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DEVELOPMENT OF THE 'KASIR-RISK' PROTOTYPE FOR RISK MITIGATION IN PRIMARY HEALTHCARE INTEGRATION TRANSFORMATION

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ABSTRACT

The transformation of Integrated Primary Healthcare (ILP) in Indonesia requires robust risk management to ensure service quality and patient safety. However, manual documentation and reporting at Community Health Centers hinder real-time risk response, creating a critical gap. This study developed 'Kasir-Risk,' a digital prototype featuring an EWS dashboard, to mitigate risks and support accreditation standards. Using a qualitative approach and prototyping method within the System Development Life Cycle, the study involved 56 respondents from Puskesmas and the Bantul District Health Office. Data were collected through FGD, observation, and documentation studies. Needs analysis revealed an urgent demand for an integrated risk management tool. The resulting Kasir-Risk application is a structured, secure, and data-driven system. Its design includes three main components: a functionality module for risk calculation and notifications, a user experience-based EWS dashboard, and a relational database. Built with modern technologies like Laravel, React.js, and MySQL. The prototype facilitates the entire risk management cycle—from identification and analysis to evaluation, mitigation, and reporting. The EWS achieved a 100% success rate in delivering real-time notifications for high-priority risks. The study concludes that Kasir-Risk serves as a viable digital solution for enhancing risk mitigation, real-time monitoring, and data-driven decision-making in primary healthcare transformation.

Keywords: *Integrated Primary Healthcare, Risk Management, Early Warning System (EWS), Prototype, Development*

ABSTRAK

Transformasi Pelayanan Kesehatan Primer Terpadu (ILP) di Indonesia membutuhkan manajemen risiko yang kuat untuk memastikan kualitas layanan dan keselamatan pasien. Namun, dokumentasi dan pelaporan manual di Puskesmas menghambat respons risiko secara real-time, sehingga menciptakan kesenjangan yang krusial. Studi ini mengembangkan 'Kasir-Risk', sebuah prototipe digital yang menampilkan dasbor EWS, untuk memitigasi risiko dan mendukung standar akreditasi. Menggunakan pendekatan kualitatif dan metode pembuatan prototipe dalam Siklus Hidup Pengembangan Sistem (SDL), studi ini melibatkan 56 responden dari Puskesmas dan Dinas Kesehatan Kabupaten Bantul. Data dikumpulkan melalui FGD, observasi, dan studi dokumentasi. Analisis kebutuhan menunjukkan adanya kebutuhan mendesak akan alat manajemen risiko terintegrasi. Aplikasi Kasir-Risk yang dihasilkan merupakan sistem yang terstruktur, aman, dan berbasis data. Desainnya mencakup tiga komponen utama: modul fungsionalitas untuk kalkulasi dan notifikasi risiko, dasbor EWS berbasis pengalaman pengguna, dan basis data relasional. Dibangun dengan teknologi modern seperti Laravel, React.js, dan MySQL. Prototipe ini memfasilitasi seluruh siklus manajemen risiko—mulai dari identifikasi dan analisis hingga evaluasi, mitigasi, dan pelaporan. Sistem EWS mencapai tingkat keberhasilan 100% dalam memberikan notifikasi real-time untuk risiko-risiko berprioritas tinggi. Studi ini menyimpulkan bahwa Kasir-Risk

berfungsi sebagai solusi digital yang layak untuk meningkatkan mitigasi risiko, pemantauan real-time, dan pengambilan keputusan berbasis data dalam transformasi layanan kesehatan primer.

Kata kunci: *Integrasi Pelayanan Kesehatan Primer (ILP), Manajemen Risiko, Sistem peringatan Dini, Pengembangan, Prototipe*

INTRODUCTION

The United Nations (UN) established the Sustainable Development Goals (SDGs) as a global framework for sustainable development, emphasising universal health coverage and improved health outcomes (Hoelman et al., 2016; ICCTF, 2020). In response, Indonesia has demonstrated a strong commitment through its National Long-Term Development Plan (RPJPN) 2025-2045, which envisions "Golden Indonesia 2045" with a key mission in the Asta Cita focusing on human resource development based on health, education, and technology (President of the Republic of Indonesia, 2024; Wahyuni et al., 2024). Aligned with this national direction, the Ministry of Health has launched a comprehensive transformation of the health system, with a particular focus on strengthening primary healthcare and leveraging health technology (Kemenkes RI, 2023; President of the Republic of Indonesia, 2024).

Primary healthcare facilities, including community health centres (Puskesmas), clinics, and independent practices of health workers, serve as the frontline of Indonesia's healthcare system (President of the Republic of Indonesia, 2023). The current transformation strategy at Puskesmas emphasizes individual-focused care integrated into comprehensive, responsive, and affordable services to address diverse health needs across the life cycle. This initiative, termed the Integration of Primary Healthcare Services (ILP) and ratified in August 2023, represents a significant shift toward more coordinated and patient-centered care (Kemenkes RI, 2023). A critical component of this transformation is effective risk management, which enables Puskesmas to establish proactive mitigation efforts before risks materialize (Kemenkes RI, 2021; Kemenkes RI, 2023). Risk, defined as the possibility of events that could negatively impact organisational objectives (Kemenkes RI, 2019; Ningsih et al., 2024), must be systematically managed according to Standard V on Quality Improvement in the Accreditation Standards, which mandates that Puskesmas compile risk lists integrated into comprehensive management programs (Kemenkes RI, 2023). These programs aim to reduce losses and prevent harm to patients, staff, visitors, and the community (Kemenkes RI, 2017; Kemenkes RI, 2023).

Digital innovation plays a crucial role in supporting these efforts. The World Health Organization (WHO) recommends that digital transformation in primary healthcare focus on community-based information systems, decision support tools, electronic medical records, and personal health records (WHO, 2024). Particularly relevant is the implementation of Early Warning Systems (EWS), which enable healthcare facilities to detect risks early and support informed decision-making to minimize negative impacts (Quansah et al., 2010; Smith et al., 2014; Zheng et al., 2020; McGaughey et al., 2021). EWS enhanced with notifications and alerts can provide timely warnings (Kwan et al., 2020; Peiffer-Smadja et al., 2020), while dashboard implementations have been shown to improve monitoring, emergency preparedness, and inter-unit collaboration (Lorenzo et al., 2016; Kavanaugh et al., 2017; Paulson et al., 2020; Pradana et al., 2023).

Despite these advancements, a significant gap remains between the potential of digital tools and their practical application in primary healthcare risk management. The Puskesmas in Bantul District, which have implemented ILP since mid-2024, continue to rely on manual documentation and reporting systems, hindering real-time risk response (Ningsih et al., 2025). Previous research by the authors revealed that while EWS and risk management frameworks exist in hospital settings, there is currently

no integrated digital prototype that combines risk identification, analysis, evaluation, and mitigation within a single EWS dashboard specifically designed for primary healthcare centers. This gap is particularly critical, given the accreditation requirements and the complex needs of implementing ILP.

This study, therefore, addresses this unmet need by developing "Kasir-Risk," a digital prototype that integrates a comprehensive risk management framework with an EWS dashboard tailored for Puskesmas. The system aims to digitalize the entire risk management cycle while providing real-time alerts and data-driven insights. By bridging digital technology with accreditation requirements, Kasir-Risk represents a novel approach to enhancing risk responsiveness in primary care. The research question guiding this study is, "How can a Kasir-Risk prototype with an EWS dashboard serve as a digital solution for risk mitigation in the ILP transformation?"

METHOD

This study employed a qualitative approach to comprehensively explore the design stages of the Kasir-Risk prototype, an Early Warning System (EWS)-based solution. The research aimed to investigate risk cases according to service clusters within the Integrated Primary Healthcare (ILP) program and to map the existing risk management workflows across sectors in community health centers (puskesmas).

Research Design

The system development followed a prototyping methodology, a form of the System Development Life Cycle (SDLC) effective for accelerating application development iterations and incorporating user feedback from the initial stages (Kemenkominfo, 2007; Syamsiyah & Sesunan, 2018). The software testing phase utilized white box testing, focusing on verifying the accuracy of program logic (functional testing) and the integrity of system workflows (workflow validation) (Nidhra, Srinivas, & Dondeti, 2012).

Participants

The study involved 56 participants from Bantul Regency, Indonesia. The respondents consisted of 27 quality assurance officers and 27 heads of community health centers (puskesmas), representing all puskesmas in the regency. Additionally, one Health Information System officer and the Head of the Primary Healthcare Section at the Bantul District Health Office participated to provide managerial and technical perspectives.

Data Collection

Data were collected from both primary and secondary sources. Primary data were gathered through two main techniques:

1. Focus Group Discussions (FGDs): FGDs were conducted using a structured guide to validate user requirements, analyze existing processes, and conduct limited demonstrations and simulations with representatives from the 27 puskesmas and the District Health Office.
2. Observation: Direct observation was carried out using a checklist to assess the hardware readiness and technological infrastructure at the participating puskesmas and the District Health Office.

Secondary data were obtained through a documentation study. A checklist was used to review regulations governing the Organizational Structure and Authority Tasks (SOTK) in puskesmas and the District Health Office, which helped in compiling a comprehensive user list and understanding the operational context.

Data Analysis

The data analysis process involved several stages. Data from FGDs, observations, and documentation studies were first checked for completeness and clarity (editing). Subsequently, the data were categorized (coding) based on the pre-established collection formats. Qualitative data were analyzed using content analysis, which involves the systematic and objective examination of communication messages to identify patterns and themes (Krippendorff, 2019). To ensure the validity and reliability of the qualitative findings, **t**riangulation was applied by cross-verifying data from different sources (methodological triangulation) and comparing perspectives from various participants (source triangulation).

Ethical Considerations

The ethical feasibility of this research was approved by the Health Research Ethics Commission of the Faculty of Health, Universitas Jenderal Achmad Yani Yogyakarta, with Reference Number: Skep/92/KEP/IV/2024. Informed consent was obtained from all participants prior to their involvement in the study.

RESULTS AND DISCUSSION

RESULTS

User Needs Findings and Prototype Design

Based on Focus Group Discussions (FGDs) involving 56 participants from various units at the Community Health Center (Puskesmas), an urgent need was revealed for an integrated digital tool to address the main problem in risk management: a manual documentation process that hinders real-time risk response and compliance with accreditation standards. The needs analysis indicated a significant gap in existing risk management practices, where the manual system was unable to accommodate the complete risk management cycle from identification to reporting.

Based on these findings, the Kasir-Risk prototype was designed using a user-centered design principle. The core features developed include:

1. A structured risk register aligned with Integrated Health Service (ILP) clusters such as Management, Maternal and Child Health, and Communicable Diseases.
2. Automated risk calculation based on severity level and probability of occurrence.
3. A tiered workflow involving the Unit Coordinator, Quality Coordinator, and Head of Puskesmas.
4. An Early Warning System (EWS) dashboard with real-time notifications for high-priority risks.
5. A reporting and analytics module enabling periodic report generation and data visualization.

User validation through simulations and iterative FGDs showed a 91% match between the prototype and user requirements. Iterative feedback was used to refine the user interface and workflow logic before technical implementation.

Technical Implementation and User Interface of Kasir-Risk

The Kasir-Risk prototype was implemented using a technology stack that supports scalability, security, and high performance. The technical implementation can be categorized into three main aspects:

Backend and Database

The server-side was built using the Laravel framework (PHP), which supports MVC architecture and Role-Based Access Control (RBAC) for managing user access rights. The database uses MySQL for storing relational data such as users, risk logs, and documents. Data security is ensured through JSON Web Token (JWT) authentication and encryption of sensitive information using AES and bcrypt algorithms.

Frontend and User Interface

The user interface was developed with React and Next.js to create a responsive and dynamic EWS dashboard. Styling was implemented using Tailwind CSS for efficiency. The main interfaces implemented include:

1. **Login and Home Page**

   Login and home page serves as the system entry point with an RBAC mechanism that directs users to menus according to their roles. Figure 1 shows the Homepage and Login page. The homepage is the first page accessed by the user. Users can log in through this menu. If the login is successful, the system will display the main menu page according to the user's access rights (authorization).

Figure 1. Login and Home Page

2. **Risk Identification Page**

   The risk identification page allows Unit Coordinators to record new risks via an input form covering general information, risk causes (based on the 4M1E framework: Man, Machine, Material, Method, Environment), and mitigation plans. Each new risk is initially assigned a "draft" status to allow for revisions, enabling the Unit Coordinator to ensure high data quality before submitting it for review. The Risk Identification menu is used to record, view, and manage the risk register. This page displays risk data in a table that can be filtered, sorted, and downloaded. The risk data table consists of the following columns: cluster, unit, risk name, risk category, risk description, cause, impact, and risk status (Figure 2).

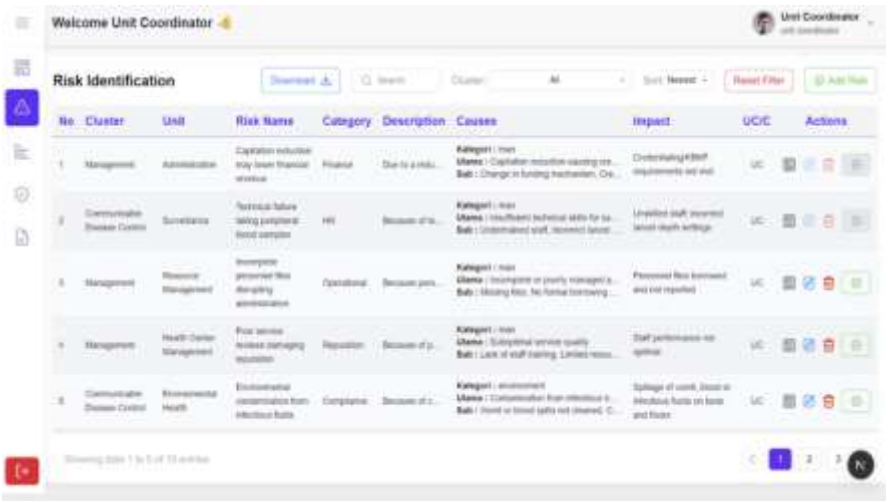

Figure 2. Risk Identification Page

3. **Risk Analysis Page**

The risk analysis page The risk analysis page automatically calculates a risk score by multiplying the severity and probability values, then determines a Risk Band to prioritize treatment. Severity indicates the severity of the impact on a scale of 1-5, while probability indicates the likelihood of the risk occurring, also on a scale of 1-5. The Risk Band category uses five determinants: Very High, High, Medium, Low, and Very Low (Figure 3).

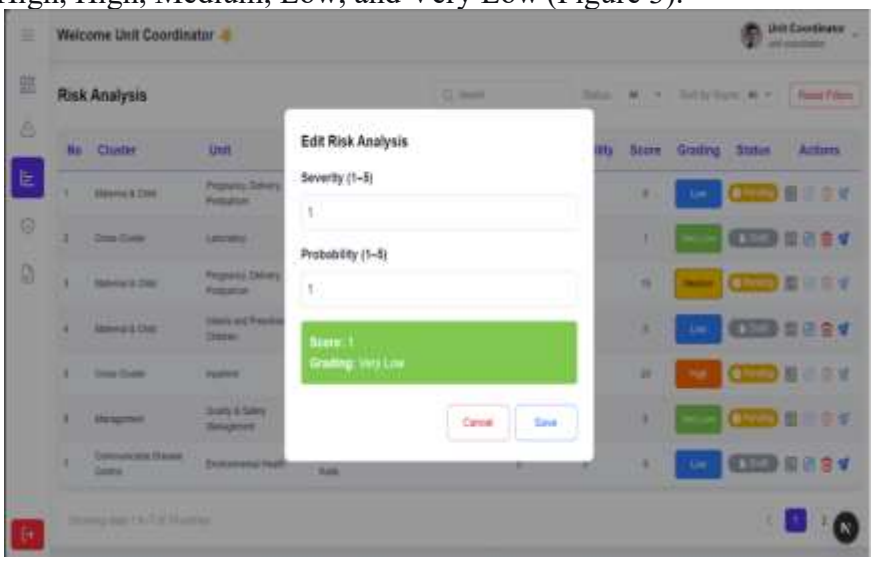

Figure 3. Risk Analysis Page

4. **Evaluation and Approval Page**

Once submitted, risks undergo a tiered review to ensure the validity, relevance, and feasibility of their mitigation plans before final approval. The risk review and approval stage involves strategic evaluation by the Risk Management Coordinator and a final assessment by the Head of the Community Health Center (Puskesmas). This process ensures that only valid, relevant, and actionable risks are processed in accordance with the organization's risk appetite.

Based on the results of the risk analysis, decisions are made regarding which risks require prioritized handling. Key considerations during this risk evaluation include: which risks need to be addressed, the priority of risk treatment, and the potential impact of the mitigation efforts. Risk Appetite is the policy used as a reference to determine whether a risk requires treatment or not. It reflects how the organization balances efficiency, growth, outcomes, and risk. By considering this risk appetite, the risk evaluation page (Figure 4) also includes a measurement of Controllability (on a scale of 1-4).

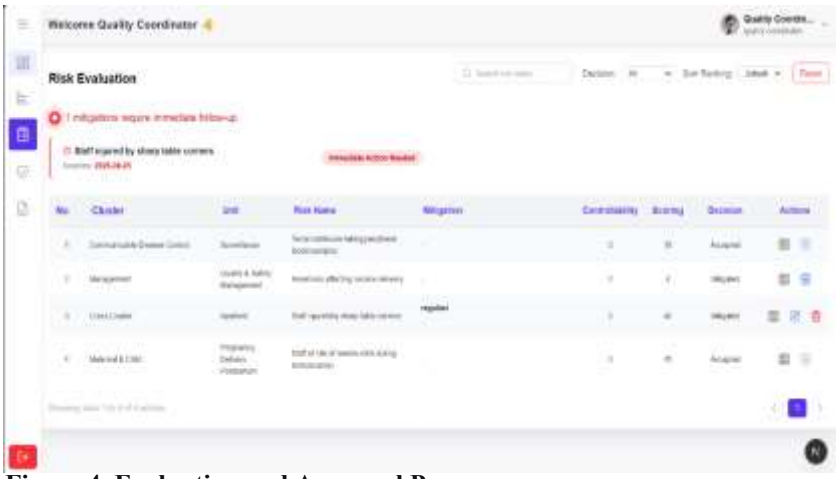

Figure 4. Evaluation and Approval Page

5. **Risk Treatment Page**

Risk treatment within the risk management cycle focuses on the execution of approved mitigation plans. This involves monitoring progress, uploading evidence of implementation, and tracking quantitative indicators to ensure the effectiveness of the actions taken and to reduce unaddressed risks (Figure 5).

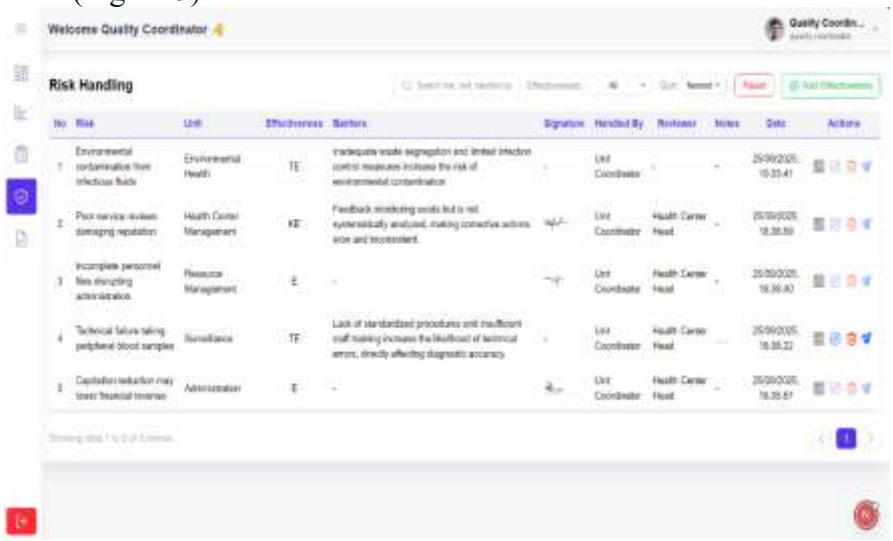

Figure 5. Risk Treatment Page

6. **Reporting and Analytics Dashboard**

The reporting and analytics dashboard presents data visualizations in the form of charts and diagrams for risk pattern identification and decision support.

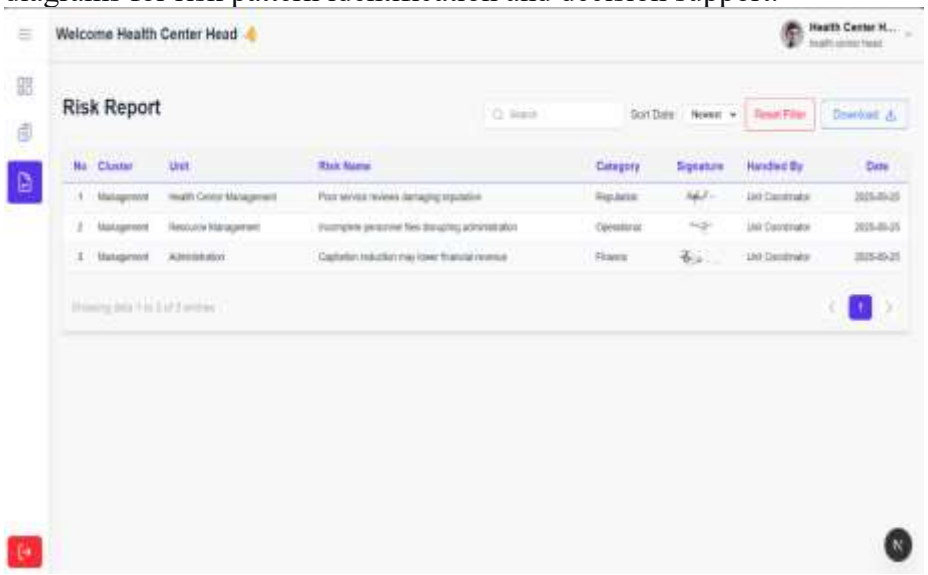

Figure 6. Reporting and Analytics Dashboard

7. **Notification and EWS Dashboard**

The notification and EWS dashboard displays real-time alerts via integration with the Pusher service for risks requiring immediate follow-up. Meanwhile, comprehensive activity logging supports accurate and accountable monitoring, internal auditing, and operational analysis. Pusher serves as the infrastructure for rapid alert communication. The Early Warning System (EWS) approach is implemented through red alert messages, which indicate the number of mitigations requiring immediate follow-up (Figure 7).

Figure 7. Notification and EWS Dashboard

8. **Security and System Architecture**
   The system implements RBAC to restrict access based on user roles (Admin, Unit Coordinator, Quality Coordinator, etc.), input validation to prevent injection attacks, as well as encryption and automatic backups for sensitive data. The system architecture digitally maps the risk management cycle from identification to final evaluation, ensuring neat documentation, technical analysis, and systematic follow-up. Functional testing was conducted iteratively during development to ensure alignment with operational needs and Puskesmas accreditation standards.

DISCUSSION

The development of Kasir-Risk in this study has successfully created an innovative digital risk management system based on an Early Warning System (EWS) for the primary healthcare level in Indonesia. The findings from the FGDs confirm a significant gap in current practice, revealing that the need for an integrated, real-time system remains largely unmet by existing solutions, which predominantly rely on manual or partial approaches. This study directly addresses this gap by designing Kasir-Risk as a structured, secure, and data-driven application, utilizing a technology stack that ensures performance, scalability, and the seamless integration of backend modules, frontend interfaces, and supporting features (Muhammad Emirzaki et al., 2022; P. Ningsih et al., 2025; Sauda & Barokah, 2022).

The novelty of this research lies in the comprehensive integration of a real-time EWS within a complete, contextually-tailored risk management cycle for Puskesmas. This system transcends mere documentation automation by incorporating a proactive notification mechanism, a collaborative tiered workflow, and an analytical dashboard. This represents a significant breakthrough, as no similar system has been specifically designed and implemented for the primary healthcare context in Indonesia. The system's design, particularly the risk identification stage which involves activities to identify events and causes that could hinder organizational goals (Kemenkes, 2019), and its clustering which aligns with the integrated primary healthcare service program (Kemenkes, 2023), ensures relevance and compliance from the ground up.

From a technical perspective, the implementation of Kasir-Risk demonstrates the effective application of contemporary software engineering principles. The backend, built with Laravel, facilitates a robust architecture and enforces Role-Based Access Control (RBAC), which is critical for regulating user access based on assigned roles and maintaining workflow integrity (Hafsah et al., 2025; Prasetia & Manongga, 2024). Data security is further fortified through authentication and the encryption of sensitive information using modern algorithms, effectively mitigating risks of data breaches (Firdaus & Dafy, 2024; Zulma et al., 2022). The use of MySQL as the relational database management system supports the efficient handling of complex data; its advantages in query optimization and deep data filtering are essential for reporting capabilities (Budiman et al., 2025). Furthermore, stringent input validation is implemented to prevent common vulnerabilities, thereby enhancing the system's overall security posture (Muhsinin & Zudi, 2025).

On the frontend, the use of relevant technologies enabled the creation of a dynamic user experience. The application of Tailwind CSS allowed for efficient and consistent styling, contributing to a user-friendly interface (Azhariyah & Mukhlis, 2024). The Early Warning System (EWS), powered by real-time notifications, operationalizes the theoretical concept of proactive risk monitoring. Furthermore, the application's approach to risk mitigation, which describes planned treatment steps and accommodates follow-up needs based on Regulations, Human Resources, and Facilities & Infrastructure (Ningsih & Nugroho, 2025), ensures that the system is not only technologically sound but also pragmatically viable.

When compared to previous studies focused on hospital settings (Yecel et al., 2012; Farokhzadian et al., 2015), Kasir-Risk offers a more contextual and affordable approach for primary care. Thus, Kasir-Risk provides a dual contribution: it addresses immediate practical needs for efficiency and accreditation compliance, while also offering a scientifically-grounded, replicable model for digital risk management in primary healthcare. This model can be adopted or adapted for similar settings in Indonesia and other countries, advancing the fields of health informatics and public health management.

LIMITATION OF THE STUDY

This study acknowledges several limitations. First, the qualitative inquiry process is inherently shaped by the researcher's epistemological stance and subjective lens. From participant selection and methodological choices to data interpretation, these decisions were informed by the researcher's predispositions and theoretical commitments, potentially influencing the findings.
Beyond this methodological reflection, the study has several substantive limitations:
Limited Scope of Testing: The prototype evaluation was conducted on a relatively small scale within a specific research context. Therefore, the findings and the perceived usability of Kasir-Risk require validation through large-scale implementation across multiple Puskesmas with diverse characteristics.
Constraints on Generalizability: The research was conducted in a particular setting with a specific group of participants. Consequently, the generalizability of the findings to other primary healthcare contexts or different regions may be limited. The applicability of the results needs to be tested in broader settings.
Absence of Long-Term Evaluation: This study focused on the design, development, and initial user validation of the prototype. It did not evaluate the long-term effectiveness of the Kasir-Risk system in sustaining risk management improvements, impacting accreditation outcomes, or integrating into daily workflows over an extended period. Future research should include a longitudinal study to assess these critical aspects.

CONCLUSIONS AND SUGGESTIONS

CONCLUSION

This study successfully developed Kasir-Risk**,** an integrated digital solution addressing the critical research gap in risk management at Indonesian Puskesmas. The prototype's novelty lies in its comprehensive Early Warning System (EWS) and structured workflow tailored for primary care. Key findings confirm that Kasir-Risk effectively digitizes the entire risk lifecycle—from 4M1E-based identification to real-time monitoring—significantly enhancing responsiveness and compliance with accreditation standards.

RECOMMENDATIONS

Based on the findings, the following practical and policy-oriented recommendations are proposed:
Large-Scale Pilot and Integration with SATUSEHAT: We recommend that the Ministry of Health adopt and pilot Kasir-Risk across multiple districts. Priority should be given to integrating the system with the national SATUSEHAT platform to ensure data interoperability, avoid duplication, and create a unified health information ecosystem.
Revision of Puskesmas Operational Regulations: A policy update should be issued to formally include digital risk management as a mandatory component of Puskesmas accreditation and quality assurance programs. This will provide a regulatory foundation for nationwide adoption.
Long-Term Impact Evaluation: A longitudinal study should be conducted to assess Kasir-Risk's long-term effectiveness in improving risk mitigation rates, accreditation outcomes, and patient safety indicators.
Advanced Feature Development: Future versions should explore AI-powered predictive analytics to proactively identify emerging risks based on historical data, transforming risk management from reactive to preventive.

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ETHICAL CONSIDERATIONS

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Conflict of Interest Statement

In this study, we sincerely state that there is no conflict of interest that can affect the objectivity and integrity of the research results.

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