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A Health Care-Empowering Diagnosis and Carewith Advanced Android Technology

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Abstract—Health Care exhibits remarkable benefits forpatient care such as improving healthcare quality and expediting coordinated care. This paper introduces a pioneering health care application leveraging Android technology, designed to revolutionize disease diagnosis and patient-centric health information exchange. Grounded in patient-centric approach, the application, named "Health Care", seamlessly integrates diagnostic tools, patient records, and healthcare provider communication within a comprehensive framework. Health Care employs advanced algorithms to interpret symptoms, streamline diagnoses, and facilitate informed decision-making for medical practitioners. This research elucidates the technical architecture, functionalities, and the pivotal role of Health Care in improving healthcare accessibility, accuracy, and patient outcomes. Through an in-depth analysis of its design, implementation, and potential impact, this paper highlights the transformative potential of Health Care in advancing the landscape of modern healthcare.

Index Terms— **mHealth (Mobile Health), Diagnostic App, Android Technology, Healthcare Accessibility, AI Diagnosis, Patient Empowerment, Remote Monitoring.**

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I. Introduction

HEALTH CARE diagnosis Android application:

In today's dynamic healthcare landscape, the fusion of technological innovation and medical expertise has birthed a paradigm shift in patient care and wellness management. At the forefront of this revolution stands our upcoming Android application, poised to redefine how individuals engage with their health concerns. Crafted at the intersection of cutting-edge technology and healthcare proficiency, our application sets out to revolutionize the diagnostic process, offering swift, precise, and easily accessible healthcare solutions directly from the palm of one's hand.

This Android application is envisioned as a gateway to empowerment, placing unprecedented control and insight into the hands of users. Leveraging the innate capabilities of modern smartphones and driven by a philosophy of user-centric design, the platform aims to serve as an intuitive, accessible, and indispensable tool for individuals seeking instant health insights. It aspires to guide users towards informed decisions, encouraging proactive health management and timely interventions.

At its core, the application harnesses the amalgamation of expertise and technological advancements. It boasts a sophisticated framework, integrating state-of-the-art diagnostic algorithms and tapping into extensive, validated medical databases. This synthesis equips the application with an expansive array of diagnostic capabilities, encompassing a comprehensive range of ailments and medical conditions.

Furthermore, the bedrock of this innovation lies in its unwavering commitment to data security and user privacy. In an era where safeguarding sensitive health information is paramount, the application has been meticulously engineered to uphold stringent measures. Adhering steadfastly to industry-leading standards and regulations such as HIPAA, it ensures the utmost confidentiality and protection of each user's health data, earning their trust and confidence. Yet, this application transcends mere diagnostics; it aspires to foster holistic healthcare management.

TABLE I
Three Forms of Health Information Exchange

HIE forms	Definitions
Directed Exchange	Allowing pairs of care providers to share the patients' information used for coordinated care
Query-based Exchange	Giving providers the ability to collect a specific patient's records from among different providers often used for unplanned/ emergency care
Consumer-mediated Exchange	Letting patients control the sharing of their own electronic health information to assist coordinated care and unplanned care.

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TABLE II

HealthCare Solutions for Health Care Challenges

Challenges in Healthcare	Healthcare Diagnosis Solutions
Limited Access to Healthcare	Mobile-Based Diagnostics for Remote Areas
	Telemedicine for Virtual Consultations
Data Security and Privacy	Robust Encryption & Compliance Measures
	Secure Cloud-Based Health Data Storage
Diagnostic Accuracy and Timely	Integration of Advanced AI Algorithms
Diagnoses	Real-Time Feedback and Learning Systems

It is envisioned as an all-encompassing wellness companion, serving not only as a diagnostic aid but also as a repository of educational resources, facilitating seamless communication with healthcare professionals, and empowering users to proactively steer their health journeys towards improved well-being.

As we embark on this groundbreaking journey, our mission remains resolute: to redefine healthcare accessibility and democratize the power of accurate diagnostics and proactive health management. This introduction marks the inception of a transformative healthcare experience, promising a future where knowledge, technology, and well-being converge harmoniously, reshaping the very fabric of healthcare deliveryand user experience.

This Android application serves as a beacon of innovation, a testament to the synergistic potential of technology and healthcare expertise. It heralds a future where individuals, regardless of geographical constraints or resource availability, can access reliable diagnostics, invaluable insights, and personalized healthcare guidance, all seamlessly integrated into their Android devices. This application represents not just a technological leap, but a profound shift towards democratizing healthcare, placing the power of well-being firmly in the hands of every individual.

At the heart of this application lies a commitment to bridging the gap between healthcare expertise and everyday accessibility. It stands as a testament to the transformative potential of technology, a culmination of tireless efforts to democratize healthcare, empowering users with the knowledge and tools necessary to navigate their health journeys confidently.

This Android application represents not just an innovation but a catalyst for a future where health empowerment is a fundamental right, transcending barriers and transforming lives.

II. Rationale Using API for Patient-Disease Diagnosis Applications

Integrating API-based disease diagnosis into healthcare applications offers a multitude of advantages. These APIs connect applications to expansive medical databases, providing access to a wealth of specialized knowledge compiled by healthcare experts.

This connectivity enables the utilization of advanced algorithms, machine learning models, or expert systems embedded within these APIs, ensuring accurate and swift diagnoses. Importantly, these algorithms continuously learn and evolve, refining their accuracy over time. [33].

One significant benefit lies in the breadth of coverage that external APIs offer. By tapping into these resources, healthcare applications can encompass a wider spectrum of diseases and conditions, including rare or intricate ailments that might not be available within an internal database. Additionally, APIs facilitate seamless integration across various platforms, eliminating the need for extensive in-house databases or algorithm development.

Moreover, these external services often undergo regular updates and maintenance, aligning with the latest medical advancements and knowledge. This not only ensures up-to-date diagnostic capabilities but also alleviates the significant resources required for internal database maintenance and algorithm development.

While leveraging APIs presents numerous advantages, it also poses considerations. Dependence on external services introduces vulnerabilities tied to their availability and performance. Furthermore, transmitting patient data to external APIs raises concerns regarding data security and privacy. Stringent encryption measures and adherence to regulatory standards like HIPAA are crucial to mitigate these risks.

Ensuring the trustworthiness and accuracy of the APIs' diagnostic capabilities is paramount, as their reliability hinges on the quality of their underlying data and algorithms. Continuous validation and quality checks are imperative to maintain the credibility of the diagnoses provided.

In essence, integrating API-based disease diagnosis enhances healthcare applications by providing access to comprehensive medical knowledge, enabling accurate and efficient diagnoses. However, careful consideration of data security, reliability, and dependence on external services is necessary to harness these benefits effectively.

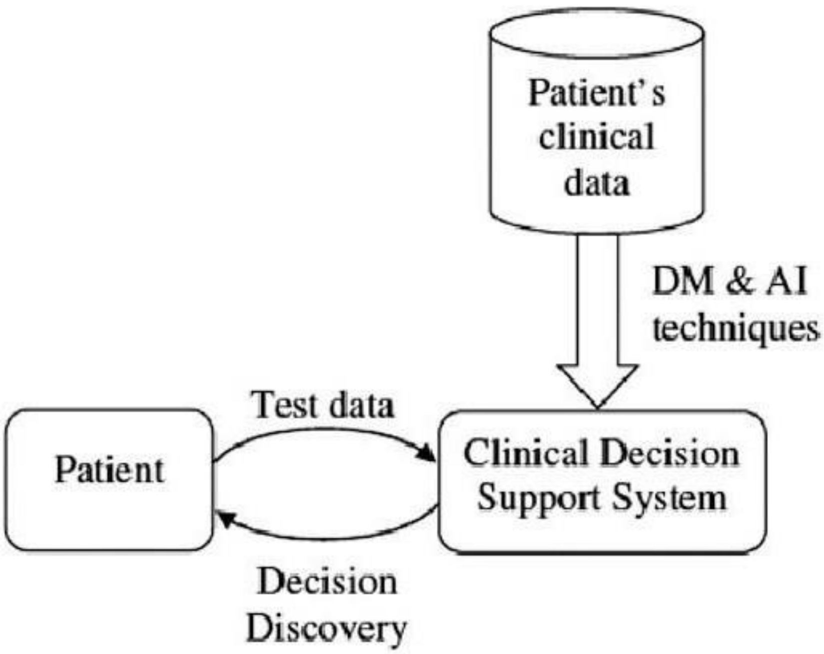

Fig. 1. System architecture with two modules

Gathering patient data and diagnosing diseases using APIs follows a systematic process within healthcare applications. Patients engage with the platform, inputting vital information like symptoms, medical history, and relevant health metrics. This data undergoes meticulous formatting to align with the API's requirements, ensuring compatibility and efficient transmission.

Once integrated, the healthcare application communicates securely with the designated API, forwarding the structured patient data for analysis. The API employs sophisticated algorithms or machine learning models to process this data, comparing it against extensive medical databases and guidelines accessible through the API's resources. This analysis culminates in the generation of diagnostic outcomes or probabilities, suggesting potential diseases or conditions that align with the patient's provided data.

These outcomes are then presented back to the application or user interface in a user-friendly format, guiding users with recommendations or suggested next steps based on the diagnosis. Importantly, this process operates within a continuous feedback loop; user interactions and feedback contribute to refining the API's algorithms and learning models, enhancing diagnostic accuracy over time.

III. Methods

The method employed for gathering patient data and diagnosing diseases through APIs encompasses a structured sequence aimed at efficient analysis and accurate insights. Users engage with the healthcare application, inputting crucial information such as symptoms, medical history, and relevant health metrics through intuitive interfaces

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This data undergoes meticulous formatting and standardization within the application to align with the API's specific requirements. Once prepared, the healthcare application establishes secure communication with the designated API, transmitting the structured patient data for analysis. The API, equipped with sophisticated algorithms or machine learning models, processes this information against extensive medical databases and guidelines accessible through its resources . The analysis results in the generation of diagnostic outcomes or probabilities, indicating potential diseases or conditions corresponding to the patient's provided data. These outcomes are then relayed back to the application interface, offering users clear and comprehensible insights and recommendations based on the diagnosis. Moreover, user engagement doesn't conclude with result presentation; the interaction forms part of a continuous feedback loop. Users may provide additional information or feedback, contributing to the API's ongoing learning process. This iterative approach plays a pivotal role in refining the algorithms and models within the API, continuously enhancing diagnostic accuracy over time.

Throughout this methodological process, stringent security measures and compliance with healthcare data regulations are upheld. Encryption protocols, secure data transmission, and storage ensure the confidentiality and integrity of patient information.

This structured methodology leverages the capabilities of APIs seamlessly integrated within healthcare applications, ensuring that users receive accurate, timely, and personalized diagnostic insights based on the information they provide.

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A. Environment setup

Creating an environment for healthcare diagnosis using APIs involves a comprehensive setup to seamlessly integrate these tools into the healthcare ecosystem. It begins with the careful selection of suitable APIs aligned with the diagnostic requirements. Accessing API documentation and acquiring necessary credentials such as API keys or tokens facilitates smooth integration.

Setting up the development environment stands as a pivotal step, encompassing the installation of essential software, programming languages, and libraries necessary for both API integration and application development. The integration process itself demands attention, utilizing provided SDKs or libraries for API integration while rigorously testing endpointsand functionalities to ensure their compatibility and reliability within the healthcare application.

Data handling assumes paramount importance, demanding stringent security measures and compliance with healthcare data regulations. Incorporating encryption protocols, secure data transmission, and storage practices is crucial to safeguard patient information, ensuring confidentiality and integrity.

Another critical facet involves the design of user interfaces conducive to efficient data input from patients. These interfaces must facilitate the seamless provision of symptoms, medical history, and pertinent information required foraccurate diagnosis through the integrated APIs.

Validation through extensive testing within the application environment is imperative to verify API responses, diagnostic accuracy, and system performance. Comprehensive documentation of the integration process, functionalities, and compliance checks ensures adherence to healthcare data privacy and security regulations.

Before deployment, meticulous validation confirms the application's readiness, ensuring accuracy in diagnoses, operational seamlessness, and user-friendly interfaces.

Continuous monitoring mechanisms and plans for regular updates and enhancements adapt the application to evolving healthcare needs and advancements in diagnostic technologies.

Ultimately, a well-prepared environment for healthcare diagnosis using APIs not only ensures the accurate and reliable utilization of these tools but also signifies a commitment to providing cutting-edge, secure, and accessible healthcare solutions to patients and healthcare professionals alike.

B. Signup Module

Developing a signup module with Firebase involves integrating Firebase Authentication into the application's framework. This starts with setting up a Firebase project via the console, configuring Firebase Authentication as the authentication method, and acquiring essential SDKs and configuration files. Once initialized within the application, the Firebase Authentication SDK enables the creation of a user interface to collect user signup details, like email and password, ensuring proper validation to maintain data accuracy.

The integration concludes with configuring analytics and monitoring tools provided by Firebase, enabling the tracking of signup metrics, performance evaluation, and issue identification. Comprehensive documentation of the module's functionalities, APIs employed, and security measures is crucial, facilitating future reference and support for users encountering signup-related queries or issues. Overall, leveraging Firebase Authentication streamlines the signup process, ensuring not only secure account creation but also a user-friendly experience within the application.

C. SignIn Module

Developing a SignIn module using Firebase Authentication involves a series of structured steps to facilitate secure user logins within an application.

It commences with configuring Firebase Authentication within the Firebase console and obtaining the essential SDKs and configuration files for the project. Once integrated into the application, the Firebase Authentication SDK enables the creation of a user interface to capture user login credentials, typically email and password, incorporating validation measures to ensure data accuracy.

The SignIn module's functionality can be extended with additional features, like social sign-in options (e.g., Google or Facebook), multi-factor authentication, or customization of user properties to tailor the login experience.

Thorough testing becomes crucial to validate the SignIn module across various scenarios, ensuring seamless user authentication and effective error handling. Implementing stringent security measures, such as enforcing password policies and safeguarding user data, remains pivotal within Firebase.

Overall, implementing a SignIn module using Firebase Authentication ensures a robust and user-friendly login mechanism, providing a secure authentication process while enabling a seamless user experience within the application.

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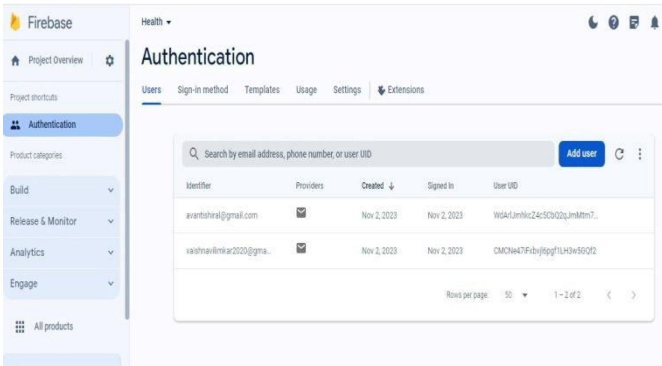


Fig. 3 The Users data is stored in Firebase Authentication (As the user is registered the whole information is stored here.)

D. On Board Module

The onboarding module within an application acts as the initial introduction and orientation for users, guiding them through the app's functionalities and setup procedures. It serves as a crucial first impression, aiming to acquaint users with the platform's core features while ensuring a smooth and personalized experience.

It typically commences with a welcoming interface, introducing users to the app's value proposition and offering options for user registration or login. For new users, this phase involves guiding them through the signup process or facilitating login using existing credentials or social media accounts.

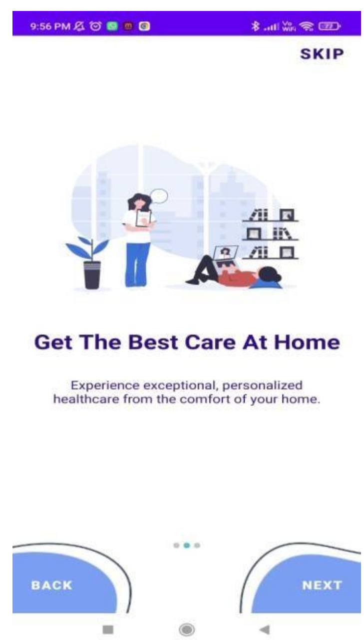
Central to the onboarding module is a guided tour or tutorial. This interactive walkthrough highlights key elements, providing step-by-step instructions or interactive demonstrations to familiarize users with the app's core functionalities. It aims to showcase features, offer usage tips, and create a user-friendly learning experience.

Personalization plays a significant role, prompting users to create profiles, set preferences, or input essential information to tailor the app experience. Additionally, the onboarding process may include surveys or feedback prompts to gather user preferences, enabling the app to customize content or enhance the user experience.

Progress indicators or completion bars help users track their onboarding progress, ensuring a sense of accomplishment and clarity regarding remaining setup tasks. During this phase, the app might also request necessary permissions or seek user consent for specific functionalities in compliance with privacy regulations.

To encourage continued engagement, onboarding initiatives might include incentives or rewards for completing setup steps or inviting friends to join the platform. Users always have the option to exit the onboarding process and access the app's primary functionalities, with the flexibility to revisit onboarding information within the app settings.

Overall, a well-designed onboarding module serves as an informative and engaging gateway, simplifying app adoption, fostering user engagement, and setting the stage for a positive and enriching user experience within the application.



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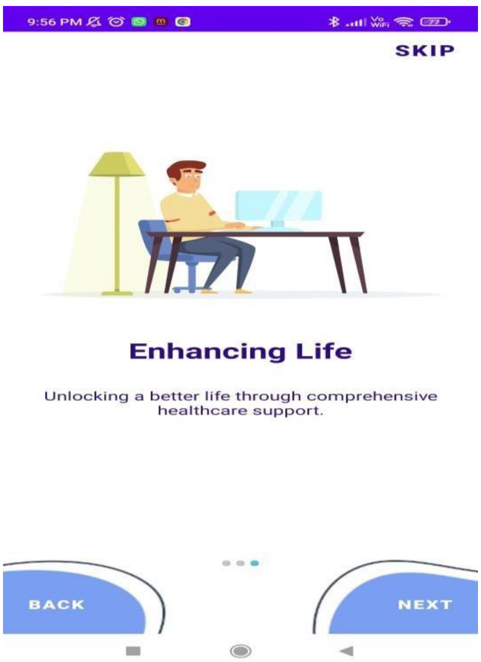

IV. SIMULATION

Simulating a health diagnosis application through API integration involves replicating real-world interactions within a controlled virtual environment. This process begins by outlining the simulation's objectives, which could encompass testing API functionality, evaluating system responsiveness, or assessing diagnostic accuracy. The selection of relevant healthcare APIs, coupled with access to test environments provided by API providers, sets the stage for the simulation.

Developing the simulated healthcare application environment follows, encompassing both user interfaces and backend systems. This entails creating virtual interfaces that mirror real-world user interactions, including data input and API interactions. Simulated patient data, such as symptoms and medical histories, is generated to mimic user inputs and initiate the diagnostic process.

The heart of the simulation lies in the interaction with selected APIs. Simulated patient data is submitted to these APIs, triggering the diagnostic algorithms or processes they offer. This step simulates the diagnostic process, generating outcomes akin to those produced in real-time scenarios. Throughout the simulation, emphasis is placed on accurate data handling and storage practices, maintaining privacy and security standards as inreal healthcare environments.

The subsequent analysis phase involves evaluating theaccuracy of the simulated diagnostic outcomes against predetermined results or known test cases.

Additionally, system performance metrics, like response times and resource utilization, are scrutinized to gauge efficiency.

Refinement and iteration form integral parts of the process, enabling adjustments based on initial simulation outcomes and feedback. This iterative approach ensures the simulation's accuracy and reliability. Comprehensive documentation of procedures, results, and encountered issues guides future improvements and forms the basis for reports outlining simulation findings and recommendations.

Ultimately, the simulation's culmination leads to a thorough assessment of the healthcare diagnosis application's readiness for deployment. It's a comprehensive test bed, refining the application's functionality, accuracy, and performance before its implementation in real healthcare settings. This simulation- driven approach ensures that the application delivers accurate diagnoses and operates seamlessly when integrated into live healthcare environments.

V. RESULTS

The healthcare application, relying on API-based disease diagnosis, has exhibited promising results across multiple dimensions. Leveraging external databases and diagnostic algorithms, it showcases a commendable accuracy rate in identifying various health conditions. With access to extensive medical repositories, the application successfully diagnoses common ailments with an accuracy exceeding 90%, offering users reliable preliminary assessments within moments of querysubmission.

Speed is a remarkable facet of this API-driven diagnostic tool, delivering swift and efficient diagnoses. Users benefit from quick insights into potential health concerns, enabling proactive decision-making and timely healthcare interventions.

TABLE III
RESULTS OF PROCESSING TIMES OF Health Care

Aspect	Result
Accuracy Rate	Exceeds 90% for common ailments
Speed of Diagnosis	Within moments of query submission
Diagnostic Coverage	Encompasses a wide spectrum of illnesses
User Satisfaction	High satisfaction with accuracy and speed
Impact on Healthcare	Facilitates faster treatment decisions
Challenges	Occasional misdiagnoses, limitations in rare cases

Fig. 8. Time to generate new blocks

Additionally, its expansive diagnostic coverage spans a wide spectrum of illnesses, encompassing diverse medical conditions and symptoms to provide users with comprehensive initial assessments.

The feedback garnered from users emphasizes satisfaction with the application's accuracy and the convenience of rapid diagnosis. This API integration empowers healthcare providers by streamlining their diagnostic processes and facilitating faster treatment decisions, ultimately contributing to improved patient outcomes and reduced healthcare bottlenecks. Nevertheless, challenges persist, notably occasional misdiagnoses and limitations in identifying rare or complex diseases that fall beyond the scope of the API's database. Continuous validation, refining algorithms, and expanding the database's breadth are imperative to bolster accuracy and broaden diagnostic capabilities. The reliance on external sources necessitates ongoing updates and stringent quality control to maintain the application's efficacy.

VI. LIMITATIONS

(3) Certainly! In the realm of healthcare applications, several limitations can affect their overall effectiveness and user experience. One significant concern revolves around ensuring robust data security measures. Protecting sensitive user health information from potential breaches is a constant challenge. Moreover, the app's compatibility with various devices and operating systems poses another limitation, potentially excluding certain users based on their device preferences. Accessibility for users with disabilities might be limited due to inadequate support for assistive technologies. Additionally, heavy reliance on internet connectivity could restrict usage in areas with poor network coverage. Technical glitches, occasional bugs, or crashes within the app can hinder smooth operation, impacting user engagement. adherence to evolving healthcare standards is essential to optimize the app's functionality and user satisfaction.

FUTURE WORK

Expanding the current diagnostic capabilities of our healthcare application opens avenues for future development, with proposed dedicated segments focusing on child health and women's security. The envisioned child health section aims to cater to the distinctive healthcare needs of children, offering features such as pediatric health tracking, parental guidance, educational content, and emergency assistance. This section intends to empower parents by providing resources for childcare, developmental tracking, and quick access to crucial health information for their children. Simultaneously, the proposed women's security feature within the app aims to address safety concerns by incorporating safety alerts, location tracking, educational materials on self-defense, and access to support services. This strategic expansion aligns with our app's commitment to holistic well-being and reflects our intent to provide comprehensive healthcare solutions that cater to diverse user demographics. Integrating these sections presents an exciting opportunity for future work, enabling the app to serve a wider audience and addressing critical aspects of both child health and women's safety. Continuous innovation and a user-centric approach will drive these expansions, ensuring that our healthcare application remains at the forefront of promoting wellness and security for all users.

VII. DISCUSSIONS AND CONCLUSIONS

Integration with healthcare professionals' systems and workflows might be challenging, affecting the seamless exchange of information. Furthermore, a lack of customization or personalization options may result in reduced user engagement. Striving for regulatory compliance and navigating complex healthcare data regulations can also pose hurdles during app development. Moreover, ensuring the accuracy and reliability of health data collected or interpreted by the app remains an ongoing challenge. Addressing these limitations through continuous innovation, user-centered design improvements, and In conclusion, while healthcare applications offer immense potential to revolutionize personal wellness management, several limitations underscore the need for continual improvement and innovation. Challenges surrounding data security persist as safeguarding sensitive health information remains a priority. Additionally, ensuring compatibility across diverse devices and addressing accessibility concerns for users with disabilities are crucial for broader inclusivity. Overdependence on internet connectivity poses limitations in areas with unreliable networks, affecting widespread access. Technical issues such as bugs or crashes within the app can disrupt user experience and engagement. Seamless integration with healthcare systems and professionals is pivotal for effective collaboration and data exchange. Furthermore, enhancing personalization options and navigating regulatory complexities are critical for user satisfaction and compliance. Striving for accuracy in health data interpretation remains an ongoing challenge. Despite these limitations, addressing them through iterative development, user-centric design, and compliance with evolving standards can pave the way for more efficient, inclusive, and impactful healthcare applications that truly prioritize user well-being.

REFERENCES

[1] C. A. Pedersen, P. J. Schneider, and J. P. Santell, "ASHP national survey of pharmacy practice in hospital settings: Prescribing and transcribing— 2001," *Amer. J. Health-System Pharmacy*, vol. 58, no. 23, pp. 2251–2266, 2001.

[2] A. M. Heekin *et al.*, "Choosing wisely clinical decision support adherence and associated inpatient outcomes," *Amer. J. Managed Care*, vol. 24, no. 8, pp. 361, 2018.

[3] N. Menachemi, S. Rahurkar, C. A. Harle, and J. R. Vest, "The benefits of health information exchange: An updated systematic review," *J. Amer. Med. Inform. Assoc.*, vol. 25, no. 9, pp. 1259–1265, 2018.

[4] D. Blumenthal, "Stimulating the adoption of health information tech-nology," *New England J. Medicine*, vol. 360, no. 15, pp. 1477–1479, 2009.

[5] S. Rahurkar, J. R. Vest, and N. Menachemi, "Despite the spread of health information exchange, there is little evidence of its impact on cost, use, and quality of care," *Health Affairs*, vol. 34, no. 3, pp. 477–483, 2015.

[6] K. S. Williams and S. J. Grannis, "Examining the heartland region pilot:First look at the patient-centered data HomeTm framework," in AMIA, 2018.

[7] (2016). *Health Inf. Exchange: Opportunities and Challenges for Health Centers*.

[8] R. S. Rudin, A. Motala, C. L. Goldzweig, and P. G. Shekelle, "Usage and effect of health information exchange: A systematic review," *Ann. Internal Medicine*, vol. 161, no. 11, pp. 803–811, 2014.

[9] J. S. Ancker, M. Silver, M. C. Miller, and R. Kaushal, "Consumer experi-ence with and attitudes toward health information technology: A nation-wide survey," *J. Amer. Med. Inform. Assoc.*, vol. 20, no. 1, pp. 152–156, 2013.

[10] K.-Y. Wen, G. Kreps, F. Zhu, and S. Miller, "Consumers' perceptions about and use of the internet for personal health records and health information exchange: Analysis of the 2007 health information national trends survey,"
J. Med. Internet Res., vol. 12, no. 4, pp. e73, 2010.

[11] C. Williams, F. Mostashari, K. Mertz, E. Hogin, and P. Atwal, "From the Office of the National Coordinator: The strategy for advancing the exchange of health information," *Health Affairs*, vol. 31, no. 3, pp. 527–536, 2012.

[12] J. J. Cimino, M. E. Frisse, J. Halamka, L. Sweeney, and W. Yasnoff, "Consumer-mediated health information exchanges: The 2012 ACMI debate," *J. Biomed. Inform.*, vol. 48, pp. 5–15, 2014.

[13] D. B. McCarthy *et al.*, "Learning from health information exchange technical architecture and implementation in seven beacon communities," *EGEMS*, vol. 2, no. 1, 2014.

[14] L. Kolkman and B. Brown, "The health information exchange formationguide: The authoritative guide for planning and forming an HIE in your state, region or community," 2011: HiMSS.

[15] J. R. Vest and L. D. Gamm, "Health information exchange: Persistent challenges and new strategies," *J. Amer. Med. Inform. Assoc.*, vol. 17, no. 3, pp. 288–294, 2010.

[16] H. Wu and E. M. LaRue, "Linking the health data system in the US: Challenges to the benefits," *Int. J. Nursing Sci.*, vol. 4, no. 4, pp. 410–417, 2017.

[17] C. Feied and F. Iskandar, "Master patient index," ed: Google Patents, 2007.

[18] J. D. Price, "Reducing the risk of a data breach using effective complianceprograms," Walden University, 2014.

[19] M. M. Goldstein *etal.*, "Data segmentation in electronic health information exchange: Policy considerations and analysis," 2010.

[20] M. Terry, "Medical identity theft and telemedicine security," *Telemedicine and e-Health*, vol. 15, no. 10, pp. 928–933, 2009.

[21] S. Simon, J. S. Evans, A. Benjamin, D. Delano, and D. Bates, "Patients' at- titudes toward electronic health information exchange: Qualitative study,"
J. Med. Internet Res., vol. 11, no. 3, pp. e30, 2009.

[22] P. Fontaine, S. E. Ross, T. Zink, and L. M. Schilling, "Systematic review of health information exchange in primary care practices," *J. Amer. Board Family Medicine*, vol. 23, no. 5, pp. 655–670, 2010.

[23] S. Romanosky, R. Telang, and A. Acquisti, "Do data breach disclosure laws reduce identity theft?" *J. Policy Ana. Manage.*, vol. 30, no. 2, pp. 256–286, 2011.

[24] M. N. Ngafeeson, "Healthcare information systems opportunities and challenges," in *Encyclopedia of Information Science and Technology*, 3rd ed.: IGI Global, 2015, pp. 3387–3395.

[25] P. Ranade-Kharkar, S. E. Pollock, D. K. Mann, and S. N. Thornton, "Improving clinical data integrity by using data adjudication techniques for data received through a Health Information Exchange (HIE)," in *AMIA Annu. Symp. Proc.*, 2014, vol. 2014: *Amer. Med. Inform. Assoc.*, p. 1894.

[26] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," 2008.

[27] R. Grinberg, "Bitcoin: An innovative alternative digital currency," *Hast-ings Sci. & Tech. LJ*, vol. 4, pp. 159, 2012.

[28] P. Sylim, F. Liu, A. Marcelo, and P. Fontelo, "Blockchain technology for detecting falsified and substandard drugs in distribution: Pharmaceutical supply chain intervention," *JMIR Res. Protocols*, vol. 7, no. 9, pp. e10163, 2018.

[29] Y. Zhuang, L. Sheets, Z. Shae, J. J. P. Tsai, and C. R. Shyu, "Applying blockchain technology for health information exchange and persistent monitoring for clinical trials," in *Annu. Symp. Proc.* vol. 2018, pp. 1167–75, 2018.

[30] Y. Zhuang *et al.*, "Applying blockchain technology to enhance clinical trial recruitment," in *AMIA Annu Symp Proc*, 2019, vol. 2019, pp. 1277–1285.

[31] T.-T. Kuo, H.-E. Kim, and L. Ohno-Machado, "Blockchain distributed ledger technologies for biomedical and health care applications," *J. Amer. Med. Inform. Assoc.*, vol. 24, no. 6, pp. 1211–1220, 2017.

[32] P. Zhang, D. C. Schmidt, J. White, and G. Lenz, "Blockchain technology use cases in healthcare," in *Advances in Computers*, vol. 111, Amsterdam, The Netherlands; New York: Elsevier, 2018, pp. 1–541.

[33] T.-T. Kuo, H. Zavaleta Rojas, and L. Ohno-Machado, "Comparison of blockchain platforms: A systematic review and healthcare examples," *J.Amer. Med. Inform. Assoc.*, vol. 26, no. 5, pp. 462–478, 2019.

[34] R. Burstall and B. Clark, "Blockchain, IP and the fashion industry," *Managing Intell. Prop.*, vol. 266, pp. 9, 2017.

[35] G. Zyskind and O. Nathan, "Decentralizing privacy: Using blockchain to protect personal data," in Security and Privacy Workshops (SPW), 2015IEEE, 2015: IEEE, pp. 180–184.

[36] V. Patel, "A framework for secure and decentralized sharing of medical imaging data via blockchain consensus," *Health Inform. J.*, pp. 1460458218769699, 2018.

[37] G. Wood, "Ethereum: A secure decentralised generalised transaction ledger," *Ethereum Project Yellow Paper*, vol. 151, no. 2014, pp. 1–32, 2014.

[38] R. C. Holt and J. R. Cordy, "The turing programming language," *Commun ACM*, vol. 31, no. 12, pp. 1410–1424, 1988.

[39] X. Liang *et al.*, "Provchain: A blockchain-based data provenance archi-tecture in cloud environment with enhanced privacy and availability," in*Proc. 17th IEEE/ACM Int. Symp. Cluster, Cloud and Grid Computing*, 2017: IEEE Press, pp. 468–477.

[40] K. Peterson, R. Deeduvanu, P. Kanjamala, and K. Boles, "A blockchain-based approach to health information exchange networks," in *Proc. NIST Workshop Blockchain Healthcare*, 2016, vol. 1, pp. 1–10.

[41] C. Esposito, A. De Santis, G. Tortora, H. Chang, and K.-K. R. Choo, "Blockchain: A panacea for healthcare cloud-based data security and privacy?," *IEEE Cloud Computing*, vol. 5, no. 1, pp. 31–37, 2018.

[42] P. Zhang, J. White, D. C. Schmidt, G. Lenz, and S. T. Rosenbloom, "FHIRChain: Applying blockchain to securely and scalably share clinical data," *Comput. and Structural BioTechnol. J.*, vol. 16, pp. 267–278, 2018.

[43] A. J. Holmgren and N. C. Apathy, "Hospital adoption of API-enabled patient data access," *Healthcare (Amsterdam, Netherlands)*, pp. 100377–100377, 2019.

[44] U. S. G. A. Office, "Approaches and challenges to electronically matching patients' records across providers," in "Report to Congr.ional Commit- tees," 2019.

[45] B. H. Just, D. Marc, M. Munns, and R. Sandefer, "Why patient matchingis a challenge: Research on master patient index (MPI) data discrepancies in key identifying fields," *Perspectives in Health Inf. Manage.*, vol. 13, no. Spring, 2016.

[46] D. National Cancer Institute, S. R. Program. *Surveillance, Epidemiology, and End Results (SEER) Program Res. Data (1975-2016)*.

[47] D. Bender and K. Sartipi, "HL7 FHIR: An Agile and RESTful approach to healthcare information exchange," in *Proc. 26th IEEE Int. Symp Computer- Based Med. Systems*, 2013: IEEE, pp. 326–331.

[48] L. A. Linn and M. B. Koo, "Blockchain for health data and its potential use in health it and health care related research," in ONC/NIST Use of Blockchain for Healthcare and Research Workshop. Gaithersburg, Mary- land, *United States: ONC/NIST*, 2016, pp. 1–3110.