Health Information Exchange in Malaysia: Leveraging Interoperability on International Standards for Health Data Exchange

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***Abstract*—This research proposal investigates the implementation of Health Information Exchange (HIE) in Malaysia, focusing on understanding the technological, policy, and financial challenges and opportunities associated with its adoption and effectiveness. Through a comprehensive survey approach targeting healthcare practitioners, policymakers, IT professionals, and patients, the study aims to elucidate the current state of HIE, assess interoperability with international standards, and identify pathways for enhancement. Key objectives include analyzing technological barriers, evaluating policy and regulatory impacts, and exploring sustainable financial models for HIE. Findings indicate a positive trajectory towards HIE implementation, underscored by a broad recognition of its potential to transform healthcare delivery. However, challenges such as system integration, policy clarity, infrastructural readiness, and privacy concerns remain. Recommendations for future improvement emphasize strengthening infrastructure, clarifying policies, enhancing security measures, providing continuous training, fostering innovation, and increasing patient engagement. Furthermore, this study highlights the alignment of HIE implementation with the Sustainable Development Goals (SDGs), particularly SDG 3, to ensure universal health coverage and enhance the healthcare workforce's capacity for process innovation. Incorporating international best practices and a validated framework will further strengthen Malaysia's healthcare system in the digital age.**

***Keywords*—Health data integration; interoperability; international health data standards; implementation; policy reforms; process innovation**

I. Introduction

In the dynamic context of global healthcare, the effective exchange of health information is fundamental to medical innovation, patient care, and public health management. Health Information Exchange (HIE) has become increasingly vital, especially in Malaysia, where the healthcare system is a blend of traditional and modern practices. HIE offers a pathway to enhance healthcare delivery through efficient, secure, and timely sharing of patient health information, facilitating care and supporting public health initiatives.

Malaysia faces unique challenges in HIE implementation, primarily due to interoperability issues. Interoperability, seamless integration, and cooperative use of data across diverse information systems, devices, and applications—is essential not only for technical compatibility but also for the harmonization of standards, protocols, and policies governing health data exchange. As healthcare increasingly transcends national borders, alignment with international standards is critical to ensure comprehensive care, facilitate research, and prepare for global health emergencies [1].

The integration of Health Information Exchange (HIE) is pivotal in modernizing healthcare delivery in Malaysia, a nation where the blend of traditional and contemporary healthcare practices presents unique challenges. These challenges, rooted in technological heterogeneity, necessitate the seamless communication and interoperability of various health information systems. Achieving this requires not only substantial technical and financial resources but also the implementation of international health data standards like HL7, SNOMED CT, and DICOM.

This study addresses the integration of Health Information Exchange within the Malaysian healthcare system, focusing on enhancing interoperability and aligning with the Sustainable Development Goals (SDGs), particularly SDG 3, which aims to ensure health coverage and promote well-being at all ages. SDG 3 includes targets like reducing mortality, fighting diseases, ensuring universal health coverage, and supporting the health workforce. Achieving these targets in the context of Malaysia involves not only enhancing the infrastructure but also addressing policy gaps, technological disparities, and privacy concerns. Through an exploration of existing systems and international best practices, this research seeks to provide actionable insights and recommendations to advance Malaysia's healthcare system in the digital age.

This study will emphasize the problem statements and research questions. The research aims to explore the multifaceted challenges of implementing a Health Information Exchange (HIE) in Malaysia, focusing on technological, policy, and financial dimensions to enhance interoperability and effectiveness. It investigates the key technological barriers to HIE implementation in Malaysia's mixed public-private healthcare system, such as interoperability issues, legacy systems, and diverse EHR integrations, seeking practical solutions and best practices from other countries. It also examines the impact of Malaysia's policy and regulatory frameworks on HIE adoption and effectiveness, identifying gaps and proposing reforms to facilitate efficient data exchange while ensuring patient privacy and data security. Additionally, the

research explores financial models and funding strategies to support sustainable HIE implementation and operation, including government funding and public-private partnerships, assessing their cost-effectiveness in improving healthcare efficiency and patient outcomes. The goal is to develop actionable strategies to address these challenges, contributing to the effective and sustainable implementation of HIE in Malaysia. Fig. 1 shows the healthcare ecosystem in Malaysia.

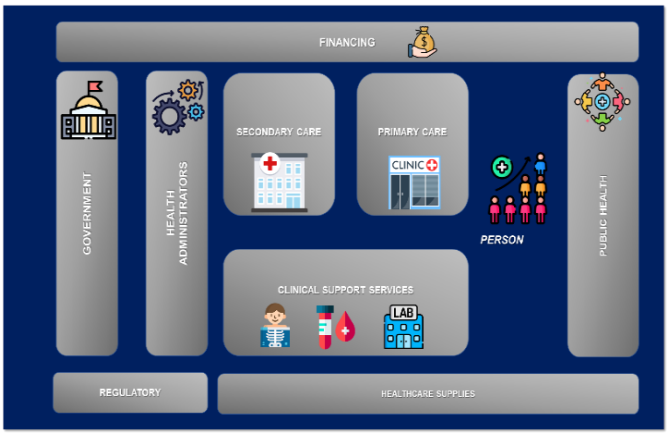

Fig. 1. Healthcare ecosystem in Malaysia.

II. Literature Review

Malaysia is at a pivotal moment in its healthcare transformation, aiming to implement Health Information Exchange (HIE) to create a more integrated, efficient, and patient-centric system. This literature review explores the challenges and opportunities in HIE implementation, focusing on technological barriers, policy and regulatory frameworks, financial models for sustainability, stakeholder engagement, and lessons from international best practices. The review highlights the importance of advanced technological solutions for overcoming interoperability issues, the need for balanced and supportive policies, innovative financial strategies for long-term viability, and robust stakeholder collaboration to align diverse interests. By synthesizing global insights and adapting them to Malaysia's unique context, this review provides a blueprint for achieving seamless health information interoperability, ultimately enhancing the efficiency, accessibility, and well-being of the nation's healthcare system.

As Malaysia moves towards a more integrated healthcare system, the successful implementation of HIE will require a concerted effort across multiple fronts. This includes fostering collaboration among government agencies, healthcare providers, and technology experts, ensuring that all stakeholders are aligned with common goals, such as improving healthcare delivery, supporting research, and addressing healthcare gaps across diverse populations. Moreover, aligning HIE strategies with Sustainable Development Goal 3 (SDG 3), which focuses on ensuring good health and well-being for all, will play a significant role in ensuring that Malaysia's healthcare transformation is not only technologically advanced but also inclusive and accessible.

A. Technological Challenges and Solutions in HIE Implementation

Malaysia's path to a fully integrated Health Information Exchange (HIE) faces challenges, such as diverse Electronic Health Record (EHR) systems operating in isolation. The need for adopting international standards like HL7, SNOMED CT, and DICOM is key to overcoming interoperability barriers, as shown by global case studies, including Tanzania's efforts to centralize health data using international standards.

The challenges in achieving interoperability in Malaysia's HIE system can be addressed by leveraging international standards such as HL7 and SNOMED CT. These standards have proven effective in overcoming interoperability barriers, especially when used in tandem with modern interoperability solutions such as FHIR. Malaysia, however, faces the additional hurdle of integrating legacy systems still prevalent in many public healthcare institutions. This requires a strategic approach to bridge the gap between old and new technologies, ensuring that healthcare systems can communicate seamlessly despite technological differences.

Facebook's role in public health communication shows how social media can overcome traditional communication barriers by disseminating health messages, conducting disease surveillance, and raising health awareness in cost-effective and far-reaching ways. Integrating social media into health information systems can extend traditional HIE mechanisms [2]. Social media platforms, particularly Facebook, have been pivotal in amplifying health communication, ensuring that critical health messages reach diverse populations. This integration can enhance the engagement of communities, allowing healthcare systems to bypass geographical and socio-economic limitations, further extending the reach and effectiveness of public health campaigns.

Tanzania's health information system challenges are due to diverse digital tools and a lack of standardized data. The development of the Health Information Mediator (HIM) facilitated seamless data exchange by implementing international standards and creating a centralized health data repository, ensuring data consistency and quality [3]. Similar challenges are being faced by many low- and middle-income countries (LMICs), where technological fragmentation hampers the smooth flow of information. Tanzania's implementation of international standards has been a key success, and Malaysia can learn from this by prioritizing the standardization of health data across its diverse healthcare systems, integrating global best practices into local contexts. The challenges of implementing HIE with the Internet of Medical Things (IoMT), focus on interoperability issues caused by varied devices, data formats, and communication protocols. Integrating legacy EHRs with IoMT platforms is difficult, but adopting international standards like HL7 can help, though challenges persist in achieving seamless interoperability [4]. As Malaysia looks to integrate the Internet of Medical Things (IoMT), these challenges highlight the critical need for interoperability frameworks that support the communication of diverse medical devices. The adoption of standards like HL7 and FHIR can facilitate the integration of newer technologies with older systems, offering a pathway to

improved data consistency and better patient outcomes across the healthcare system.

The potential of cloud computing to optimize healthcare services by offering a scalable and flexible IT infrastructure. Cloud computing can help manage health records in a distributed environment, addressing challenges related to client assistance, cost, online connectivity, and emergency recovery [5]. Malaysia's transition to cloud computing would not only provide a cost-effective solution for data storage but also enable real-time data sharing and collaboration across multiple healthcare providers. Cloud infrastructure could reduce dependency on expensive, localized data centers, making the system more resilient, especially during health emergencies or natural disasters.

Hospital Information Systems (HIS) play a role in improving healthcare quality through integration and data management. Major challenges include interoperability between EHR systems and integration with legacy systems. HIS adaptations aim to enhance information efficiency using statistical and data mining techniques [6]. HIS is critical for enhancing healthcare delivery and efficiency. However, system integration remains one of the biggest hurdles in Malaysia, where older technologies are still prevalent. Leveraging data mining techniques can help uncover patterns in healthcare delivery, making it easier for policymakers to make data-driven decisions for improving healthcare access and outcomes.

AI and big data analytics have potential but face issues like data security and privacy [7], and addressing healthcare challenges in LMICs. However, digital health application fragmentation and interoperability issues remain significant hurdles [8]. The role of AI in HIE systems is becoming increasingly evident, particularly in its ability to analyze vast amounts of health data and predict patient outcomes. However, for AI to be effective in Malaysia, there needs to be a comprehensive framework that addresses ethical concerns, privacy, and the integration of AI systems with existing infrastructures. As AI becomes more prevalent, these considerations must be addressed to prevent disparities in healthcare services.

Hence, FHIR is important in enhancing interoperability across healthcare systems using web technologies and standardized APIs. FHIR can integrate legacy systems by being compatible with existing HL7 standards (9-10). The adoption of FHIR in Malaysia could serve as a significant change in achieving interoperability across diverse health data systems, bridging the gap between legacy and modern technologies. As FHIR continues to gain global traction, Malaysia has the opportunity to position itself as a leader in digital healthcare innovation, ensuring that healthcare providers can share and access critical patient information seamlessly and securely. Despite the technological challenges, leveraging mobile networks, web-based technologies, and data standardization can help address these challenges [10]. Overcoming technological challenges in HIE implementation requires a multi-pronged approach, combining mobile networks, cloud technologies, and data standardization. This will ensure that Malaysia's HIE system is not only scalable but also adaptable to future technological advancements, such as the IoMT and AI, which will undoubtedly play a pivotal role in the future of healthcare delivery.

B. Policy and Regulatory Frameworks Supporting HIE

Navigating policy and regulatory frameworks is crucial for successful HIE implementation in Malaysia. Different countries have tailored policies addressing privacy, data protection, and governance. Malaysia must develop policies that protect patient privacy and ensure data security while promoting data sharing. Lessons from successful jurisdictions emphasize stakeholder engagement and flexible yet stringent regulations. To successfully implement HIE, Malaysia needs a dynamic regulatory framework that aligns with international standards. This framework must not only emphasize patient privacy and data security but also create a supportive environment that fosters trust among all stakeholders. Global examples like Estonia's and Finland's digital health strategies have shown that robust regulations can facilitate HIE adoption and improve healthcare outcomes by balancing privacy with accessibility.

There is a need for health organizations to engage effectively on social media and calls for policies ensuring the reliability of online health information,1 and establish strong leadership and clear governance, as seen in Tanzania's digital health strategy, supported by a National eHealth Steering Committee and technical working groups [3]. Malaysia can take inspiration from Tanzania's digital health governance model, where clear leadership and coordinated efforts across government bodies, healthcare providers, and technological partners were critical to the success of their health information systems. Implementing similar strategies would allow Malaysia to build strong, collaborative frameworks that involve all stakeholders in creating policies that promote trust in digital health systems. In addition to traditional governance, health organizations must engage with the public through social media. Clear, accurate health information can be disseminated rapidly via Facebook, Twitter, and other platforms, enhancing public health engagement. Policies should ensure that online health information is reliable, verified, and accessible, fostering an informed population that trusts digital health technologies.

Among other things, there are also concerns about data privacy and security concerns on the Internet of Medical Things (IoMT), emphasizing the need for flexible healthcare platforms and unified policy frameworks to ensure privacy, security, and interoperability [8]. Given the rise of IoMT devices, Malaysia needs to develop comprehensive regulatory frameworks that can accommodate the growing diversity of connected health devices, safeguarding patient data while ensuring seamless interoperability across platforms. This will require a balance of technology-specific standards with broad regulatory guidelines to create an adaptable and secure environment for digital healthcare solutions. In room for policy reforms, Policy gaps in EHR systems, telemedicine, and digital healthcare highlight the need for updated regulations, such as revising the Telemedicine Act 1997, to support modern telehealth practices (7, 11). The Malaysian Telemedicine Act must be revised to reflect the advancements in digital health technologies and telemedicine practices.

It is also important to have comprehensive policies for data management, device usage, and care delivery, advocating for a

national digital health strategy to support HIE implementation that emphasizes adhering to international standards like FHIR, which enhance data privacy and security, crucial for effective HIE implementation. (7, 9). Developing a national digital health strategy is essential for HIE success in Malaysia. This strategy must prioritize data management, patient confidentiality, and device standardization. Moreover, adherence to international standards like FHIR is vital for maintaining data security and interoperability, ensuring that Malaysia's healthcare system can evolve while staying aligned with global best practices in digital health.

C. Financial Models and Funding Strategies for Sustainable HIE

Sustainability is the key to successful Health Information Exchange (HIE) initiatives. Various funding models, from government allocations to public-private partnerships, offer different benefits and challenges. For Malaysia, it is essential to find a model that supports both the initial setup and long-term operations. Cost-benefit analyses highlight the economic advantages of HIE, showing potential efficiencies and savings in healthcare delivery. Creative financial solutions are needed to support technological and policy advancements. While government allocations can support the initial setup of HIE systems, long-term sustainability requires finding flexible funding mechanisms that allow continuous system improvements, including maintenance, updates, and expansion. Public-private partnerships (PPP) offer a potential model that blends both public funding and private sector efficiency, ensuring HIE's financial viability over time. These partnerships can leverage private sector innovation and public resources, creating an environment that fosters long-term operational success and adaptability [11].

Platforms like Facebook can be a cost-effective part of broader funding strategies to maximize health information reach with minimal expense [2]. By using social media not only for public engagement but also for fundraising campaigns, Malaysia can generate additional funding and raise awareness about HIE's benefits. In Tanzania's HIE project, it is primarily funded by international donors like USAID. However, long-term sustainability, including maintenance and expansion costs, remains a challenge, indicating a need for sustainable funding models [3]. Moreover, transitioning from donor-based funding to domestic funding sources will be crucial for Malaysia's future self-sufficiency in HIE initiatives. However, in the long run, the cost implications of cloud computing in healthcare suggest a financial model that shifts from capital expenditure to operational expenditure, reducing the burden of maintaining large IT systems (5, 12). Cloud computing allows Malaysia to move away from large upfront costs for IT infrastructure and instead adopt a pay-as-you-go model. This makes it easier for healthcare organizations to manage operational costs and ensure that funds are allocated efficiently for maintenance and expansion.

It is challenging to secure funding for digital health systems, suggesting various financing models like insurance, grants, and pay-as-you-use schemes to support HIE development and scaling. scaling [8] and by the adoption of Fast Healthcare Interoperability Resources (FHIR) by leading tech companies, emphasizing its cost-effectiveness and efficiency in healthcare data exchange. The potential for private investment and public-private partnerships (PPPs) will be crucial in funding sustainable HIE initiatives. Malaysia should look into models that encourage private companies to invest in HIE infrastructure, especially those that align with global interoperability standards. These partnerships can stimulate innovation, enhance resource mobilization, and ensure that Malaysia's HIE systems are adaptable and resilient in the long term [9].

D. Stakeholder Perspectives and Engagement in HIE

The success of Health Information Exchange (HIE) in Malaysia depends on engaging healthcare providers, policymakers, and patients. Effective communication, transparent operations, and inclusive policymaking are crucial for gaining support and transitioning to an integrated healthcare network. Engaging all stakeholders, such as healthcare providers, policymakers, patients, and the public, is essential for the success of HIE in Malaysia. Each group plays a vital role in ensuring that the system meets their needs and is adopted widely. Engaging healthcare professionals early in the process, ensuring policymakers understand the long-term benefits, and addressing patient concerns about privacy and data security will create an environment of collaboration and trust.

It is very crucial and vital to engage internet users on social media, showing how strategic use of platforms like Facebook can enhance health information dissemination [2]. Engaging on social media platforms allows healthcare systems to reach broader audiences, including younger, tech-expert generations who are the key to driving health awareness in digital spaces. Taking the example of HIE in Tanzania, stakeholder engagement involved government, NGOs, healthcare facilities, and international partners, and the importance of training and capacity building [9]. Malaysia could benefit from the collaborative model used in Tanzania, where government, NGOs, and healthcare facilities worked together, ensuring diverse stakeholder participation and effective HIE implementation.

Other than that, we should not neglect the presence of Internet of Medical Things (IoMT) and its potential to enhance stakeholder engagement by granting patients greater access to their health data and streamlining healthcare processes [4]. The IoMT offers opportunities for real-time health data sharing, enhancing patient engagement, and streamlining healthcare delivery. This integration can improve patient-provider communication and foster better healthcare outcomes. It is essential to get to users' perspectives on their understanding of cloud-based health systems, focusing on compatibility, complexity, security, and privacy to ensure acceptance and usage. Ensuring patients and healthcare providers are well-informed about the cloud-based systems is critical to successful adoption. Clear communication regarding security and data privacy concerns can help build trust.

On that note, it is also equally important to highlight the importance of user satisfaction, system quality, and technology compatibility for the success of Hospital Information Systems (HIS), using various evaluation models [6]. User satisfaction and system compatibility are critical for the success of HIS. Ensuring these systems meet user needs will lead to better

adoption rates and more effective healthcare delivery. From the perspective of healthcare professionals, the concerns from medical practitioners and the need for patient engagement and digital health literacy must be addressed to ensure successful digital health technology adoption [7]. Addressing healthcare professionals' concerns with continuous education and offering clear benefits of digital health adoption will help ease resistance and improve technology integration. Going aerial, collaborations between governments and external stakeholders [13], highlighting successful partnerships, like Kenya's mobile technology initiative for community health worker training is also evidenced to accelerate good outcomes [8]. Collaboration, such as Kenya's model, demonstrates how external partnerships can drive successful digital health integration.

The adoption of FHIR will enhance data interoperability and has gained support from major technology companies, highlighting the role of collaboration in advancing HIE3, and through the implementation of FHIR, it reflects a shared commitment to improving healthcare data exchange and accessibility [8]. FHIR adoption is a critical component for improving interoperability in Malaysia's HIE system. It will enable seamless data exchange, making healthcare delivery more efficient and effective. Each organizational culture, staff awareness, and skill levels in the successful implementation of EHR systems must be emphasized to address specific barriers [9]. Organizational culture and staff readiness must be aligned with digital health goals to ensure smooth EHR system integration and successful HIE adoption.

E. International Best Practices and Lessons Learned

The global landscape of Health Information Exchange (HIE) offers valuable lessons for Malaysia. Countries like Estonia and the United States provide insights into successful practices and common pitfalls. Learning from these experiences can help Malaysia adapt effective strategies and avoid mistakes. Malaysia can improve health communication by adopting global best practices in social media use [2]. Global best practices, such as Tanzania's integration of social media for health information dissemination, can be useful for engaging the public and spreading awareness about the benefits of HIE. For instance, in Tanzania, they use international best practices and global networks to develop their HIE system, emphasizing collaboration and iterative design [3]. International collaboration in HIE development allows Malaysia to learn from countries with successful digital health systems, adapting global solutions to local contexts.

Apart from Tanzania, challenges and solutions from Iraq's healthcare cloud computing can offer relevant insights for Malaysia's HIE implementation [5]. Iraq's cloud-based healthcare systems provide relevant insights into managing health data securely and efficiently. Malaysia can adapt these lessons to improve its cloud infrastructure and reduce costs. Actually, looking back at Malaysia's blueprint, Malaysia's telemedicine progress with the U.S., India, and China suggests that international examples can guide improvements in digital health [7]. Telemedicine advancements from the U.S., India, and China serve as valuable blueprints for Malaysia's progress, allowing Malaysia to build upon successful global telemedicine models. In other cited articles, there are several success stories of HIE implementation strategies from Tanzania, Estonia, and Chile, emphasizing the importance of learning from global experiences to overcome technological and policy challenges [8]. Global case studies, such as those from Estonia and Chile, show how standardization and collaborative policy development can overcome barriers and help improve HIE adoption.

While learning from other country is paramount, the standardization is a concern that need to be addressed and global adoption of Fast Healthcare Interoperability Resources (FHIR) as a model for improving healthcare interoperability, which Malaysia can adopt to enhance its HIE capabilities [9] as it provides valuable components of data analytics in improving healthcare quality, showcasing successful examples from prominent healthcare organizations. FHIR adoption is a critical step for Malaysia's HIE success. By embracing this global standard, Malaysia can improve interoperability, enhance data quality, and streamline healthcare delivery, fostering long-term healthcare innovation.

III. METHODOLOGY

This study employs a comprehensive questionnaire-based approach to explore the multifaceted challenges and opportunities of implementing Health Information Exchange (HIE) in Malaysia. Utilizing both closed-ended questions for statistical analysis and open-ended questions for thematic exploration, this methodology is designed to elicit a wide range of perspectives from key stakeholders such as healthcare providers, policymakers, IT professionals, and patients. This approach aims to generate a rich dataset that provides nuanced insights into the barriers and facilitators of HIE adoption and effectiveness, leading to actionable recommendations for enhancing healthcare delivery through improved data interoperability.

The questionnaire-based approach has been chosen to capture both quantitative and qualitative data, providing a comprehensive understanding of the challenges and opportunities that Malaysia faces in adopting HIE. This methodology ensures that data from diverse perspectives, such as healthcare providers, policymakers, IT professionals, and patients, are systematically gathered, allowing for rich insights that can inform future strategies for improving Malaysia's HIE infrastructure.

A. Data Collection and Analysis Method

Data collection is conducted through an online survey platform, Google Forms, ensuring broad accessibility and participation. The survey is structured to gather only demographic information, adhering to ethical guidelines to ensure participant anonymity and data confidentiality. The analysis involves descriptive and inferential statistics to identify patterns and correlations relevant to the study's goals.

B. Questionnaire Structure and Research Objectives

Four distinct sets of questionnaires are tailored to different respondent groups to address specific research objectives and questions including healthcare practitioners such as doctors, nurses, administrative officers, medical assistants; policy makers, doctors or health authority in the Ministry who are involved in policy making and decision making; IT professionals such as IT experts in the ministry as well as on

ground operation level and patients. These questionnaires cover topics such as system integration, technological barriers, policy awareness, and the impact of HIE from multiple stakeholder perspectives. The questions are designed to assess the current state of HIE technology use, policy understanding, and financial strategies impacting HIE implementation in Malaysia. Each set aims to collect targeted data that informs the broader research aims, focusing on technological challenges, policy impacts, and financial sustainability of HIE initiatives.

This methodological framework supports a comprehensive analysis of the current and potential future state of Health Information Exchange in Malaysia, contributing valuable insights into the advancement of HIE systems and their alignment with both national healthcare goals and global health objectives. In aligning the findings with national healthcare goals and global health objectives, this methodology helps position Malaysia's efforts within the international context of digital health [17] transformation. By focusing on both local challenges and global standards, the study provides actionable recommendations for Malaysia to improve its HIE infrastructure while contributing to global health goals such as Universal Health Coverage and Sustainable Development Goal 3 (SDG 3).

IV. Results and Analysis

The survey findings offered a significant understanding of the status of Health Information Exchange (HIE) deployment in Malaysia, comparing it with global practices while also addressing technological barriers, accessibility issues, and potential financial strategies for its implementation. This comprehensive approach delivers diverse viewpoints on the awareness, understanding, and opinions regarding HIE implementation in Malaysia. The detailed discussion of each questionnaire is further elaborated in the next sections. The findings from this study provide a detailed view of HIE adoption in Malaysia, illustrating both progress and challenges. The analysis highlights not only the technological barriers and policy concerns but also the financial models necessary to ensure sustainability. Through comparing local findings with global trends, the study offers insights into how Malaysia can enhance its HIE infrastructure and better align with international standards [12].

A set of seven targeted questions, each with a specific objective, is directed at healthcare practitioners. This questionnaire is essential for assessing users' comprehension of the interoperability platform and their perceptions of its long-term impact.

A. Analysis of Healthcare Practitioners

The survey findings reveal a diverse landscape of EHR usage in Malaysia, with HIS@KKM and HIE RekodPesakit each used by 26.7% of respondents, 30% utilizing various other systems, and 16.7% relying on manual records. Integration challenges are evident, with 46.7% of respondents reporting poor EHR system interoperability and 43.3% unsure of their systems' capabilities. Technological barriers are significant, with 63.3% encountering major obstacles, primarily insufficient devices (73.3%), and poor internet connectivity (53.3%). Familiarity with the FHIR standard varies, with 40% somewhat familiar and 20% very familiar, though 16.7% are not familiar at all. Policy support for HIE is viewed positively by 73.3% of respondents, yet 26.7% remain uncertain about its effectiveness. Government and private sector support for HIE implementation is generally well regarded, with most respondents rating it 4 or 5 out of 5, though some see room for improvement in engagement and support. The findings from healthcare practitioners reveal a diverse level of understanding and engagement with HIE systems. While the usage of EHR systems is widespread, issues with integration and interoperability remain significant challenges. The lack of familiarity with FHIR among some practitioners highlights a critical gap in education and training, suggesting that awareness campaigns and capacity-building initiatives are crucial to improving HIE adoption in the healthcare workforce.

The survey responses from healthcare practitioners reveal mixed familiarity and perceptions regarding Health Information Exchange (HIE) in Malaysia. While many are somewhat familiar with international standards like FHIR and view current policies as supportive, a significant portion remains unsure or unfamiliar, indicating a need for better education and communication. Technological barriers, such as insufficient devices and internet connectivity, are prevalent concerns. Although there is general positivity about support from authorities, some practitioners rate this support as moderate or low, highlighting potential gaps in engagement and resources. Overall, the findings suggest a positive trend towards digitization and HIE support, but emphasize the need for enhanced awareness, technological infrastructure, training, and consistent communication to fully realize HIE's benefits in healthcare delivery and patient outcomes in Malaysia.

B. Analysis of Policy Makers and Regulators

The survey of policy makers and regulators reveals a strong awareness of existing policies supporting HIE, with 88% recognizing a general operating policy and 68% aware of hospital procedures. However, there is less recognition of health data policies (48%). The majority (68%) believe HIE clarifies data exchange issues and supports digital transformation (64%), though fewer see it easing system adaptation (48%). Uncertainty prevails regarding policy revisions for HIE (52%), and there is a lack of clarity on FHIR adoption, with 56% unsure. Funding models primarily include tender-based projects (52%) and national insurance schemes (24%), while 72% report no financial incentives for healthcare providers to adopt HIE. This highlights a need for clearer communication and policy direction to enhance HIE adoption and support.

The findings suggest that policy makers and regulators are aware of the importance of HIE, yet they still face challenges with unclear policy directions, especially regarding privacy and data security. The lack of clarity around FHIR adoption and its strategic implementation shows that further education and guidance are needed for regulators to make informed decisions. Moreover, the absence of financial incentives for healthcare providers is a major barrier to wider adoption, suggesting that a robust financial framework must be put in place to encourage HIE integration at all levels.

Policy makers and regulators in Malaysia demonstrate strong awareness and acknowledgment of the policy frameworks supporting Health Information Exchange (HIE),

recognizing operational policies and health data policies. They perceive these policies as facilitating data exchange clarity and enabling digital transformation, although there is less confidence in their role in easing HIE adaptation within facilities. Uncertainty about revisions to privacy and security policies suggests a need for clearer communication and collaborative planning. The adoption of FHIR standards is mixed, with many respondents uncertain about the strategic direction, indicating a need for better information dissemination. Diverse funding models, mainly tender-based projects and national insurance schemes, support HIE, but a perceived lack of financial incentives for healthcare providers may hinder wider adoption. Overall, while supportive of HIE policies, policy makers see opportunities for improved communication, strategic clarity, and financial incentives to enhance HIE implementation and effectiveness in Malaysia's healthcare system.

C. Analysis of IT Professionals

The survey of IT professionals reveals a strong implementation of FHIR standards (92%) and cloud computing (72%) to address interoperability challenges. Data privacy and security measures focus on extensive assessments (80%) and role-based access control (76%). A significant majority (76%) believes in AI's potential to enhance HIE capabilities. International models influence Malaysia's HIE strategies, acknowledged by 64%, though 24% are uncertain. Lessons learned highlight the need for strong leadership, comprehensive funding models, integration to avoid system silos, robust infrastructure, clear policies, diverse use cases, and sustainable implementation strategies to improve healthcare quality. These insights emphasize the importance of a structured and well-supported approach to HIE implementation in Malaysia. IT professionals emphasize the critical role of international standards like FHIR and cloud computing in overcoming interoperability challenges within Malaysia's HIE system. However, for HIE to reach its full potential, there must be a concerted effort to address technical and operational barriers, particularly in system integration and data security. The adoption of AI and machine learning in HIE also requires stronger education and training for IT professionals, as they are key to driving these technologies forward.

IT professionals in Malaysia emphasize several key factors for the successful implementation of Health Information Exchange (HIE). They stress the need for strong, informed leadership with clear mandates to ensure cohesive implementation. Adequate devices and reliable internet connectivity are critical for smooth operation, while moving away from siloed systems towards an integrated HIE platform is necessary to avoid fragmentation. Consistent and collective financial support is vital for the sustainability of HIE, alongside government mandates and regulatory frameworks to guide its implementation. There is also a need for further education on the benefits of AI and machine learning in HIE. Malaysia's HIE strategies benefit from international models, but there is a need for clarity on this influence. Professionals believe HIE can improve healthcare quality and patient outcomes. In conclusion, they advocate for a strategic, well-supported HIE approach with strong leadership, robust infrastructure, comprehensive integration, sustainable financial backing, clear policies, and ongoing education, envisioning a system that significantly enhances Malaysia's healthcare.

D. Analysis of Patients

The patient survey reveals a majority awareness (70%) of HIE and its benefits, though 23.3% remain unsure and 6.7% are unaware, indicating a need for better communication and education. Nearly half of the respondents (46.7%) noticed improvements in healthcare delivery due to HIE, while 26.7% did not see improvements, and another 26.7% were unsure, suggesting mixed experiences and the need for further evaluation and education. Concerns about data privacy and security are significant, with 43.3% expressing worries, 33.3% feeling secure, and 33.3% unsure, highlighting the importance of transparency and robust security measures to build patient trust in the HIE system. The mixed awareness levels and concerns regarding data privacy emphasize the need for ongoing education and transparency. As Malaysia continues to roll out its HIE initiatives, patient engagement and trust will be pivotal for the system's success. Clear communication about how data is shared and secured will help patients feel more confident in using these systems.

The survey of patients in Negeri Sembilan, where Malaysia's HIE pilot is implemented, reveals promising awareness and initial positive impacts of HIE, with 70% aware of its benefits and nearly half (46.7%) noticing improvements in healthcare delivery. However, 26.7% do not perceive improvements, and another 26.7% are unsure, highlighting the need for ongoing education and system integration. Privacy and security concerns are significant, with 43.3% expressing worries and an equal proportion uncertain about data security. In conclusion, while there is a positive trajectory towards HIE implementation, further education and reassurance are essential, especially regarding data privacy and security. Continuous efforts in these areas will be crucial for building patient trust and fully realizing HIE's potential to improve healthcare delivery in Malaysia. Addressing integration, policy communication, technical readiness, and privacy concerns remains essential for success [14] [15] [16].

E. Future Recommendations to Enhance HIE Implementation

Based on the comprehensive insights from the research on Health Information Exchange (HIE) implementation in Malaysia, several future recommendations have emerged to address identified challenges and leverage opportunities for enhancing the HIE system. These recommendations and their strategies are outlined below: strengthen infrastructure and integration by enhancing technical infrastructure through investment in robust systems, reliable internet connectivity, and adequate devices to ensure seamless HIE operation across all healthcare facilities; and promote system integration by supporting the integration of manual and legacy systems with the HIE platform through technical assistance and incentives, enabling comprehensive participation. This will require a multi-tiered approach involving government support, private sector investment, and collaboration across various healthcare levels to ensure system scalability and reliability.

Under policy and governance, clarify and communicate policies to improve understanding of stakeholder roles and responsibilities, and develop incentive structures to encourage

healthcare providers and patients to actively participate and share data. Clear, transparent policies will help align all stakeholders, ensuring a cohesive approach to data sharing and privacy protection. Introducing incentives will motivate stakeholders to adopt and fully engage with the system.

For security and privacy measures, implement robust security protocols through regular audits, encryption, and secure access controls, while educating stakeholders on data privacy through awareness campaigns to build trust in the HIE system. Continuous monitoring and improvements in security measures are essential to maintain patient trust and confidence in the system. Stakeholder education should focus on data security best practices and the importance of adhering to regulatory standards.

Training and support should include offering continuous training for healthcare practitioners and IT professionals on HIE technologies and best practices, and developing IT expertise focused on cybersecurity, database management, and system integration. Providing ongoing professional development is crucial for ensuring healthcare providers are equipped with the knowledge and tools necessary to use HIE systems efficiently and securely. This includes both technical and policy-oriented training.

Research and development efforts should foster innovation in HIE by investing in R&D to explore technologies such as AI and blockchain for secure and efficient data exchange, while evaluating and adapting international best practices to suit the Malaysian context. By encouraging R&D in emerging technologies, Malaysia can ensure that its HIE system remains innovative and resilient to future challenges. Blockchain can enhance data security, and AI can improve data analysis and decision-making processes.

Lastly, patient engagement and awareness should be enhanced by increasing patient education and communication to highlight HIE benefits and promote patient-centered care, along with implementing feedback mechanisms to gather input from all stakeholders, particularly patients, for continuous HIE improvement. Implementing these recommendations requires collaboration among government agencies, healthcare providers, IT professionals, and the community. By addressing current challenges and focusing on continuous improvement, Malaysia can maximize the potential of its HIE system to enhance healthcare delivery, patient outcomes, and overall system efficiency.

V. Conclusion and Future Enhancement

The comprehensive research on Health Information Exchange (HIE) implementation in Malaysia reveals significant insights from diverse stakeholders, including healthcare practitioners, policymakers, IT professionals, and patients. These findings underscore a strong commitment to enhancing health service delivery through HIE but highlight several critical challenges, such as diverse EHR systems, technological barriers, infrastructural deficits, and concerns over privacy and security. Policymakers demonstrate awareness and support for existing HIE policies but recognize the need for clearer communication and incentive structures. IT professionals emphasize the importance of robust infrastructure, adopting international standards, and leveraging AI's potential. Patients show awareness and positive perceptions of HIE benefits but express significant privacy and security concerns.

Overall, the findings indicate that while Malaysia has made meaningful progress towards digital health integration, the implementation of HIE remains uneven, particularly across different stakeholder groups and operational levels. This highlights the need for a more coordinated and inclusive approach to ensure that technological advancements translate into practical, system-wide benefits. To address these challenges and leverage opportunities, future recommendations include investing in robust technical infrastructure, supporting system integration, improving policy communication, developing incentive structures, implementing robust data privacy measures, providing continuous training, fostering innovation through R&D, and enhancing patient engagement. Implementing these recommendations requires collaboration among government agencies, healthcare providers, IT professionals, and the community. Such collaboration is essential in order to ensure that HIE implementation is not only technically feasible but also trusted, sustainable, and widely adopted across the healthcare ecosystem.

By addressing current challenges and focusing on continuous improvement, Malaysia can realize the full potential of its HIE system, improving healthcare delivery, patient outcomes, and overall system efficiency. This study's insights and recommendations provide a roadmap for advancing Malaysia's healthcare system in alignment with national and global health objectives, particularly the Sustainable Development Goals (SDGs). In conclusion, the successful advancement of HIE in Malaysia depends not only on technology but also on policy clarity, stakeholder readiness, and public trust, all of which must progress together to achieve long-term digital health transformation.

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References

[1] A. Rahim, A. I., Ibrahim, M. I., A. Salim, F. N., & Ariffin, M. A. I. (2019). Health information engagement factors in Malaysia: A content analysis of

facebook use by the ministry of health in 2016 and 2017. International journal of environmental research and public health, 16(4), 591.

[2] Aerts, A., & Bogdan-Martin, D. (2021). Leveraging data and AI to deliver on the promise of digital health. International Journal of Medical Informatics, 150, 104456.

[3] Ayaz, M., Pasha, M. F., Alzahrani, M. Y., Budiarto, R., & Stiawan, D. (2021). The Fast Health Interoperability Resources (FHIR) standard: systematic literature review of implementations, applications, challenges and opportunities. JMIR medical informatics, 9(7), e21929.

[4] Ayaz, M., Pasha, M. F., Alahmadi, T. J., Abdullah, N. N. B., & Alkahtani, H. K. (2023, June). Transforming Healthcare Analytics with FHIR: A Framework for Standardizing and Analyzing Clinical Data. In Healthcare (Vol. 11, No. 12, p. 1729). MDPI.

[5] Dewadas, H. D., Michael, J. A. J., Nadarajan, R., Adrus, N., Shukor, S. F. A., & Fei, L. K. (2023, December). Digitalisation in Healthcare: A Review of Present Developments in Malaysia. In 11th International Conference on Business, Accounting, Finance and Economics (BAFE 2023) (pp. 77-92). Atlantis Press.

[6] Dornan, L., Pinyopornpanish, K., Jiraporncharoen, W., Hashmi, A., Dejkriengkraikul, N., & Angkurawaranon, C. (2019). Utilisation of electronic health records for public health in Asia: a review of success factors and potential challenges. BioMed research international, 2019(1), 7341841.

[7] Holmgren, A. J., Everson, J., & Adler-Milstein, J. (2022, February). Association of hospital interoperable data sharing with alternative payment model participation. In JAMA Health Forum (Vol. 3, No. 2, pp. e215199-e215199). American Medical Association.

[8] Meri, A., Hasan, M. K., Danaee, M., Jaber, M., Safei, N., Dauwed, M., ... & Al-bsheish, M. (2019). Modelling the utilization of cloud health information systems in the Iraqi public healthcare sector. Telematics and Informatics, 36, 132-146.

[9] Nsaghurwe, A., Dwivedi, V., Ndesanjo, W., Bamsi, H., Busiga, M., Nyella, E., ... & Taylor, P. (2021). One country's journey to interoperability: Tanzania's experience developing and implementing a national health information exchange. BMC Medical Informatics and Decision Making, 21(1), 139.

[10] Powell, K., & Alexander, G. (2019). Mitigating barriers to interoperability in health care. On-Line Journal of Nursing Informatics, 23(2).

[11] S. Rubí, J. N., & L. Gondim, P. R. (2019). IoMT platform for pervasive healthcare data aggregation, processing, and sharing based on OneM2M and OpenEHR. Sensors, 19(19), 4283..

[12] Saripalle, R., Runyan, C., & Russell, M. (2019). Using HL7 FHIR to achieve interoperability in patient health record. Journal of biomedical informatics, 94, 103188.

[13] Sebetci, Ö. (2018). Enhancing end-user satisfaction through technology compatibility: An assessment on health information system. Health Policy and Technology, 7(3), 265-274.

[14] Torab-Miandoab, A., Samad-Soltani, T., Jodati, A., & Rezaei-Hachesu, P. (2023). Interoperability of heterogeneous health information systems: a systematic literature review. BMC Medical Informatics and Decision Making, 23(1), 18.

[15] Wright, K. B. (2005). Researching Internet-based populations: Advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. Journal of computer-mediated communication, 10(3), JCMC1034.

[16] Sa'ari, H., Amin, M. M., Abbas, M. S., Ismail, A. F., Fadzilah, A. H. H., & Nordin, M. (2023, May). Transforming Industrial Operations with Blockchain: The Healthcare Application Health-Chain. In 2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE) (pp. 1175-1179). IEEE.

[17] W. Y. Leong, "Digital Technology for ASEAN Energy," 2023 International Conference on Circuit Power and Computing Technologies (ICCPCT), August 2023, pp. 1480-1486. DOI: 10.1109/ICCPCT58313.2023.10244806