive constituents may explain the antifungal activity demonstrated by the ethyl acetate extract despite the absence of detectable saponins.

Compared with studies focusing solely on phytochemical identification, the present study further linked the phytochemical profile with biological screening and extract selection for formulation development. This integrated approach strengthens the rationale for selecting the ethyl acetate extract as the active ingredient in the herbal shampoo and provides a more comprehensive basis for subsequent formulation and efficacy evaluation.

Antifungal Activity of the *Centella asiatica* Leaf Extracts

Table 4. Antifungal activity of *Centella asiatica* leaf extracts against *Candida albicans* and *Malassezia furfur*

Treatment	<i>Candida albicans</i> (mm)	<i>Malassezia furfur</i> (mm)
Positive control (ketoconazole)	36	42
Negative control (DMSO)	0	0
Ethyl acetate extract	12	11
96% Ethanol	7	6
<i>n</i> -Hexane	6	7

As presented in Table 4, the ethyl acetate extract showed the largest inhibition zones among the three extracts, producing inhibition zones of 12 mm against *Candida albicans* and 11 mm against *Malassezia furfur*, compared with 7 and 6 mm for the 96% ethanol extract and 6 and 7 mm for the *n*-hexane extract, respectively. In contrast, the negative control (DMSO) produced no inhibition, confirming that the observed antifungal activity originated from the plant extract rather than the solvent. As expected, ketoconazole exhibited substantially larger inhibition zones owing to its well-established fungicidal activity.

Although the inhibition zones produced by the extract were smaller than those of ketoconazole, the results clearly demonstrate that the ethyl acetate extract possesses intrinsic antifungal activity. This finding supports the selection of the ethyl acetate extract as the active ingredient for shampoo formulation. Similar observations have been reported in previous studies, where semi-polar fractions of medicinal plants frequently exhibited stronger antifungal activity than highly polar extracts because of their enrichment with bioactive flavonoids, phenolic compounds, and triterpenoids^{6-8,11}.

The antifungal activity observed in the present study is likely associated with the synergistic action of the phytochemicals identified during qualitative screening. Rather than acting through a single molecular target, flavonoids, phenolic compounds, tannins, and triterpenoids collectively disrupt fungal membrane integrity, interfere with ergosterol biosynthesis, and impair essential metabolic pathways. Such synergistic interactions have been proposed as one of the major advantages of plant-derived antifungal agents because they reduce the likelihood of fungal adaptation to a single mechanism of action^{6,7,10,12}.

An important finding of this study is that the extract demonstrated inhibitory activity against both *Candida albicans* and *Malassezia furfur*. While *Malassezia furfur* is one of the microorganisms associated with dandruff and seborrheic dermatitis, *Candida albicans* may colonize the scalp under conditions of microbial imbalance and contribute to opportunistic infections. Therefore, the observed antifungal activity against both fungal species supports further investigation of *Centella asiatica* as a potential active ingredient in topical scalp-care formulations.

Overall, these findings demonstrate that the ethyl acetate extract of *Centella asiatica* possesses sufficient antifungal activity to justify its incorporation into a topical shampoo formulation for subsequent evaluation.

Physicochemical Characteristics of Shampoo Formulations

Table 5. Physicochemical characteristics of the *Centella asiatica* shampoo formulations

Parameter	F1	F2	F3
Appearance	Lotion	Lotion	Lotion
Color	Light green	Moss green	Dark green
Odor	Lavender	Lavender	Lavender
pH	6.95	6.42	6.62
Foam height (cm)	4.1	4.0	4.2

Viscosity (cP)	1569.33	1438.67	1577.33
Specific gravity	1.0288	1.0220	1.0242
Moisture content (%)	0.82	0.79	0.86

As summarized in **Table 5**, all shampoo formulations exhibited acceptable physicochemical characteristics. No marked differences in appearance or odor were observed among the formulations, whereas the color became progressively darker with increasing extract concentration. The gradual color change is expected because higher concentrations of *Centella asiatica* extract contribute greater amounts of natural chlorophyll and phenolic pigments without adversely affecting formulation homogeneity.

The pH values ranged from 6.42 to 6.95, which fall within the acceptable range for scalp application. Maintaining a pH close to that of the scalp is important for preserving skin barrier integrity, minimizing irritation, and maintaining microbial homeostasis. Comparable pH values have been reported for herbal shampoo formulations containing plant extracts intended for routine scalp care^{20–22}.

Viscosity values ranged from 1438.67 to 1577.33 cP, indicating that incorporation of the ethyl acetate extract did not adversely affect the rheological properties of the shampoo base. The relatively uniform viscosity among formulations indicates satisfactory compatibility between the extract and formulation excipients. Appropriate viscosity contributes to product stability, ease of application, and prolonged contact of the active ingredients with the scalp surface.

Foam heights varied only slightly (4.0–4.2 cm), demonstrating that increasing extract concentration did not interfere with the foaming performance of the surfactant system. Although foam height is not a direct indicator of cleansing efficiency, it remains an important quality attribute because consumers frequently associate abundant foam with effective cleansing performance.

Similarly, all formulations exhibited comparable specific gravity and moisture content, indicating uniform dispersion of formulation components and acceptable physical stability. Moisture contents below 1% further indicate minimal free water, which may contribute to improved storage stability and reduced microbial contamination.

Collectively, the physicochemical evaluation demonstrates that the incorporation of *Centella asiatica* extract does not compromise the quality of the shampoo formulations. Instead, all formulations fulfilled the fundamental physicochemical characteristics expected of a herbal shampoo while maintaining acceptable sensory properties.

Antifungal Activity of Shampoo Formulations

Table 6. Antifungal activity of *Centella asiatica* shampoo formulations against *Candida albicans* and *Malassezia furfur*

Treatment	<i>Candida albicans</i> (mm)	<i>Malassezia furfur</i> (mm)
Positive control (ketoconazole)	19.0	34.0
Negative control (Shampoo base)	0	0
F1 (5%)	19.7	17.3
F2 (10%)	16.7	20.7
F3 (15%)	19.7	18.0

As shown in Table 6, all shampoo formulations inhibited the growth of both *Candida albicans* and *Malassezia furfur*, whereas the shampoo base produced no inhibition zone. These findings confirm that the observed antifungal activity was attributed to the incorporation of *Centella asiatica* extract rather than the formulation base itself. Formulas F1 and F3 exhibited the largest inhibition zones against *Candida albicans* (19.7 mm), whereas Formula F2 showed the greatest activity against *Malassezia furfur* (20.7 mm).

A notable finding of this study is that the inhibition zones produced by the shampoo formulations were greater than those produced by the ethyl acetate extract before formulation. During the preliminary screening, the

extract produced inhibition zones of 12 mm against *Candida albicans* and 11 mm against *Malassezia furfur*. After incorporation into the shampoo base, the inhibition zones increased to 16.7–19.7 mm and 17.3–20.7 mm, respectively. This observation indicates that the antifungal activity of the extract was retained after incorporation into the shampoo formulation. The larger inhibition zones may be related to differences in dispersion and diffusion of the formulation components in the agar medium.

One possible explanation is that the surfactant system, consisting of Tween, betaine, and cocodiethanolamide, improved the dispersion and diffusion of the extract within the agar medium. Enhanced dispersion may facilitate the release of bioactive compounds from the formulation, allowing greater interaction with fungal cells. Similar improvements in biological activity following formulation have been reported for several plant-based topical preparations, in which formulation excipients enhanced local delivery without altering the phytochemical composition of the extract^{20–22}.

Differences in antifungal activity among the formulations were relatively small, indicating that increasing extract concentration did not proportionally increase antifungal activity. Formula F2 demonstrated the highest activity against *Malassezia furfur*, whereas F1 and F3 were slightly more effective against *Candida albicans*. These findings indicate that antifungal performance is influenced not only by extract concentration but also by formulation characteristics affecting the release and diffusion of active compounds. Similar variations in fungal susceptibility have been reported previously and are associated with differences in fungal cell wall composition, membrane lipids, and adaptive responses to antifungal agents^{1,3–5}.

Dandruff is a multifactorial scalp condition, and *Malassezia* species, including *Malassezia furfur*, are among the microorganisms associated with its development. Therefore, the antifungal activity observed against *Malassezia furfur* in this study should be interpreted as activity against one microorganism associated with dandruff, rather than evidence that *Malassezia furfur* is the principal etiological factor of dandruff^{1,3–5}.

Compared with previous studies that primarily evaluated crude *Centella asiatica* extracts, the present study demonstrates that the antifungal activity of the extract was retained after incorporation into a shampoo formulation while maintaining acceptable physicochemical characteristics. This finding provides additional evidence supporting the feasibility of developing *C. asiatica*-based herbal shampoos as multifunctional topical products for scalp care.

Collectively, these results demonstrate that the developed shampoo formulations exhibited antifungal activity against both dandruff-associated and opportunistic fungi, supporting the potential application of *Centella asiatica* as a natural active ingredient in herbal antidandruff shampoos.

Hedonic Evaluation

Table 7. Hedonic evaluation of the *Centella asiatica* shampoo formulations

Attribute	Formula	Score 1	Score 2	Score 3	Score 4	Score 5	p
Texture	F1	0	2	9	16	3	0.262
	F2	0	3	12	12	3	
	F3	0	1	11	10	8	
Aroma	F1	1	3	12	8	6	0.768
	F2	0	5	12	11	2	
	F3	1	5	8	13	3	
Color	F1	0	4	4	11	11	0.002
	F2	0	5	11	10	4	
	F3	2	8	9	10	1	

Note: Data represent the number of panelists at each hedonic score. A difference was considered statistically significant when $p < 0.05$

As summarized in **Table 7**, the hedonic evaluation was performed to assess consumer acceptance of the developed shampoo formulations based on color, odor, and texture. Sensory acceptability is an important quality attribute because consumer preference strongly influences the practical use and commercial feasibility of cosmetic products.

The hedonic test involved 30 panelists aged 16–18 years, comprising male and female participants. Inclusion criteria were willingness to follow the research protocol, provide informed consent, and assess the color, odor, and physical form of the shampoo. Exclusion criteria included having flu, being color-blind, refusing participation, or experiencing fatigue or significant mental stress. Before participation, the researcher provided a research information sheet, and all panelists provided informed consent. Ethical considerations were applied to protect the safety, rights, and well-being of the participants.

Overall, the participants considered all formulations acceptable, indicating that incorporating *Centella asiatica* extract did not negatively affect the sensory characteristics of the shampoo. The lavender fragrance effectively masked the characteristic odor of the plant extract, while the lotion-like consistency and homogeneous appearance contributed to favorable user perception.

Differences in consumer preference among formulations may be associated with variations in extract concentration that influenced the intensity of the green coloration and the overall appearance of the products. Nevertheless, these differences did not substantially reduce consumer acceptance, indicating that the selected formulation components successfully balanced functional performance and esthetic quality.

The hedonic findings complement the physicochemical evaluation by demonstrating that the developed formulations not only exhibited acceptable quality characteristics but were also well accepted by potential users. This aspect is particularly important because successful cosmetic products require both biological efficacy and positive consumer perception.

Overall Discussion

This study systematically integrated pharmacognostic characterization, phytochemical screening, extract selection, shampoo formulation, physicochemical evaluation, and antifungal assessment within a single experimental framework. Unlike many previous studies that focused primarily on the biological activity of *Centella asiatica* extracts, this study demonstrated that the ethyl acetate extract retained its antifungal activity after formulation into a herbal shampoo while maintaining acceptable physicochemical characteristics and consumer acceptability.

The combination of satisfactory physicochemical properties and measurable antifungal activity against both *Candida albicans* and *Malassezia furfur* indicates that *Centella asiatica* has considerable potential as a natural active ingredient for herbal antidandruff shampoo formulations. These findings provide additional scientific evidence supporting further investigation of Indonesian medicinal plants for the development of plant-based cosmeceutical formulations.

LIMITATION

This study had several limitations. First, the antifungal activity of the developed shampoo formulations was evaluated using an agar diffusion method; therefore, minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) values were not determined. Second, the study did not evaluate the in vitro release profile, skin permeation, or long-term stability of the active compounds in the shampoo formulation. Third, although a hedonic evaluation was conducted, the numerical scores and detailed statistical results should be further documented

to provide a more comprehensive assessment of product acceptability. In addition, the study did not include clinical evaluation in subjects with dandruff or seborrheic scalp conditions. Therefore, further studies are needed to determine the MIC and MFC, characterize the release and skin-permeation behavior, assess long-term stability, and evaluate the clinical efficacy and safety of the developed *Centella asiatica* herbal shampoo.

This study demonstrated that *Centella asiatica* (L.) Urb. leaf extract can be successfully incorporated into a herbal shampoo formulation with acceptable physicochemical characteristics and measurable in vitro antifungal activity against *Candida albicans* and *Malassezia furfur*. The developed formulations showed acceptable physicochemical properties while maintaining the antifungal activity of the extract, supporting the potential of *Centella asiatica* leaf extract as a natural active ingredient for further development of herbal shampoo formulations. Furthermore, the integration of pharmacognostic characterization, phytochemical screening, extract selection, formulation development, physicochemical evaluation, and antifungal assessment provides a basis for further development of plant-based cosmeceutical products. Further studies are recommended to investigate the minimum inhibitory concentration (MIC), minimum fungicidal concentration (MFC), in vitro release behavior, skin permeation, long-term stability, and clinical efficacy of the developed formulations.

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AUTHOR CONTRIBUTION STATEMENT

AES: Conceptualization, Methodology, Investigation, Data Curation, Writing—Original Draft Preparation; L: Methodology, Validation, Investigation, Supervision; DH: Investigation, Data Curation, Writing—Review & Editing.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

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Identification of Dexamethasone in Jamu Pegal Linu Distributed in Ciracas Market Using Thin Layer Chromatography (TLC) – Spectrophotodensitometry

Identifikasi Deksametason dalam Jamu Pegal Linu yang Diedarkan di Pasar Ciracas Menggunakan Kromatografi Lapis Tipis (KLT)– Spektrofotodensitometri

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Abstract

Jamu is a traditional medicinal product widely utilized for health maintenance, health promotion, and disease prevention. One notable example is jamu pegal linu, which demonstrates therapeutic efficacy in alleviating muscle and joint pain. However, the increasing prevalence of jamu consumption raises significant concerns regarding adulteration with chemical drug additives, including dexamethasone. The prolonged consumption of jamu adulterated with dexamethasone can result in severe adverse health effects, including gastric ulcers, hypersensitivity reactions, hypertension, diabetes mellitus, and hepatorenal damage, with potentially fatal outcomes. This study aims to identify the dexamethasone content in jamu pegal linu distributed in Pasar Ciracas, East Jakarta. A qualitative test was performed using Thin Layer Chromatography (TLC), with the results were evaluated by spot visualization and the comparison of Retention Factor (Rf) values. The TLC results of ten jamu pegal linu samples revealed that one sample (sample 3) exhibited a spot corresponding to the dexamethasone reference standard under UV 254 nm light. The Rf value of sample 3 (0.538) matched that of the dexamethasone standard. The test procedure proceeded with sample spot scanning, which revealed that only a single sample (sample 3) exhibited a chromatogram spectrum comparable to the dexamethasone standard, whereas the remaining samples displayed no such alignment. Identification via high performance liquid chromatography at a maximum wavelength of 254 nm revealed that the chromatographic profile of sample 3 matched that of the dexamethasone standard. This result confirms the presence of dexamethasone in sample 3. Consequently, it is concluded that one out of the ten samples tested contained dexamethasone.

Abstrak

Jamu merupakan produk obat tradisional yang banyak digunakan untuk pemeliharaan kesehatan, peningkatan kesehatan, dan pencegahan penyakit. Salah satu contoh yang umum adalah jamu pegal linu, yang memiliki khasiat terapeutik dalam meredakan nyeri otot dan sendi. Namun, meningkatnya konsumsi jamu menimbulkan kekhawatiran serius terkait adanya pemalsuan produk dengan penambahan bahan kimia obat, termasuk deksametason. Konsumsi jamu yang mengandung deksametason dalam jangka panjang dapat menyebabkan dampak kesehatan yang merugikan dan parah, seperti tukak lambung, reaksi hipersensitivitas, hipertensi, diabetes melitus, serta kerusakan hati dan ginjal, yang bahkan dapat berakibat fatal. Penelitian ini bertujuan untuk mengidentifikasi kandungan deksametason dalam jamu pegal linu yang beredar di Pasar Ciracas, Jakarta Timur. Uji kualitatif dilakukan menggunakan metode Kromatografi Lapis Tipis (KLT), dengan hasil yang dievaluasi melalui visualisasi bercak dan perbandingan nilai *Retention Factor* (Rf). Hasil KLT terhadap sepuluh sampel jamu pegal linu

menunjukkan bahwa satu sampel (sampel 3) memperlihatkan bercak yang sesuai dengan standar pembandingan deksametason di bawah sinar UV 254 nm. Nilai Rf sampel 3 (0,538) sama dengan nilai Rf standar deksametason. Prosedur pengujian dilanjutkan dengan pemindaian bercak sampel, yang menunjukkan bahwa hanya satu sampel (sampel 3) yang memiliki spektrum kromatogram serupa dengan standar deksametason, sedangkan sampel lainnya tidak menunjukkan kesesuaian tersebut. Identifikasi menggunakan *High Performance Liquid Chromatography* (HPLC) pada panjang gelombang maksimum 254 nm menunjukkan bahwa profil kromatografi sampel 3 sesuai dengan standar deksametason. Hasil ini mengonfirmasi keberadaan deksametason dalam sampel 3. Dengan demikian, disimpulkan bahwa satu dari sepuluh sampel yang diuji mengandung deksametason.

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INTRODUCTION

Traditional medicine refers to substances or concoctions derived from plants, animals, minerals, or a combination thereof, which have been used empirically for generations. To guarantee efficacy and safety, the National Agency of Drug and Food Control (BPOM) categorizes traditional medicines into three levels: Jamu (herbal medicine), Standardized Herbal Medicine (OHT), and Phytopharmaca⁷.

Despite these regulations, the safety of traditional medicines remains a critical concern. To provide rapid therapeutic effects, some packaged Jamu products are illegally mixed with chemical drug additives. While traditional herbal preparations typically exhibit a gradual therapeutic response compared to fast-acting synthetic alternatives, market competition has driven this dangerous practice. To protect the public, BPOM strictly prohibits adding chemical drug additives to traditional medicines. This illegal practice is hazardous because it occurs without controlled dosage measurements. The resulting adverse health effects include stomach ulcers, allergic reactions, hypertension, diabetes, liver and kidney damage, and even death.

According to BPOM Press Release Number HM.01.1.2.12.23.50, monitoring results from September 2022 to October 2023 identified 50 traditional medicine products containing chemical drug additives distributed across Indonesia³. Notably, dexamethasone is one of the chemical drug additive substances most frequently misused in muscle ache remedies (jamu pegal linu). Dexamethasone is a synthetic corticosteroid drug with primary glucocorticoid activity. According to the National Information Center for Drug and Food (PIONAS), it is primarily indicated to treat inflammation, allergic disorders, congenital adrenal hyperplasia, cerebral edema, and rheumatic or ocular diseases. However, its use without proper medical supervision carries a high risk of serious adverse effects, including gastric ulcers, hypersensitivity reactions, hypertension, diabetes mellitus, and hepatorenal damage, with potentially fatal outcomes⁹.

The illicit addition of chemical drug additives to traditional herbal medicine has been documented in previous studies. Research by Purwanitingsih at Cisalak Market in Depok revealed that two out of six samples of jamu pegal linu tested positive for dexamethasone¹⁷. Similarly, Ryansyah detected dexamethasone in all four samples of jamu pegal linu distributed in e-commerce marketplaces²¹. Based on evidence from various regions, this study aims to identify the presence of chemical drug additives in jamu pegal linu distributed in Ciracas Market, helping protect consumers from the risks and harmful side effects associated with dexamethasone.

METHODS

This was a descriptive laboratory study designed to identify and quantify dexamethasone content in jamu pegal linu distributed in Ciracas Market, East Jakarta. Based on reports regarding traditional medicines and health supplements containing illegal chemical drug additives (BKO), 97 brands are suspected of containing dexamethasone². To address the limitations of localized sampling and potential selection bias from a single marketplace, the scope of this study is explicitly framed as an initial exploratory surveillance of high-risk outlets. A purposive sampling method was utilized based on strict criteria: powder or capsule formulations, single-serving packaging, and direct seller recommendations. While the sample size was limited to ten representative products from Ciracas Market as a localized index, this targeted approach captures formulations most frequently associated with illegal dexamethasone adulteration. For laboratory analysis, the study performed a preliminary screening using Thin Layer Chromatography (TLC), followed by confirmatory identification and semi-quantitative/ quantitative evaluation via spectrophotodensitometry. To ensure methodological rigor, analytical validation parameters for the spectrophotodensitometric procedure—including specificity, linearity, limit of detection (LOD), and limit of quantification (LOQ) were established.

Tools and Materials

The tools and materials used in this study were as follows. Tools: aluminum foil, stirring rod, chromatographic chamber, evaporating dish, glass funnel, measuring cylinders (5, 10, and 100 mL), filter paper, silica gel 60 GF 254 TLC plates (20 x 10 cm), Erlenmeyer flask (100 mL), volumetric flasks (25 and 100 mL), Memmert oven, water bath, capillary pipette, pasteur pipette, metal spatula, CAMAG TLC scanner 3 for spectrophotodensitometry, and Mettler Toledo analytical balance. Materials: purified water, acetone, dexamethasone reference standard (purity 1, Indonesian Pharmacopoeia Reference Standard issued by BPOM), diethyl ether, dichloroethane, 96% ethanol, chloroform, methanol (pro-analysis grade), and ten of jamu pegal linu samples.

Research Procedure

1. Qualitative Test using Thin Layer Chromatography (TLC) Method

a. Preparation of the Test Solution

Approximately 500 mg of the jamu pegal linu sample was weighed and transferred into an Erlenmeyer flask. Add 25 mL of 96% ethanol was added, the mixture was shaken for 30 minutes until homogeneous, and it was filtered. The preparation of the test solution was repeated for ten samples.

b. Preparation of the Dexamethasone Standard Solution

Dexamethasone standard solution 0.1%w/v was prepared in methanol (purity 1, Indonesian Pharmacopoeia Reference Standard issued by BPOM). Approximately 100 mg of the dexamethasone reference standard was weighed, transferred into a volumetric flask, dissolve with methanol up to the 100 mL mark, and homogenized.

c. Preparation of the Mobile Phase (Eluent)

The mobile phase mixture used in this study is prepared using a Chloroform : Acetone ratio of 4 : 1.

d. Preparation of the Stationary Phase

The TLC plate (20 x 10 cm) was activated by heating it in an oven for 30 minutes at 110°C. The plate was marked with a pencil at a distance of 1 cm from both the top and bottom edges. The spotting scale for the test solution was set at 1.5 cm intervals.

e. Identification using Thin Layer Chromatography (TLC)

Each solution was spotted separately, and the TLC procedure was performed under the following conditions using stationary phase (silica gel 60 GF 254), mobile phase (Chloroform : Acetone ratio of 4 : 1), chamber the sample was saturated for 20 minutes using filter paper, development distance at 10 cm, spotting volume 5 µL, spot visualization (UV light at 254 nm). The sample labels STD1, STD2, and STD3 represent the dexamethasone standards, while S1 through S10 represent the jamu pegal linu samples.

The Retention Factor (Rf) was calculated using the following formula:

$$Rf = \frac{\text{distance traveled by the compound from the spotting origin to the center of the spot}}{\text{distance traveled by the mobile phase from the spotting origin to the solvent front}}$$

2. Spectrophotodensitometry Method

Following the TLC identification, sample spots that aligned with and exhibited the same Rf value as the reference standard were presumed to contain dexamethasone. Confirmatory testing was then conducted by scanning the spots to obtain chromatogram spectra using a spectrophotodensitometer at a wavelength of 254 nm and a scanning speed of 20 mm/s to obtain their chromatogram spectra.

Data Identification Criteria

A positive result is defined by a Thin Layer Chromatography (TLC) test showing spots that align with the reference standard (indicating suspected dexamethasone), and a confirmatory spectrophotodensitometry test showing an matching spectrum to the standard.

RESULT AND DISCUSSION

1. Qualitative Analysis of Dexamethasone

The Thin Layer Chromatography (TLC) analysis of the sample against a dexamethasone standard was conducted using a silica gel 60 GF 254 stationary phase and a mixture of Chloroform : Acetone (4:1) as the mobile phase.

The formula for calculating the Rf value is as follows:

$$Rf = \frac{\text{distance traveled by the compound from the spotting origin to the center of the spot}}{\text{distance traveled by the mobile phase from the spotting origin to the solvent front}}$$

Table 1. Rf Values of Dexamethasone Standard and Jamu Pegal Linu Samples

No.	Sample	Distance of the spot (cm)	Distance of the solvent front (cm)	Rf value
1	STD1	3.500	6.500	0.538
2	S1	-	-	-
3	S2	-	-	-
4	S3	3.500	6.500	0.538
5	STD2	3.500	6.500	0.538
6	S4	-	-	-
7	S5	-	-	-
8	S6	-	-	-
9	S7	-	-	-
10	S8	-	-	-
11	S9	-	-	-
12	S10	-	-	-
13	STD3	3.500	6.500	0.538

Information:

STD1, STD2, STD3 : dexamethasone standard

S1, S2, S3, S4, S5, S6, S7, S8, S9, S10 : jamu pegal linu samples

Based on the results presented in the table above, Sample 3 was presumptively positive because its R_f matched the dexamethasone standard under the specified chromatographic conditions. This is supported by the test results, which indicate that the sample has the same R_f value (0.538) as the dexamethasone standard.

TLC Chromatogram Visualized under UV Light at 254 nm
(Stationary Phase Silica Gel 60 GF 254; Mobile Phase Chloroform : Acetone (4:1))

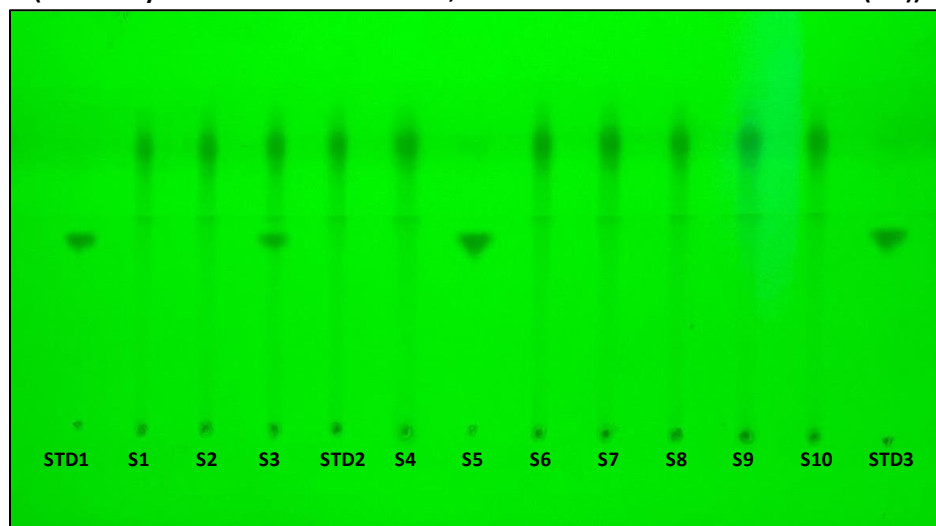


Figure 1. TLC Chromatogram Visualized under UV Light at 254 nm
(Stationary Phase Silica Gel 60 GF 254; Mobile Phase Chloroform : Acetone (4:1))

Information:

STD1, STD2, STD3 : dexamethasone standard
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10 : jamu pegal linu samples

Furthermore, as shown in the TLC plate image, UV light visualization at 254 nm demonstrated that Sample 3 exhibited a matching R_f and spot position to those of the dexamethasone standard. This finding was further confirmed by spectrophotodensitometry evidence. Therefore, Sample 3 is concluded to be positive for dexamethasone.

This finding aligns with a study by Purwanitningsih & Ryansyah on monitoring adulterated products, which frequently detected dexamethasone as a hidden ingredient due to its potent anti-inflammatory effects^{17,21}. From a regulatory perspective, the presence of dexamethasone in this sample constitutes a severe violation, as BPOM strictly mandate a zero-tolerance policy for prescription-only synthetic corticosteroids in over-the-counter commercial products.

2. Spectrophotodensitometry as a Confirmation Test of Dexamethasone

Following the separation by TLC, the process was continued with spot scanning to determine the chromatogram profile of each spot that was aligned or had a similar R_f value to the dexamethasone standard.

Spectrophotodensitometry profiles of separated chromatographic spots
The scanning profiles display spots with R_f values corresponding or close to the reference standard

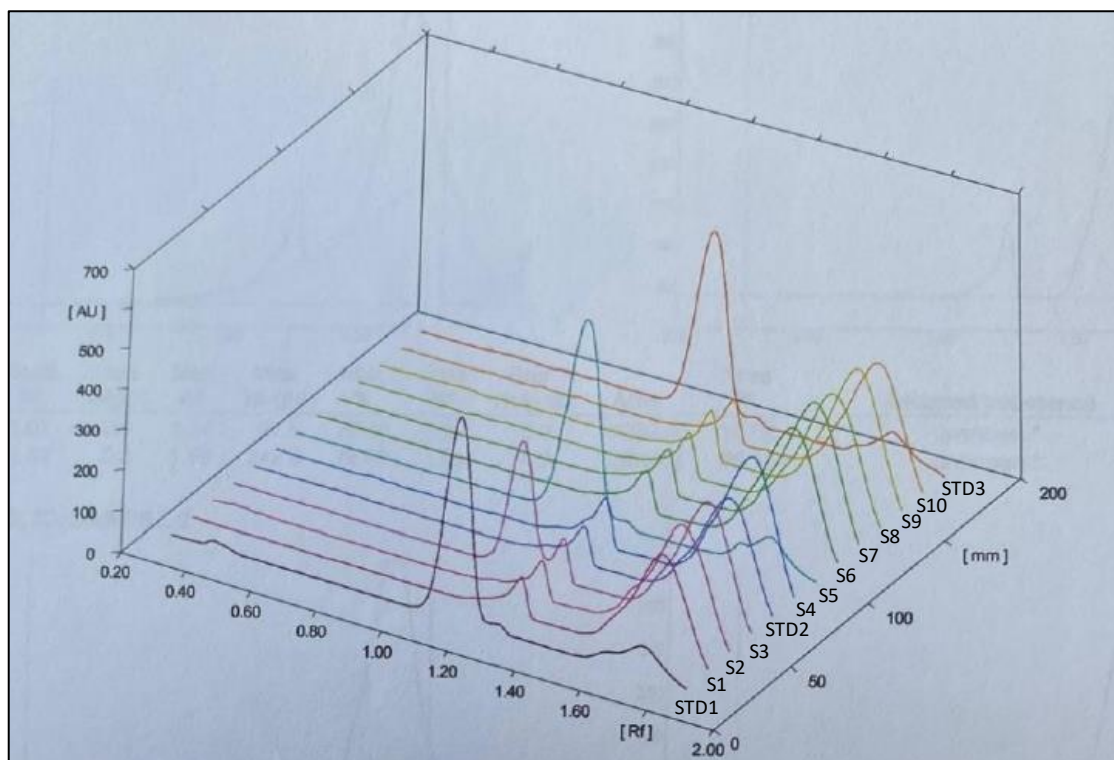


Figure 2. Spectrophotodensitometry profiles of separated chromatographic spots. The scanning profiles display spots with Rf values corresponding or close to the reference standard.

Information:

STD1, STD2, STD3 : dexamethasone standard

S1, S2, S3, S4, S5, S6, S7, S8, S9, S10 : jamu pegal linu samples

Based on the scanning results of all sample spots, Sample 3 showed a peak λ_{max} and spectral overlay consistent with the dexamethasone standard within the allowed Rf tolerance, while the other samples did not meet these identification criteria.

UV spectral overlay of all sample spots and the dexamethasone standard

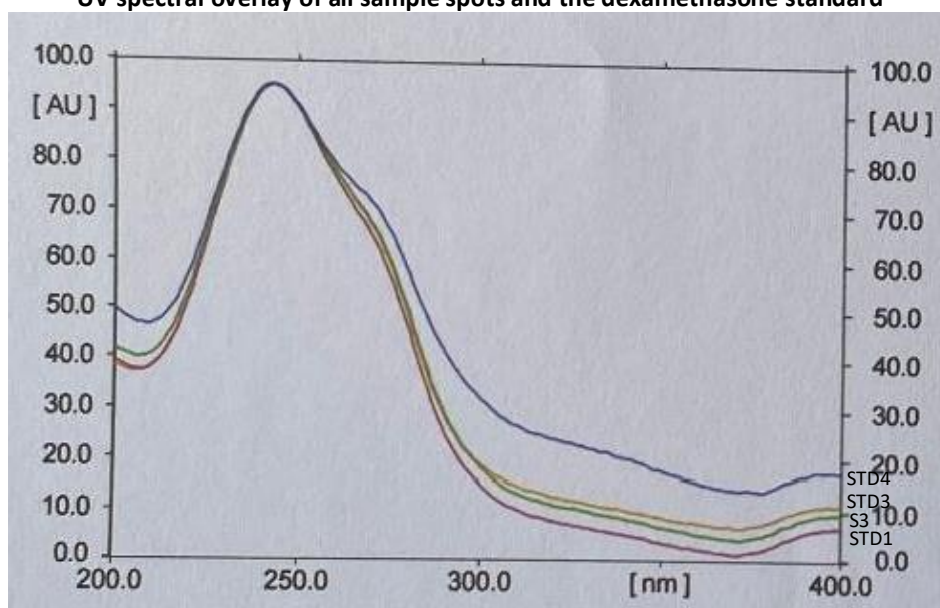


Figure 3. UV spectral overlay of all sample spots and the dexamethasone standard

Information:

STD1, STD2, STD3 : dexamethasone standard
 S3 : jamu pegal linu samples

Furthermore, visual inspection under UV light at 254 nm confirmed that the spot migration and appearance of Sample 3 matched the dexamethasone standard. This indicated that Sample 3 showed a profile consistent with dexamethasone. Thus, it can be concluded that one out of the ten samples studied (10%) was detected to contain dexamethasone under the applied analytical conditions.

The detection of dexamethasone in 10% of the surveyed samples poses significant risks regarding potential consumer exposure levels. Because consumers often take these products daily without professional medical supervision, they are vulnerable to uncontrolled chronic exposure. Such unregulated intake can lead to severe health risks, including adrenal suppression, metabolic disturbances (like Cushing's syndrome), osteoporosis, and compromised immune responses. Compared to similar surveillance studies conducted in neighboring regions where adulteration rates often fluctuate between 5% and 15%, this 10% positivity rate highlights a persistent public health challenge and underscores the urgent need for stricter market enforcement and routine post-market screening.

Limitation

This study has several limitations. First, the sample size was limited to ten samples collected exclusively from a single location, Ciracas Market, which may not represent the broader market of jamu pegal linu products, thereby limiting the generalizability of the findings regarding consumer exposure levels. Second, the analytical methods focused solely on the detection and identification of dexamethasone; consequently, other potential chemical drug additives commonly added to traditional medicines were not investigated. Lastly, this study was qualitative in nature, utilizing Thin Layer Chromatography (TLC) and spectrophotodensitometry for confirmation. While a qualitative positive result is sufficient to confirm a violation of the zero-tolerance policy for synthetic drugs set by the National Agency of Drug and Food Control (BPOM), the lack of quantification prevents an exact calculation of the adulterant's concentration. Consequently, this introduces methodological uncertainties regarding the precise magnitude of consumer exposure and limits the ability to assess the specific severity of acute or chronic health risks associated with the contaminated samples.

CONCLUSION

Of the ten jamu pegal linu samples distributed at Ciracas Market, one sample (Sample 3) tested positive for dexamethasone based on Thin Layer Chromatography (TLC) screening and spectrophotodensitometry confirmation.

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AUTHOR CONTRIBUTION STATEMENT

WKS: Writing – reviewing & editing, PI: Writing – reviewing & editing, DA: Writing – original draft.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

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Formulation and Evaluation of Antibacterial Activity of Roll-On Deodorant Based on Arab Jujube Leaf Extract (*Ziziphus spina-christi* L.) against *Staphylococcus epidermidis*

Formulasi dan Evaluasi Aktivitas Antibakteri Deodoran Roll-On Berbasis Ekstrak Daun Bidara Arab (*Ziziphus spina-christi* L.) terhadap *Staphylococcus epidermidis*

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Abstract

This study aimed to develop a roll-on deodorant formulation based on Arab jujube leaf extract (*Ziziphus spina-christi* L.) and to evaluate its antibacterial activity against *Staphylococcus epidermidis*. The research methods included extraction of Arab jujube leaves using 70% ethanol, phytochemical screening to identify secondary metabolites, formulation of roll-on deodorant with varying extract concentrations, and evaluation of physical characteristics and antibacterial activity using the disc diffusion method. The results showed that the extract contained flavonoids, alkaloids, and saponins, which contribute to antibacterial effects. The formulation with the highest extract concentration produced the largest inhibition zone against *Staphylococcus epidermidis*, while maintaining stable and user-friendly physical properties. In conclusion, Arab jujube leaf extract is effective as a natural active ingredient in roll-on deodorants, providing an alternative herbal-based cosmetic product that is safe and efficient.

Abstrak

Penelitian ini bertujuan untuk mengembangkan formulasi deodoran roll-on berbahan dasar ekstrak daun bidara Arab (*Ziziphus spina-christi* L.) serta mengevaluasi aktivitas antibakterinya terhadap *Staphylococcus epidermidis*. Metode penelitian meliputi ekstraksi daun bidara Arab menggunakan etanol 70%, skrining fitokimia untuk mengidentifikasi kandungan metabolit sekunder, formulasi deodoran roll-on dengan variasi konsentrasi ekstrak, serta pengujian karakteristik fisik dan aktivitas antibakteri menggunakan metode difusi cakram. Hasil penelitian menunjukkan bahwa ekstrak daun bidara Arab mengandung senyawa flavonoid, alkaloid, dan saponin yang berperan dalam aktivitas antibakteri. Formulasi dengan konsentrasi ekstrak tertinggi menghasilkan zona hambat terbesar terhadap *Staphylococcus epidermidis* dengan tetap mempertahankan karakteristik fisik yang stabil dan nyaman digunakan. Berdasarkan hasil tersebut, ekstrak daun bidara Arab berpotensi dimanfaatkan sebagai bahan aktif alami dalam sediaan deodoran roll-on serta menjadi alternatif produk kosmetik berbasis herbal yang efektif dan aman.

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INTRODUCTION

Body odor is one of the most common personal care problems in society. It is caused by the interaction between excessive sweat and microorganisms on the skin, particularly *Staphylococcus epidermidis* bacteria.¹ The activity of eccrine and apocrine glands in the skin, especially in the underarm area, can produce high levels of moisture that create

ideal conditions for microbial growth. If not properly controlled, excessive sweat production may lead to the accumulation of bacterial metabolites that contribute to body odor and user discomfort. This condition often causes psychological distress, decreased self-confidence, and impaired social interaction. Therefore, addressing body odor through the use of topical preparations, such as deodorants, is an important strategy in daily personal hygiene.²

Deodorant is a cosmetic product designed to reduce or mask body odor by inhibiting microbial growth and decreasing sweat gland activity. This product can be formulated using either synthetic or herbal ingredients.³ Herbal ingredients have become increasingly popular because they are considered safe for the skin, environmentally friendly, and often contain bioactive compounds with additional functions, such as antioxidant and antibacterial activities.⁴ One promising herbal plant as an active ingredient in deodorant is Arabian bidara leaves (*Ziziphus spina-christi* L.), which have been widely recognized in traditional medicine in various countries, including Indonesia, India, and Malaysia, for treating skin diseases, diarrhea, fever, and beauty-related concerns.⁴

Arabian bidara leaves contain various secondary metabolite compounds, such as flavonoids, saponins, alkaloids, tannins, and terpenoids, which have antibacterial and antioxidant potential.⁵ These compounds are known to inhibit the growth of *Staphylococcus epidermidis*, one of the dominant bacteria found on human skin and frequently associated with body odor.⁶ Previous studies have shown that Arabian bidara leaf extract, both with 96% ethanol as a solvent and through maceration methods, can form inhibition zones against *S. epidermidis* at certain concentrations. However, its effectiveness varies depending on the dosage form, concentration, and testing method used.⁷

Although previous studies have demonstrated the antibacterial potential of Arabian bidara leaves, most of them have used dosage forms such as paper soap or ointment.⁸ The development of deodorant formulations, particularly in roll-on form, remains limited. Roll-on deodorant has advantages in the form of compact packaging that facilitates direct application to the skin, reduces the risk of spillage, and allows more precise dose regulation.⁹ In addition, the more fluid physical characteristics of roll-on deodorant enable even distribution, making it more comfortable to use while reducing sweat secretion and effectively inhibiting bacterial growth.¹⁰

The novelty of this study lies in the use of 70% ethanol as a solvent for extracting Arabian bidara leaves, which is more polar than 96% ethanol. A more polar solvent is capable of extracting more complex and diverse bioactive compounds while minimizing the risk of irritation on sensitive skin. This is important because deodorant products are applied directly to the underarm area, where the skin is relatively thin and prone to irritation.¹¹ Furthermore, this study evaluates formulations with different extract concentration variations, thereby allowing the identification of the optimal concentration that is effective as an antibacterial agent without reducing user comfort.¹²

This study also considers the safety and physical quality aspects of the preparation. Evaluation of organoleptic properties, pH, homogeneity, viscosity, and spreadability is an important indicator in determining whether the product is suitable for use and safe for human skin.¹³ Optimal physical characteristics not only influence user comfort but may also affect antibacterial effectiveness, since uneven distribution of the active ingredient can reduce inhibitory activity against bacteria.¹⁴ Thus, this study is designed to produce a roll-on deodorant preparation based on Arabian bidara leaves that is not only antibacterial in effectiveness but also safe and comfortable to use.¹⁵

Overall, this study has two main objectives: (1) to explore the antibacterial potential of Arabian bidara leaves against *Staphylococcus epidermidis*; and (2) to develop a roll-on deodorant preparation that is stable, safe, and effective. This study is expected to provide a scientific contribution to the development of herbal cosmetics, as well as to offer an alternative personal care product based on natural ingredients that is environmentally friendly and has minimal side effects. Through this study, the public may also gain greater awareness of the benefits of Arabian bidara leaves in the form of an easy-to-apply cosmetic preparation, thereby supporting healthier and safer personal hygiene practices.¹⁶

METHODS

Materials. This study used a set of standard laboratory instruments for the formulation and evaluation of deodorant preparations, including an analytical balance (Shimadzu, Japan), a pH meter (Hanna Instruments, model HI991001), a water bath (Mettler, Germany), a rotary evaporator (Buchi, Switzerland), an autoclave (Sanyo, Japan), dropper pipettes (Eppendorf, Germany), a glass mortar and pestle, and an Ostwald viscometer. The materials used included Arabian bidara leaf extract (*Ziziphus spina-christi* L.), carbopol, triethanolamine, propylene glycol, distilled water, fragrance, and a bacterial culture medium for *Staphylococcus epidermidis* in the form of Mueller Hinton Agar (MHA). All chemical materials were obtained from a standardized laboratory at the Mathematics and Natural Sciences

Laboratory Unit, UIN Siber Syekh Nurjati Cirebon, as attached on the final page, and were used in accordance with laboratory safety protocols.

Research Procedure. This study was designed as an experimental study focusing on the formulation and evaluation of a roll-on deodorant preparation based on Arabian bidara leaf extract, as well as the antibacterial activity test against *Staphylococcus epidermidis*. The research procedure consisted of the following stages:

Collection and Preparation of Simplicia

Arabian bidara leaves were collected from Klagenan Village, Klagenan District, Cirebon Regency, with a total weight of approximately 10 kg. The collected leaves were subjected to wet sorting to remove foreign particles, such as soil and small insects, and were then dried under sunlight for 2 to 3 days. After drying, the leaves were ground into powder and sieved using a 60-mesh sieve to obtain homogeneous simplicia.

Preparation of the Extract

A total of 500 g of simplicia powder was macerated with 2,500 mL of 70% ethanol in a closed glass container for 3 × 24 hours, with occasional stirring. The solution was filtered using filter paper, after which the solvent was evaporated using a rotary evaporator at 50°C to obtain a thick extract. The extract yield was calculated using the following equation:

$$\text{Yield (\%)} = \frac{\text{Extract Weight}}{\text{Simplicia Weight}} \times 100\%$$

Phytochemical Screening

The extract was tested for the presence of secondary metabolite compounds, including flavonoids, alkaloids, saponins, tannins, and terpenoids, using standard color reaction and precipitation methods.¹⁷

Formulation of the Roll-On Deodorant Preparation

Arabian bidara leaf extract was formulated into a roll-on preparation with three different concentrations: F1 (5 g), F2 (15 g), and F3 (20 g). The thickening agent, namely carbopol, the pH neutralizer, namely triethanolamine, the solvents, namely propylene glycol and distilled water, and fragrance were added according to the formulation procedure. The mixture was stirred until homogeneous and then transferred into roll-on containers.

Table 1. Formulation of the Roll-On Deodorant Preparation

No.	Formulation	Function	Control	F1	F2	F3
1	Arabian bidara leaf extract	Active ingredient	(-)	5 g	15 g	20 g
2	Carbopol	Thickening agent	1 g	1 g	1 g	1 g
3	Triethanolamine	pH neutralizer	0.25 g	0.25 g	0.25 g	0.25 g
4	Propylene glycol	Solvent	15 g	15 g	15 g	15 g
5	Distilled water	Solvent	q.s. ad 100	q.s. ad 100	q.s. ad 100	q.s. ad 100

Evaluation of the Preparation

The preparation was evaluated for its organoleptic properties, including color, odor, and physical form, as well as pH, homogeneity, viscosity, and spreadability in accordance with cosmetic preparation standards. The organoleptic test was conducted through visual and sensory observation. The pH was measured using a pH meter, homogeneity was observed on a glass slide, viscosity was measured using an Ostwald viscometer, and spreadability was tested using the graded-load method on a Petri dish.¹⁸

Antibacterial Activity Test

The antibacterial activity test was conducted using the disk diffusion method against *Staphylococcus epidermidis*. The bacterial suspension was prepared according to the McFarland standard and inoculated onto Mueller Hinton Agar (MHA) medium. Paper disks that had been soaked in the deodorant extract were then placed on the surface of the medium. Incubation was carried out for 24 hours at 37°C, and the inhibition zones were measured vertically and horizontally.¹⁹ After incubation, the inhibition zones formed were measured using a vernier caliper in vertical (Dv) and horizontal (DH) directions. The disk diameter (Dc) was subtracted from the measurement results, and the mean inhibition zone was calculated using the following equation:

$$\text{Inhibition zone} = \frac{(\text{DV} - \text{Dc}) + (\text{DH} - \text{DC})}{2}$$

Notes:

DC: Disk diameter

DV: Vertical diameter of the inhibition zone

DH: Horizontal diameter of the inhibition zone

Data Analysis

The data obtained from the preparation evaluation, including pH, viscosity, spreadability, and antibacterial inhibition zones, were analyzed descriptively. The mean values and standard deviations were calculated from three replications for each parameter. The interpretation of the results focused on the effectiveness of the preparation in inhibiting the growth of *S. epidermidis*, its physical stability, and the relationship between extract concentration and antibacterial activity. These results were used to determine the optimal formulation of the Arabian bidara leaf-based roll-on deodorant.

RESULT AND DISCUSSION

Extract Yield of Arabian Bidara Leaves

The extraction of Arabian bidara leaves using 70% ethanol produced a yield of 15.2%, indicating that 76 g of thick extract was obtained from 500 g of simplicia. This yield reflects the efficiency of the maceration method in extracting polar and semi-polar compounds with potential antibacterial activity.²⁰

The yield value was relatively high compared with previous studies using 96% ethanol, indicating that 70% ethanol was able to extract a greater amount of bioactive compounds and was more skin-friendly. This finding supports the objective of the study, namely to obtain a deodorant preparation that is safe and effective.²¹

Phytochemical Screening

The extract was tested for the presence of secondary metabolites. The screening results are presented in Table 2.

Table 2. Phytochemical screening results of Arabian bidara leaf extract

Compound	Result	Conclusion
Flavonoids	Positive	Supports antibacterial activity
Alkaloids	Positive	Supports antibacterial activity
Saponins	Positive	Supports antibacterial activity
Tannins	Negative	Not detected
Terpenoids	Negative	Not detected

The presence of flavonoids, alkaloids, and saponins supports the antibacterial potential of the extract, in accordance with the target of developing a roll-on deodorant preparation. These compounds may work by damaging bacterial cell membranes or inhibiting bacterial metabolism.²²

Formulation of the Roll-On Deodorant Preparation

The evaluation was conducted on four formulas, namely F0 as the control, F1, F2, and F3. The most significant results were shown in three main parameters: pH, viscosity, and spreadability.

Evaluation of the Roll-On Deodorant Preparation

The evaluation was conducted on four formulas, namely F0 as the control, F1, F2, and F3. The most significant results were shown in three main parameters: pH, viscosity, and spreadability.

Table 3. Evaluation of pH, viscosity, and spreadability of the preparation

Formula	pH	Viscosity (P)	Spreadability (cm)
F0	4.73	38.37	6.6
F1	5.14	14.70	6.83
F2	4.86	2.21	6.73
F3	4.97	1.80	6.93

Notes:

1. The pH of the preparations was within the safe range for the skin, namely 4.5 to 5.5, thereby reducing the risk of irritation.
2. Viscosity decreased as the extract concentration increased, resulting in a more fluid preparation in F2 and F3, which may influence spreadability.
3. F3 showed the highest spreadability, indicating that a higher extract concentration improved the ability of the preparation to spread on the skin.

Antibacterial Activity Test

The inhibition zones against *Staphylococcus epidermidis* are presented in Table 4.

Table 4. Antibacterial inhibition zones of the roll-on deodorant preparation

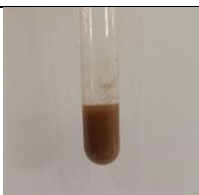
Formula	Replication 1 (mm)	Replication 2 (mm)	Replication 3 (mm)	Mean inhibition zone (mm)
F0	0	0	0	0
F1	6.2	8.2	8.6	7.2
F2	7.8	10.85	10.05	9.5
F3	8.8	11.1	13.05	10.9
Positive control	5.95	5.65	6.25	5.95

Notes:

1. F3, with the highest extract concentration, demonstrated the best antibacterial activity, even exceeding the positive control.
2. The inhibition zone increased with increasing extract concentration, indicating a dose-response relationship.
3. These results indicate the potential of Arabian bidara leaf extract as a natural active ingredient for antibacterial deodorant products.

Phytochemical Screening Results of Arabian Bidara Leaf Extract

Table 5. Secondary metabolite compounds

Phytochemical compound	Criterion	Observation result	Conclusion
Flavonoids	A yellow color was formed without ring formation		Positive
Alkaloids	An orange-brown precipitate was formed		Positive
Saponins	Foam was formed		Positive
Tannins	A bluish-black precipitate was formed		Positive

Terpenoids	A brown ring was formed between the two liquid layers		Positive
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Notes:

1. The extract showed positive results for flavonoids, alkaloids, and saponins, which support its antibacterial potential against *Staphylococcus epidermidis* and its antioxidant activity.
2. Tannins and terpenoids were negative, possibly due to degradation during drying, exposure to heat or light, the limited sensitivity of the test method, or low compound levels resulting from the age of the leaves at the time of sample collection.
3. The characteristic odor of Arabian bidara leaves confirmed the authenticity of the sample.
4. Overall, this phytochemical profile supports the use of Arabian bidara leaf extract as an active ingredient in roll-on deodorant formulations, with sufficient bioactive compound content to provide antibacterial and antioxidant effects.

Limitation

This study has several limitations that should be considered when interpreting the findings. The antibacterial activity test was limited to *Staphylococcus epidermidis*, although body odor may also involve other microorganisms; therefore, the antibacterial effectiveness of the formulation cannot be generalized to all bacteria associated with body odor formation. In addition, the antibacterial test was conducted using the disk diffusion method under in vitro laboratory conditions, which does not fully represent actual underarm skin conditions, where sweat production, skin temperature, friction, skin microbiota balance, and product contact duration may influence deodorant performance. This study also evaluated only selected physical characteristics of the roll-on deodorant preparation, including organoleptic properties, pH, homogeneity, viscosity, and spreadability, without conducting long-term stability testing, accelerated stability testing, storage stability testing, microbial contamination testing, irritation testing, or user acceptability assessment. Furthermore, the extract was not standardized based on the quantitative levels of its active compounds, since phytochemical screening only provided qualitative information on the presence of secondary metabolites such as flavonoids, alkaloids, and saponins. The plant material was also obtained from one specific location, namely Klenganan Village, Cirebon Regency, so variations in soil condition, climate, leaf maturity, harvesting time, and drying process may influence the chemical composition of the extract. Despite these limitations, this study provides preliminary evidence that Arabian bidara leaf extract has potential as a natural active ingredient in roll-on deodorant formulations, although further studies involving broader antibacterial testing, standardized extraction, long-term stability evaluation, irritation testing, and user acceptability assessment are needed to support its development as a safe and effective herbal cosmetic product.

CONCLUSION

This study demonstrates that Arabian bidara leaf extract can be formulated into a roll-on deodorant with stable physical characteristics and good user comfort. The formulation with the highest extract concentration produced the most effective antibacterial activity against *Staphylococcus epidermidis*. These findings support the hypothesis that Arabian bidara leaf extract can serve as a natural active ingredient in a deodorant preparation that is safe and effective.

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Author Contribution Statement

The author was responsible for the conceptualization of the study, research design, preparation of plant materials, extraction process, formulation of the roll-on deodorant preparation, laboratory evaluation, antibacterial activity testing, data analysis, and manuscript preparation. The academic supervisors contributed to research guidance, methodological supervision, critical review, and revision of the manuscript to ensure scientific accuracy and academic quality.

Conflict of Interest Declaration

The author declares that there is no conflict of interest related to this research. The study was conducted objectively, and no financial, personal, institutional, or commercial interests influenced the research design, data collection, analysis, interpretation, or manuscript preparation.

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The Relationship Between Education Level and Public Knowledge of DAGUSIBU in RW 02, Rambutan Village, East Jakarta

Hubungan antara Tingkat Pendidikan dan Tingkat Pengetahuan Masyarakat mengenai Dagusibu (Dapatkan, Gunakan, Simpan, Buang) di RW 02, Kelurahan Rambutan, Jakarta Timur

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Abstract

DAGUSIBU knowledge itself can be obtained from various sources, one of which is education, where the higher a person's education, the higher the level of expertise they have. This study aimed to the relationship between education level and public knowledge level regarding DAGUSIBU in RW 02, Rambutan Village, East Jakarta.

The population in this study was the entire community in RW 02, Rambutan Village, East Jakarta. The sample was calculated using the Slovin formula. The sampling technique used a simple random sampling approach. The data obtained were analyzed with SPSS with the Chi-Square method. If the *p*-value is less than 0.05, it is judged as "significant," and if the *p*-value is greater than 0.05, it is judged as "not significant. Before distributing the questionnaire, the questionnaire was tested through validity and reliability testing. Hypothesis: There is a significant positive impact of education level on a level of knowledge regarding DAGUSIBU (Get, Use, Save, Dispose).

The results showed that the level of knowledge regarding DAGUSIBU in RW 02, Rambutan Village, was good for 20.9% of respondents, poor for 30.7% of respondents, while 48.4% possessed adequate knowledge. There was a significant correlation between education level and public knowledge about DAGUSIBU, with a *p*-value of 0.05. It can be concluded that the higher education level was associated with higher knowledge about the correct use of medication. Therefore, public education about DAGUSIBU is crucial to reduce the risk of medication errors

Abstrak

Pengetahuan mengenai DAGUSIBU dapat diperoleh dari berbagai sumber, salah satunya adalah pendidikan; semakin tinggi tingkat pendidikan seseorang, semakin tinggi pula tingkat keahlian yang dimilikinya. Penelitian ini bertujuan untuk mengetahui hubungan antara tingkat pendidikan dan tingkat pengetahuan masyarakat mengenai DAGUSIBU di RW 02, Kelurahan Rambutan, Jakarta Timur.

Populasi dalam penelitian ini adalah seluruh warga di RW 02, Kelurahan Rambutan, Jakarta Timur. Ukuran sampel dihitung menggunakan rumus Slovin, dan teknik pengambilan sampel yang digunakan adalah simple random sampling. Data yang diperoleh dianalisis menggunakan perangkat lunak IBM SPSS Statistic Version 22 dengan metode *Chi-Square*.

Hasil dinyatakan "signifikan" jika nilai *p* kurang dari 0,05, dan "tidak signifikan" jika nilai *p* lebih dari 0,05. Sebelum disebarkan, kuesioner telah melalui uji validitas dan reliabilitas. Hipotesis penelitian menyatakan bahwa terdapat pengaruh positif yang signifikan dari tingkat pendidikan terhadap tingkat pengetahuan mengenai

DAGUSIBU (Dapatkan, Gunakan, Simpan, Buang). Hasil penelitian menunjukkan bahwa tingkat pengetahuan mengenai DAGUSIBU di RW 02, Kelurahan Rambutan, tergolong baik 20.9% responden, kurang pada 30,7% responden, sementara 48,4% responden memiliki pengetahuan yang cukup Terdapat korelasi yang signifikan antara tingkat pendidikan dan pengetahuan masyarakat mengenai DAGUSIBU, dengan nilai p sebesar 0,05. Dapat disimpulkan bahwa tingkat pendidikan yang lebih tinggi berkaitan dengan pengetahuan yang lebih baik mengenai penggunaan obat yang tepat. Oleh karena itu, edukasi masyarakat mengenai DAGUSIBU sangat penting untuk mengurangi risiko kesalahan penggunaan obat

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INTRODUCTION

DAGUSIBU (Get, Use, Save, Dispose) is an educational program initiated by the Indonesian Pharmacists Association to enhance public literacy regarding the safe use of medicines. In Indonesia, the implementation of DAGUSIBU is crucial, considering that many people still use medicines without prescriptions, store them improperly, or dispose of expired medicines carelessly, posing risks to both health and the environment. This lack of understanding is influenced by limited access to information, insufficient education in healthcare facilities, and the common habit of sharing medicines among family members or neighbors. The implementation of DAGUSIBU in Indonesia represents a strategic effort to build collective awareness of the importance of rational, safe, and responsible medicine use.¹

The 2018 Basic Health Research indicates the following breakdown of household perceptions regarding ease of access to hospitals: easy (37.1%), difficult (36.9%), and very difficult (26%).² However, Previous research indicates that irrational medication use persists, as evidenced by the inappropriate administration of antibiotics relative to standard therapy.³ Research conducted in Bandung City—specifically in the Babakan Sari Urban Village—indicates that residents' practices regarding medication storage remain inadequate.⁴ Improper medication storage (including storage in humid or hot environments), irrational medication use, and resource wastage can lead to medication misuse.⁵

Based on a quantitative study regarding the baseline knowledge of DAGUSIBU within the Solok Urban Village population in Jambi. Utilizing a sample size of 30 respondents, the study indicated that 20 individuals (66.7%) fell into the poor knowledge category, whereas 10 individuals (33.3%) maintained an adequate understanding. Notably, no respondents exhibited a good level of knowledge, indicating that local pharmaceutical education frameworks require optimization.⁶

Public knowledge regarding medication use is often inadequate, leading to improper practices influenced by advertisements or advice from friends, family, and neighbors. These practices highlight the importance of the "Dagusibu" (Get, Use, Save, Dispose) guidelines, a public health initiative whose awareness is significantly influenced by demographic factors such as age, gender, education, occupation, and income. To evaluate and improve adherence to these guidelines, researchers can administer surveys and questionnaires within the community. Ultimately, assessing and enhancing this public knowledge is essential to ensuring the health, well-being, and overall quality of life of the local population.⁷

Based on the data above, this research aims to determine the relationship between education level and community knowledge regarding DAGUSIBU in Rambutan Village.

METHODS

This DAGUSIBU study employs a cross-sectional design and quantitative method to assess the level of public knowledge regarding the DAGUSIBU program. The tools and materials used in this research include writing instruments and questionnaires; the research materials consist of questions addressing aspects of knowledge concerning the DAGUSIBU program. The respondents were residents of RW 02, Rambutan Village, East Jakarta. Data collection was conducted in May 2025 by distributing questionnaires to 316 respondents. The target population consisted of Rambutan Village residents, specifically focusing on individuals aged 18 to 65 years. This age group was selected to represent the productive population, assuming that minors may lack the cognitive capacity to fully comprehend the DAGUSIBU protocols.⁸

DATA ANALYSIS

Data analysis was carried out in two stages:

1. Instrument Validity and Reliability Testing.

The research instrument was tested for validity using item validity through the Corrected Item-Total Correlation technique in SPSS, where an item is considered valid if the correlation coefficient is significant at the 0.05 level or exceeds the minimum correlation threshold. Subsequently, a reliability test was conducted using the Cronbach's Alpha method to ensure instrument consistency, where a value of ≥ 0.7 indicates acceptable reliability, and a value of > 0.8 reflects good reliability.⁹

2. Data Analysis

Quantitative data were collected by distributing questionnaires to respondents. The resulting data were analyzed using IBM SPSS Statistics version 22, and the quantitative findings were further reinforced through integration with the chi-square method.¹⁰ Levels of knowledge are classified into the categories of good (76–100%), sufficient (56–75%), and poor ($< 56\%$).¹¹

RESULT AND DISCUSSION

Validity Test Result

The validity test in this study utilized a sample of 20 respondents and 14 questionnaire items. Validity testing was conducted using IBM SPSS Statistic version 22 based on the Pearson Product-Moment method; the calculated value (r -count) was compared against the critical value from the Pearson Product-Moment table (r -table), and the questionnaire was deemed valid if r -count exceeded 0.4438.¹²

Reliability Test Results

The reliability test utilized Cronbach's Alpha; a construct or variable is considered reliable if it yields a Cronbach's Alpha value greater than 0.6, indicating that the instrument used is reliable.¹³

Respondent Characteristics

In this study, the characteristics of respondents examined, related to gender, age, occupation, and education, are shown in Table 1 below:

Table 1. Respondent Characteristics

Variable	Number of Samples (N)	Percentage (%)
Gender		
Male	135	42.7%
Female	181	57.3%
Age		
18-25 years	52	16.5%
26-35 years	81	25.6%
36-45 years	84	26.6%
46-55 years	66	20.9%
56-65 years	33	10.4%
Employment Status		
Civil/private employee	149	47.2%
Entrepreneur	50	15.8%
Housewife	87	27.5%
Student	3	0.9%
Unemployed	27	8.5%
Education		
Elementary School	28	8.9%
Junior High School/Islamic	40	12.7%
Junior High School		
Senior High School	186	58.9%
University	62	19.6%

Responses to the DAGUSIBU knowledge items are presented in Table 2:

Table 2. Respondents' Knowledge Level about DAGUSIBU Medication

No	Question	Score Answer Value			
		Correct (N)	Correct (%)	Incorrect (N)	Incorrect (%)
1	Do you know the abbreviation DAGUSIBU?	44	13.9	272	86.1
2	Is a Pharmacy the right place to get medication?	306	96.8	10	3.2
3	Should prescription medications from a private doctor be obtained from a pharmacy?	269	85.1	47	14.9
4	Do you pay attention to the expiration date printed on the medication packaging?	261	82.6	55	17.4
5	Do you know that antibiotics should be taken until they are finished?	292	92.4	24	7.6
6	Do you use liquid/solution medication according to the dosage on the spoon?	246	77.8	70	22.2
7	Do you know how to properly store medication at home?	231	73.1	85	26.9
8	Do you store syrup medication in the refrigerator?	143	45.3	173	54.7
9	Do you store liquid/solution medication in its original packaging and tightly closed container?	273	86.4	43	13.6

10	Do you know that exposure to direct sunlight can cause medication to deteriorate?	244	77.2	72	22.8
11	Do you still keep medication that has changed shape, color, or taste?	220	69.6	96	30.4
12	Do you dispose of medication directly without first destroying the medication and packaging?	97	30.7	219	69.3
13	Do you dispose of tablets, capsules, and suppositories by crushing them and burying them in the ground?	43	13.6	273	86.4
14	Do you destroy medication by throwing it directly into the trash?	46	14.6	270	85.4

Research results regarding gender indicate that the majority of respondents were female, totaling 181 individuals (57.3%). This aligns with the findings of Pristiyantoro and Fadillah (2020), who noted that 71.2% (274 individuals) of their total respondents were female. The high proportion of women in the samples of both studies is thought to be linked to traditional gender roles in society, wherein women—or housewives—are often responsible for managing health and meeting the family's medication needs at home.¹⁴ To date, existing literature remains inconclusive regarding the cognitive or knowledge-based disparities between genders. In practice, while females frequently demonstrate higher levels of diligence, meticulousness, and perseverance when executing tasks, these behavioral tendencies do not inherently indicate superior cognitive capacity or higher knowledge levels.¹⁵ An analysis of respondent characteristics by age reveals that the largest proportion falls within the 36–45 age group, comprising 84 individuals (26.6%). This finding aligns with the study by Pristiyantoro and Fadillah (2020), which was also dominated by respondents in the productive age range (26–45 years). Contextually, the 36–45 age group represents a life stage where individuals often shoulder dual family responsibilities—characteristic of the "sandwich generation"—involving the health management of both children and elderly parents; consequently, they are the group most frequently exposed to, or engaged with, medication management needs (DAGUSIBU)..¹⁴

Occupational characteristics indicate that the largest number of respondents worked as civil servants or private sector employees, at 149 (47.2%). This aligns with research by Friska, Sylvia, and Milda (2024), which concluded that work is one factor influencing a person's knowledge because working often involves interacting with others. This leads to a better knowledge base, as found in the work of 74.4% of civil servants/private sector employees.¹⁶

According to the scoring criteria in Notoatmodjo's framework the work environment constitutes a critical determinant of an individual's knowledge, as it provides both direct and indirect experiential learning.¹⁸

Based on educational characteristics, the highest level of education was high school/vocational high school, with 186 respondents (58.9%). This is inconsistent with research by Pristiyantoro and Fadillah (2023), which found that 184 respondents (47.8%) had higher education (D1-S3).¹⁴ This finding suggests that higher education leads to greater knowledge about how to obtain, use, store, and dispose of medications. One factor that can influence a person's knowledge is their level of education, which is an effort to provide knowledge that leads to positive, binding behavioral changes.¹⁸

Respondents' Level of Knowledge Regarding DAGUSIBU Medication

This study, using a 14-item questionnaire with 316 respondents, measured their level of knowledge regarding DAGUSIBU. The results are shown in Table 3 below:

Table 3. Level of Knowledge Regarding DAGUSIBU

Knowledge Level	N	%
Good	66	20.9
Sufficient	153	48.4
Poor	97	30.7
Total	316	100

The results show that residents of RW 02, Rambutan Village, had level knowledge of dagusibu with 153 people (48.4%) categorizing it as sufficient. This sufficient level of knowledge indicates that although some residents are familiar with the concept of DAGUSIBU medication, there are still gaps in understanding that need to be improved.

A person's knowledge will influence their behavior in using drugs. Knowledge is the result of knowing, and occurs after a person becomes familiar with a particular object.¹⁹

Relationship between Respondents' Education Level and Knowledge of DAGUSIBU Medicine

The relationship between education level and community knowledge about DAGUSIBU medicine in RW 02, Rambutan Village, East Jakarta, can be seen in Table 4 below:

Table 4. Relationship between Education Level and Knowledge of DAGUSIBU Medicine

Category Education	Knowledge Level DAGUSIBU						Total		P
Level	Good		Sufficient		Poor				Value
	N	%	N	%	N	%	N	%	
Elementary School	0	0%	4	14.3%	24	85.7%	28	100%	0.000
Junior High School/Islamic Junior High School	0	0%	20	50%	20	50%	40	100%	
Senior High School	21	11.3%	115	61.8%	50	26.9%	186	100%	
University	45	72.6%	14	22.6%	3	4.8%	62	100%	

Table 4 presents the community's level of knowledge based on education: the "good" knowledge category was most prevalent among respondents with a higher education background (45 individuals or 72.6%); the "sufficient" knowledge category was most common among those with a high school or vocational school education (115 individuals or 61.8%); and the "poor" knowledge category was most frequently found among respondents with only an elementary school education (24 individuals or 85.7%). These results are consistent with the theoretical framework proposed by Lukman, which states that a person's breadth of knowledge expands proportionally with their level of education.²⁰ A person with a higher level of education may possess more medical information and read more about medications compared to someone with a low level of education or no education.²¹ Individuals with higher

educational attainment are more likely to possess a comprehensive understanding of medical information and exhibit greater literacy regarding pharmaceutical products compared to those with lower levels of education or no formal education.²²

The results of this study indicate a relationship between education level and knowledge regarding the DAGUSIBU medication guidelines among residents of RW 02, Rambutan Urban Village, East Jakarta. This bivariate analysis employed the Pearson Chi-square test. The statistical test yielded a p-value of 0.000 (< 0.05), leading to the conclusion that there is a relationship between education and knowledge regarding DAGUSIBU. This indicates that a higher level of education leads to a better quality of life, as higher education fosters good knowledge and contributes to a high-quality life. Therefore, supervision, information dissemination, and public education regarding the DAGUSIBU guidelines for medication management are necessary. Knowledge influences medication-related behavior; thus, by enhancing public knowledge through outreach or education, it is hoped that positive public behavior regarding DAGUSIBU practices will increase.^{23,24,25}

LIMITATION

This study has several limitations, including the use of a cross-sectional design, which precludes definitive conclusions regarding cause-and-effect relationships. Furthermore, as sampling was restricted to a specific geographical area, the findings cannot be generalized to a broader population. Future research should expand the sample scope and explore other factors potentially influencing DAGUSIBU knowledge, such as exposure to information media and the frequency of interactions with healthcare professionals.

CONCLUSION

The majority of respondents in this study were female (181 respondents, 57.3%). Most respondents were aged between 36 and 45 years (84 respondents, 26.6%), worked primarily as civil servants or private-sector employees (149 respondents, 47.2%), and held a high school or vocational high school diploma as their highest level of education (186 respondents, 58.9%). Respondents' knowledge regarding DAGUSIBU was classified as "sufficient"; 153 respondents (48.4%) possessed adequate knowledge, while 97 respondents (30.7%) possessed inadequate knowledge. There was a significant correlation between education level and public knowledge of DAGUSIBU ($p = 0.000 < 0.05$), with higher education levels indicating a higher level of knowledge about DAGUSIBU medicine.

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AUTHOR CONTRIBUTION STATEMENT

OKP: Conceptualization, Methodology, Writing – original draft. CSN: Investigation, Data curation, Resources. ADP: Formal analysis, Visualization, Supervision, Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST DECLARATION

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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