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Navigating the Maze of AI in Pharma: Validation, Regulatory Compliance, and Continuous Inspection Readiness

Hans de Raad – 14th March 2024

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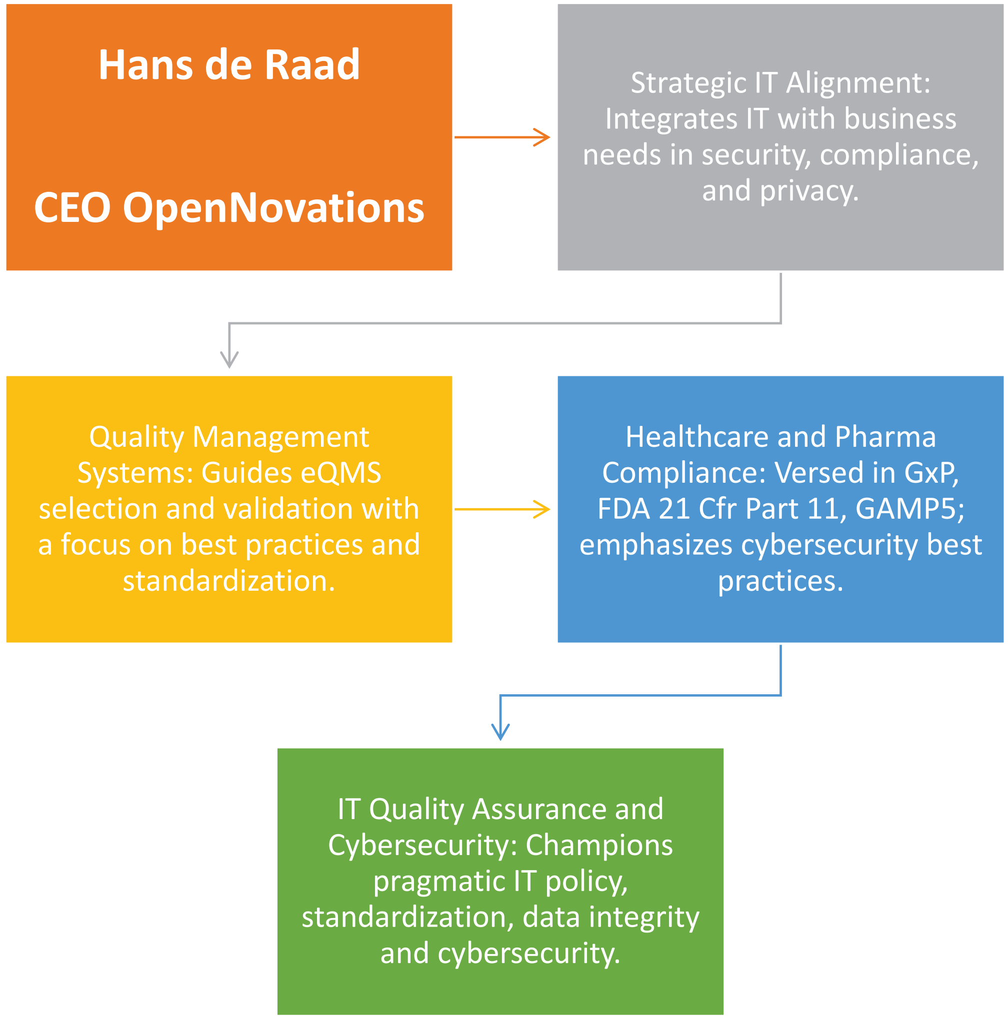
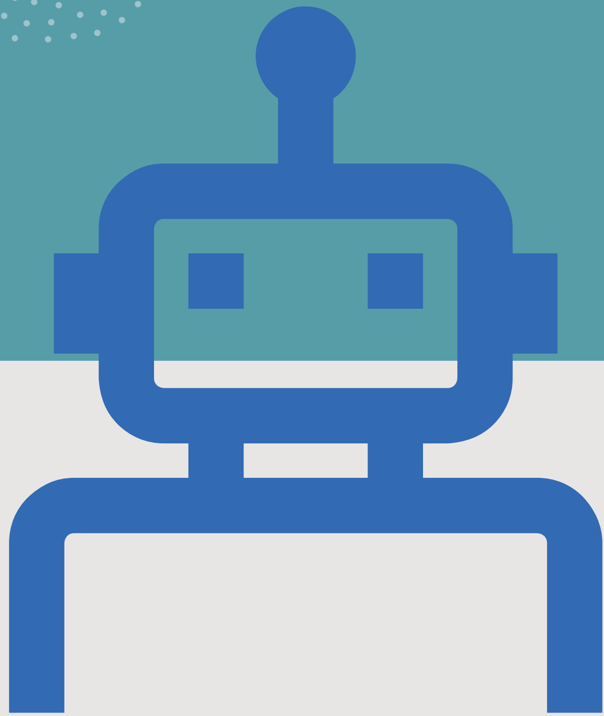
Who am I?


Hans de Raad
CEO OpenNovations
Strategic IT Alignment: Integrates IT with business needs in security, compliance, and privacy.
Quality Management Systems: Guides eQMS selection and validation with a focus on best practices and standardization.
Healthcare and Pharma Compliance: Versed in GxP, FDA 21 Cfr Part 11, GAMP5; emphasizes cybersecurity best practices.
IT Quality Assurance and Cybersecurity: Champions pragmatic IT policy, standardization, data integrity and cybersecurity.

Improving Drug Discovery with AI

- **AI's Role in Accelerating Drug Discovery**: AI technologies are reshaping how pharmaceutical companies approach the discovery and development of new drugs by analyzing biological and chemical data at unprecedented speeds.
- **Predictive Modeling to Identify Drug Candidates**: Leveraging AI algorithms to predict how different chemical compounds will behave and interact with targets in the body, significantly speeding up the identification process.

Improving Drug Discovery with AI (2)



- **Integration with Genomics for Personalized Medicine:** AI's ability to integrate genetic information with clinical data, paving the way for more personalized and effective treatment options.
- **Collaborative Efforts in Pharma:** Collaborations such as IMPALA with Roche and many others, which publish open-source AI models and verification tools for innovative drug discovery.

AI-Driven Manufacturing Optimization in Pharma

- **Enhancing Quality Control with AI**: Implementing AI to automate quality control processes, detect defects, and reduce waste, thereby improving the manufacturing efficiency.
- **Continuous Process Verification (CPV):** AI's role in CPV, using real-time data analysis to ensure manufacturing processes remain within defined parameters, ensuring product quality and compliance.
- **AI in Production Decision-Making:** Smith+Nephew medical imaging platform as an example of AI's application in making precise decisions during manufacturing, especially in medical device production, regarding surgical molds.
- **Reducing Material Waste through AI:** Applying machine learning algorithms to predict and minimize waste production, leading to more sustainable manufacturing practices.
- **Case Study to follow: AI for Quality Assurance:** How AI technologies are integrated into the pharmaceutical manufacturing workflows to anticipate issues before they affect product quality.

Personalized Medicine with AI

- **Predictive Biomarkers for Treatment Plans:** Utilizing AI to identify biomarkers that can predict how patients will respond to treatments, enabling more tailored therapeutic approaches.
- **QUALITOP Project:** The QUALITOP project employs an open digital platform to monitor the quality of life of cancer patients' post-treatment, showcasing the benefits of AI in post-care management.
- **Generative AI in Drug Design:** McKinsey's analysis on how generative AI can significantly impact drug design by creating novel chemical entities with desired properties, accelerating the drug discovery process.
- **Personalization at Scale:** The capability of AI to handle vast amounts of genetic and phenotypic data, enabling the personalization of medicine at an unprecedented scale.
- **Outcomes and Impacts:** The benefits observed from integrating AI into personalized medicine, include improved patient outcomes and more efficient use of healthcare resources.

Enhancing Clinical Trials through AI

- **Streamlining Participant Selection:** AI's utility in refining the process of selecting suitable participants for clinical trials, enhancing the efficiency and effectiveness of studies.
- **ASCAPE Project:** Example; the ASCAPE project's efforts to develop an open AI infrastructure aimed at enhancing cancer patient care through intelligent interventions and early diagnosis.
- **Improving Study Design and Execution:** How AI technologies are applied to optimize clinical trial design, monitoring, and data analysis, ensuring faster and more reliable outcomes.
- **AI in Adaptive Trials:** The role of AI in facilitating adaptive clinical trials, where algorithms can suggest real-time adjustments to study parameters based on interim results.
- **Impact on Drug Development Timeline:** Evaluating AI's potential to reduce the time and cost associated with bringing new therapeutics to market, from discovery through clinical trials.

The Evolution of AI in Healthcare

- **McKinsey's Phases of AI Integration:** Three key phases of AI integration into healthcare, initial focus on administrative tasks and imaging applications, a shift towards home-based care with remote monitoring and virtual assistants, and advanced integration into clinical decision support based on clinical trials evidence.
- **Addressing Healthcare Challenges with AI:** AI is being used to tackle major healthcare issues such as reducing hospital readmission rates and managing chronic illnesses more effectively.
- **AI's Role in Remote Monitoring and Care:** The growing use of AI in supporting home-based care, including remote patient monitoring and the use of virtual health assistants for early warning on deviations in vital signs.
- **Clinical Decision Support Systems (CDSS):** The advancement towards AI-powered CDSS that utilize clinical evidence and patient data to assist healthcare providers in making informed treatment decisions.
- **Case Study:** Utilization of NLP for patient matching in clinical cancer studies. By analyzing patient data and matching it with relevant clinical trials, AI technologies like NLP improve the accuracy and efficiency of patient selection.

Ensuring Data Integrity in Pharma through AI

- **Role of AI in Data Verification:** AI's capability to automatically verify the accuracy and completeness of data collected from various sources, reducing human error in pharmaceutical R&D.
- **Knowledge Extraction from Unstructured Data:** Utilizing NLP and machine learning to analyze patents, scientific publications, and clinical trial data, extracting valuable insights for drug development.
- **Traceability and Transparency:** How blockchain and advanced database solutions can ensure that each data point can be traced back to its origin, maintaining a clear audit trail for regulatory compliance.
- **Real-time Data Evaluation:** The importance of AI tools in continuously monitoring data integrity, allowing for immediate corrective actions to maintain the quality and reliability of research findings.
- **Compliance with Regulatory Standards:** AI's role in ensuring that data handling and processing comply with stringent industry standards, such as FDA's 21 CFR Part 11 and EMA's Annex 11, through automated compliance checks.

Overview of AI Analytics Data Pipeline Components

1. **Data Collection Origin:** The starting point of the data journey, encompassing APIs, IoT devices, databases, and manual data entry points critical in pharmaceutical research.
2. **Serialization & Event Frameworks:** The standardization of data into a format that's easily accessible and manageable. This includes the use of technologies like Apache Kafka for real-time data processing.
3. **Workflow Management Systems:** Systems like Apache Airflow or Debezium that manage the flow of data, ensuring tasks are executed in sequence or parallel based on their dependencies.
4. **Data Storage Solutions:** Role of databases, like PostgreSQL, and data lakes in storing incoming data securely and efficiently, crucial for later retrieval and analysis in R&D.
5. **Dataflow and Processing:** Process of data transformation, cleaning, and preparation for analysis. This involves machine learning models for pattern recognition or statistical tools for normalization.

Streamlining Data Flow with AI in Pharmaceutical R&D

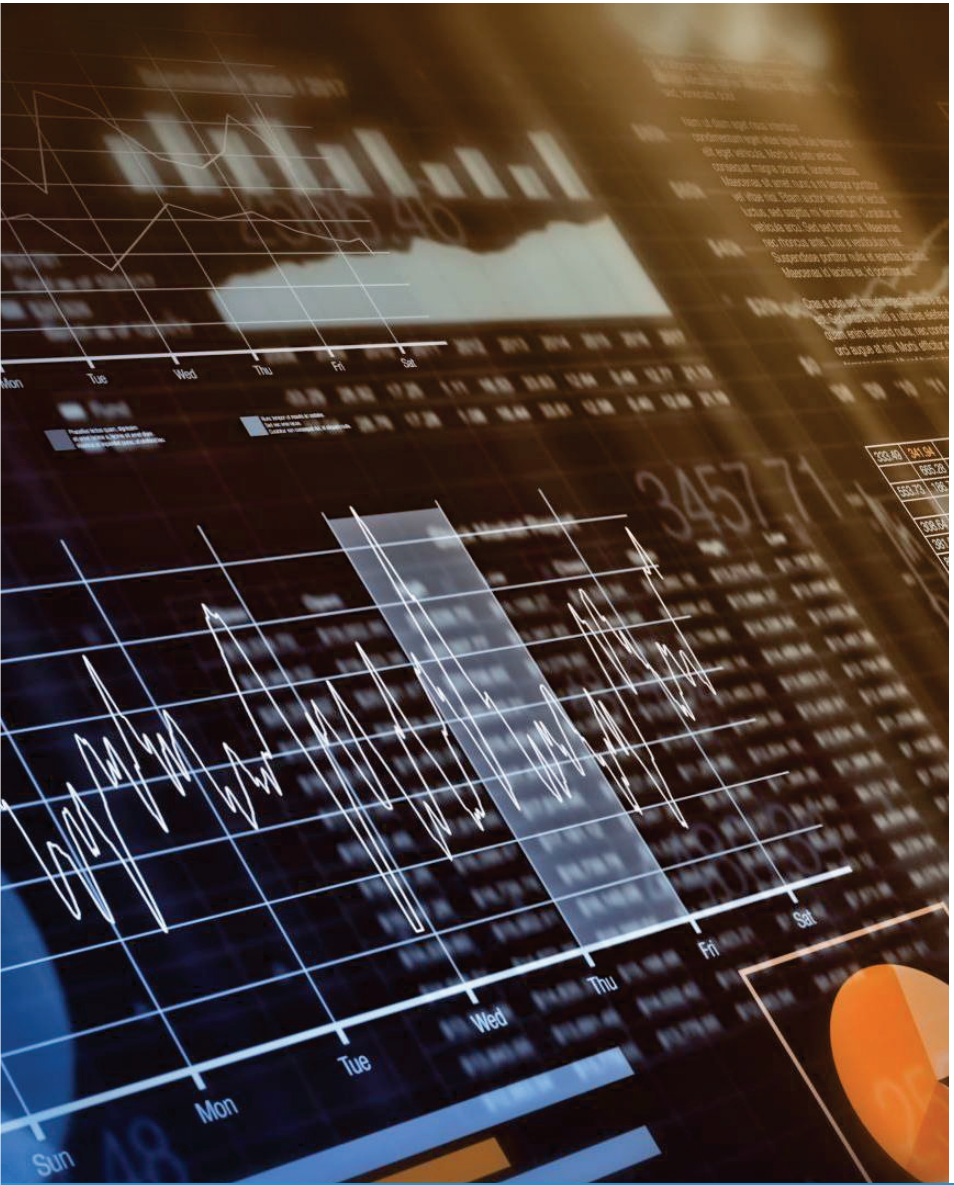
- **Integration of Source Systems:** AIs ability to correlate data from disparate source systems, including electronic health records (EHRs), laboratory information management systems (LIMS), and research databases, to create a harmonized data ecosystem.
- **AI-Driven Data Curation:** The use of AI for curating data by identifying and discarding irrelevant, anomalous or redundant information, ensuring only high-quality data is used in the drug development process.
- **Predictive Analytics for Decision Support:** Applying AI algorithms to analyze data flow and predict outcomes, supporting decision-making in drug design, clinical trials, and market strategies.
- **Enhancing Collaboration through Data Sharing:** AI's role in enabling secure and efficient data sharing among researchers, clinicians, and regulatory bodies, fostering collaboration and speeding up the drug development cycle.
- **Prospects of AI in Data Management:** The evolving role of AI in transforming data analytics, with advancements in AI technologies promising even greater efficiencies, accuracy, and insights in pharmaceutical research.

Enhancing Interface and Interoperability Management with AI

- **AI in Interface and Interoperability Management:** AI technologies, including machine learning (ML) and natural language processing (NLP), are pivotal in streamlining interface and data interoperability management in healthcare, ensuring systems communicate effectively and data flows seamlessly across different platforms.
- **Semantic Interoperability Enabled by AI:** Semantic interoperability refers to the ability of computer systems to exchange data with unambiguous, shared meaning. AI aids in achieving this by interpreting and classifying data in a way that is universally understandable, thus enhancing the compatibility and usefulness of data exchanged between disparate healthcare systems.
- **Contextual Compatibility of Datasets:** AI technologies ensure that data is not only exchanged but also contextually relevant, maintaining the integrity and applicability of information. This involves understanding the context in which data is used and ensuring compatibility across different systems and use cases.
- **Importance and Future Directions:** The role of AI in data exchange is crucial for the future of healthcare IT, offering solutions for improved data interoperability, accuracy in patient care, and overall system efficiency. Ongoing advancements in AI and machine learning will continue to push the boundaries of what's possible in data exchange and system integration.

Model Training, Testing, and Validation (OpenNovations/ Sonador)

- **Model Training Process**
  - **Data Preparation:** Datasets from diverse sources, including medical imaging and patient records, are prepared and logged for analysis, leveraging the MLFlow framework for effective tracking.
  - **AI Model Training:** Utilizing MONAI, AI models specifically tailored for medical imaging are trained, enabling the creation of highly accurate diagnostic tools.
- **Testing and Validation Strategies**
  - **GxP Regulatory Compliance:** Validation processes are designed to adhere to Good Practice (GxP) guidelines, focusing on risk-based approaches and comprehensive documentation to ensure regulatory compliance.
  - **Continuous Validation Methods:** Post-deployment, continuous validation techniques are implemented, ensuring the AI models remained effective and accurate over time, adjusting to new data and conditions.



Model Training, Testing, and Validation (OpenNovations/ Sonador) (2)

- **Image Processing Validation:** Employed ground truth verification alongside accuracy measurement techniques such as Receiver Operating Characteristic (ROC) curves and confusion matrices, verifying model classification performance against known outcomes.
- **Technical and Security Considerations**
  - **Apache Kafka for Data Pipelines:** The integration with Kafka supports efficient real-time data processing, crucial for handling the volume and velocity of healthcare data.
  - **DICOM and EHR Data Management:** Utilizing PostgreSQL for DICOM data management and Aranei for Electronic Health Record (EHR) data handling ensures robust and efficient management of critical healthcare information.
  - **Security Measures:** Implementation of stringent security protocols, including data protection, access control, and incident response, is crucial in maintaining the integrity and confidentiality of sensitive healthcare data. Also providing comprehensive audit trails of any data operation.

Leveraging AI for Enhanced Regulatory Compliance

Improving Data Extraction Processes: AI and NLP are used to efficiently discover, highlight, and extract crucial data from regulatory documents, significantly reducing manual effort and increasing accuracy.

Streamlining Regulatory Affairs: AI is speeding up regulatory affairs, from filing to monitoring, and how it helps in correlating regulatory data across different systems and platforms.

Supporting Digital Transformation: AI is supportive in driving digital transformation within regulatory compliance, enabling more agile responses to regulatory changes and simplifying complex processes.

Enhancing Decision-Making: AI-supported analytics provide deeper insights for regulatory decision-making, ensuring that compliance strategies are data-driven and more effective.

Real-World Applications of AI in Regulatory Compliance

NLP in Compliance: Real-world example is how NLP is being utilized in regulatory compliance to automate and improve processes such as regulatory labelling and the extraction of key information.

Mapping to Standards: The application of AI in mapping unstructured regulatory data to standardized formats, such as the Identification of Medicinal Products (IDMP), facilitating better product requirements specification and eventually compliance.

Data-Driven Risk Management: How AI technologies support data-driven approaches to risk management in regulatory compliance, identifying deviations in data which could point to potential issues before they escalate.

Semi-Automated Regulatory Intelligence Monitoring: How companies are integrating AI to semi-automate the monitoring of regulatory changes and guidelines, enhancing the efficiency and accuracy of compliance efforts.

Collaboration Between AI and Human Expertise: The synergies between AI technologies and human regulatory experts, and how these collaborations are setting new standards for efficiency, accuracy, and agility in regulatory compliance.

Predictions for Safety and Regulatory Compliance in 2024

Forecasting AI's Growing Influence: Predictions on how AI and machine learning technologies are expected to revolutionize safety and regulatory compliance in the pharmaceutical industry by 2024.

Trend Analysis: Upcoming trends and the potential impact of new AI technologies on the regulatory landscape, including advancements in predictive analytics and machine learning models.

Strategic Adaptations for Compliance: How companies are preparing to integrate these AI advancements into their regulatory compliance strategies to stay ahead of the curve.

Challenges and Opportunities: Challenges, especially for QA, that come with adopting new technologies and the opportunities they present for improving regulatory compliance processes.

AI Innovations in Pharmacy and Inspection Readiness

Automated Data Analysis for Real-Time Compliance: AI systems continuously analyze production data against regulatory standards, allowing for immediate identification and rectification of compliance issues, a significant leap from periodic manual reviews which are prone to delays and human error.

Predictive Maintenance in Manufacturing Equipment: By predicting equipment failures before they occur, AI ensures manufacturing processes are not only uninterrupted but also consistently adhere to quality standards, contrasting with reactive maintenance strategies of the past.

Streamlined Document Management for Audits: AI enhances document management by organizing and retrieving necessary documents instantly for regulatory inspections, moving away from manual sorting and filing which is time-consuming and susceptible to misplacement or damage.

Enhanced Quality Control through Machine Vision: Machine vision systems, powered by AI, conduct detailed inspections of products at a speed and accuracy level unattainable by human inspectors, identifying defects in real-time and ensuring only products that meet stringent quality standards reach the market.

AI in Environmental Monitoring: Continuously monitoring manufacturing environments for parameters like temperature and humidity, AI systems ensure conditions remain within regulatory requirements, a significant advancement over manual checks which provide only snapshots in time.

Improving Quality Control and Regulatory Inspections with AI

Manufacturing Defect Detection with Deep Learning: Deep learning models identify subtle defects and anomalies in pharmaceutical products by analyzing images and sensor data, providing a more accurate and comprehensive inspection than traditional methods, which often rely on random sampling and human observation.

Global Regulatory Compliance Monitoring: AI systems scan and analyze the global regulatory landscape, automatically updating compliance strategies to align with the latest regulations, a marked improvement over the manual tracking and implementation of regulatory changes.

Facilitating Pharmacovigilance: AI algorithms sift through vast amounts of adverse event data and literature to detect signals of potential drug safety issues more quickly and accurately than manual methods, enhancing patient safety and compliance with safety monitoring regulations.

Streamlining Regulatory Submission Processes: AI tools automate the assembly of regulatory submission documents, ensuring accuracy and completeness, and reducing the submission preparation time significantly compared to manual compilation methods.

Adapting to New Regulations with AI Analytics: AI analytics tools assess the impact of regulatory changes on existing processes and products, guiding pharmaceutical companies in making informed decisions on necessary adjustments, thereby maintaining continuous readiness for inspection and compliance.

Integrated AI Solutions for Complex Healthcare Challenges

Challenge Identification: The COVID-19 pandemic underscored the need for innovative solutions in managing complex conditions like long COVID, characterized by varied and persistent symptoms.

Solution by OpenNovations and Sonador: The collaboration utilized Sonador's open-source medical data platform and the Aranei data management platform to analyze intricate imaging and signal information, leading to cutting-edge patient treatment and diagnosis.

Innovative Approach: Employing AI to discern patterns in medical data, thereby offering new avenues for tackling diseases with complex manifestations.

Semantic Interoperability and Standardization: Leveraging industry standards such as DICOM, HL7/FHIR, and CDISC ensured the seamless integration and analysis of diverse data types, crucial for accurate diagnosis and treatment strategies.

Transformative Diagnosis and Treatment of Long COVID

Patient Case Analysis: A case where a patient's smartwatch alerted them to irregular heart rates, leading to an emergency room visit where AI analyses of chest X-ray and EKG data were crucial.

AI-Driven Diagnostic Insights: AI capabilities of Sonador analyzed diagnostic tests, suggesting a preliminary diagnosis of Long COVID based on patterns indicative of pulmonary scarring and inflammation.

Integrated Data for Comprehensive Analysis: Data from diagnostic images, the patient's smartwatch, and medical charts were integrated and analyzed, demonstrating the power of combining AI with diverse data types for complex case management.

System Integration and Security: A technical setup utilizing Apache Kafka for data pipeline integration with PostgreSQL, and employing MLFlow and MONAI for AI model development and deployment, ensuring a secure, efficient, and reliable system.

Validation and Compliance: Rigorous AI model testing and validation protocols were established, focusing on GxP regulatory compliance and employing continuous validation methods to maintain model efficacy and accuracy.

Outcomes and Future Directions: The case highlighted the critical role of AI-powered analytics and open-source technologies in enhancing diagnostic accuracy and patient care, pointing towards a future where technology bridges gaps between diverse data sets for holistic patient care.

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