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Artificial Intelligence in EHR-Integrated Patient-Generated Health Data: Transforming Clinical Decision Support and Beyond

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Abstract: ***This article reviews aims to find and conceptualise the role of artificial intelligence in the application of integrated electronic health records (EHRs) and patient-generated health data in clinical decision support. Focus was on data that patient generated health data (PGHD) and EHR data, for investigating the role of artificial intelligence (AI) in the application. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was used to to search articles in various databases like PubMed, Web of Science, Scopus etc. Beside these other sources of systematic reviews, reports, articles and editorials were taken into account, to form the context, history, and development of this field. 18 publications met the review criteria after screening. The EHR-integrated with PGHD brought benefits to health care, including patient empowerment and their families to engage. Further there was improvement in the patient-provider relationship, with reduction of the time and cost of clinical visits. AI's role was to include filtering and management of various datasets, to help in identifying patterns to improve clinical care processes, and providing more sophisticated predictive and non-predictive algorithms for better outcomes. Challenges mainly came from the large volume of integrated data, data standards, data exchange and operational issues, security and privacy, interpretation, and meaningful use. The use of PGHD in health care is at a meaningful stage but needs further work for widespread adoption and smooth integration into health care systems. AI-driven, EHR-integrated PGHD systems can greatly improve clinicians' abilities to diagnose patients' health issues, classify risks at the patient level by drawing on the power of integrated data, and provide much-needed support to clinics and hospitals. With EHR-integrated PGHD, AI can help transform health care by improving diagnosis, treatment, and the delivery of clinical care, thus improving clinical decision support.***

Keywords: AI, Artificial intelligence, patient generated health data (PGHD), Electronic health records (HER)

1. Introduction

The ongoing digital transformation in healthcare is fueled by the widespread adoption of smartphones, wearable sensors, and Internet of Things (IoT) technologies. These devices serve as promising data sources for research and clinical care, dramatically increasing personal health information available to both patients and providers. The ease of access to low-cost health devices allows individuals to monitor, record, and share information about their lifestyles, leading to an exponential increase in patient-generated health data (PGHD). When integrated with electronic health records (EHR), PGHD enables a more comprehensive patient view, driving targeted engagement, improved diagnosis, and better health outcomes through advanced analytics and artificial intelligence (AI).

What is Patient-Generated Health Data?

PGHD encompasses a wide spectrum of information—including symptoms, biometric readings, medical history, treatment details, and daily lifestyle data—created or recorded by patients themselves or by their caregivers. The Office of the National Coordinator for Health Information Technology (ONC) defines PGHD as any health-related data that is initiated, gathered, and recorded by patients or designees to address specific health concerns.

Unlike traditionally collected clinical data, PGHD fills gaps between clinical visits by providing continuous insights and enabling remote clinical discussions. Such data empowers patients, reduces the need for in-person appointments, and allows for more proactive, real-time interventions. Furthermore, PGHD enhances communication between patients and providers, fosters mutual understanding, and improves follow-up and adherence, particularly when combined with EHR data within interoperable platforms.

The Role of Artificial Intelligence in Healthcare Data Integration

AI is fundamentally redefining health data analytics. Its primary aim is to mimic human cognitive functions for analyzing, interpreting, and presenting complex health datasets. The increasing volume of health records—from both clinical and personal sources—creates unique opportunities for AI to:

- Collect, process, and synthesize data using advanced algorithms
- Reduce diagnostic and therapeutic errors
- Extract actionable insights for risk prediction, outcome forecasting, and real-time alerts
- Assist clinical workflows in diagnosis, treatment, patient monitoring, and personalized medicine

Many nations are investing heavily in AI healthcare initiatives, recognizing its capacity to revolutionize patient safety, care quality, and operational efficiency. AI can process heterogeneous, integrated data sources, such as PGHD and EHR, to inform clinical decision support and enable more nuanced patient profiles than ever before.

AI-Driven Clinical Decision Support Systems

Clinical decision support (CDS) systems, enhanced with AI, present critical knowledge during care delivery. They intelligently manage electronic health datasets, generate timely clinical advice, and streamline workflows by integrating real-time PGHD into EHRs. Tools within CDS systems include:

- Clinical guidelines
- Documentation templates
- Alerts and reminders

- Patient reports and summaries
- Diagnostic support
- Contextual reference information

The integration of PGHD and EHR expands the clinician's ability to track patient status outside the hospital or clinic, providing a longitudinal health perspective vital for personalized interventions. AI assists in prioritizing symptoms, predicting complications, and recommending diagnostic possibilities, accelerating intervention and increasing the safety and efficacy of medical care.

2. Major Applications of AI in EHR-Integrated PGHD

Administrative Automation

AI simplifies documentation, code selection, and note auto-fill, freeing healthcare workers from burdensome data entry tasks. For instance, EHR platforms like Epic Systems now allow patients to actively contribute information, prompting reviews and new data acquisition at critical points in care.

Clinical Management

AI-driven analytics help clinicians visualize a patient's health journey, adherence to treatment, and risk factors over time. Algorithms analyze PGHD to diagnose conditions such as diabetic retinopathy with high accuracy using images acquired from smartphone-based devices.

Diagnostics Support

By deploying technologies including image recognition, natural language processing (NLP), and deep learning, AI can rapidly analyze patient data for early detection of life-threatening disease risks such as brain cancer or heart disease. This support is especially valuable for patients who face communication barriers, as AI can interpret nontraditional datasets for tailored recommendations.

Patient Decision Support

AI empowers individuals and caregivers through shared decision-making, personalized to patient preferences and real-time PGHD tracking. AI models analyze integrated PGHD-EHR combinations to identify early deterioration signals—such as possible progression from concussion to coma—driving preventive interventions.

Cost Containment

Automation through AI reduces duplicative testing, suggests cost-effective medication options, and streamlines repetitive clinical tasks. By continuously monitoring integrated PGHD, providers can reduce unnecessary office visits and ensure timely interventions, leading to significant resource savings.

Workflow Improvement

AI improves clinical workflows with better data retrieval and presentation, reducing human errors and expediting processes. AI-assisted pattern recognition enables accurate diagnosis and treatment planning, such as in diabetic retinopathy.

Challenges in PGHD-EHR Integration via AI

Realizing the full potential of AI-integrated PGHD within EHR systems faces several obstacles:

- Data Storage and Infrastructure: Handling the vast volume and complexity of PGHD demands robust architectures and ongoing technical investments.
- Data Quality and Standardization: Variability in device calibration, data formats, and user input challenges the clinical utility of PGHD, especially when compared to regulated medical devices.
- Interoperability: With each system developing its own standards, lack of unified protocols impedes data normalization, sharing, and completeness. Emerging standards like Fast Healthcare Interoperability Resources (FHIR) and SMART-on-FHIR APIs are addressing these issues, but widespread agreement is yet to be achieved.
- Security and Privacy: PGHD often falls outside strict regulatory frameworks, exposing data to breaches, unauthorized access, and integrity risks.
- Resource Allocation: Reviewing PGHD outside patient visits is often uncompensated, placing additional burdens on healthcare providers.

Strategic Recommendations

To harness the advantages of EHR-integrated PGHD, the following strategies are recommended:

- Employ AI for data cleaning, filtering, and deduplication before integration with EHRs.
- Leverage APIs for seamless and secure data exchange, authentication, and functionality expansion.
- Utilize advanced verification systems (biometric authentication, multi-step identity checks) for improved data validity.
- Draw on big data infrastructures and graphical processing units (GPU) for high-speed analysis and aggregation.
- Encourage open sharing of AI algorithms to boost reproducibility and model accuracy.
- Implement standards-based exchange protocols (such as FHIR, SMART-on-FHIR) for interoperable, flexible, and secure integration.
- Embrace user-centred design and visualization methodologies to ensure PGHD is interpretable and clinically actionable.

Ethical Considerations and Future Directions

The use of PGHD and AI must actively counteract entrenched disparities that may skew model accuracy or limit equitable care. Developers should incorporate research from user experience and human-computer interaction fields to create accessible, relevant, and actionable data interfaces. The ongoing evolution of standards, security frameworks, and workflow models will determine the trajectory of PGHD's impact on healthcare systems.

Artificial Intelligence in Health Data

AI algorithms are transforming healthcare by mimicking human cognition in complex data analysis, presentation, and comprehension. With abundant structured and unstructured health data, rapid analytics, and integration capacities, AI enables:

- Error reduction in diagnosis and therapy
- Real-time outcome prediction and alerts
- Processing PGHD and EHR for population-level insights
- Successes in diagnosis, treatment protocols, personalized medicine, and patient monitoring
- Major investments in AI healthcare innovation globally

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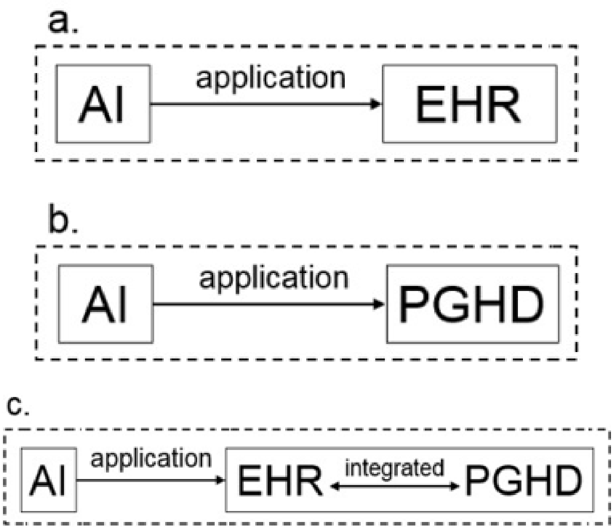

Figure 1: Domains of AI Applications

Artificial intelligence applications on EHR, PGHD, and EHR-integrated patient generated health data.

Clinical Decision Support (CDS) Systems

CDS systems leverage integrated electronic health data—including PGHD—to provide clinical guidelines, documentation, templates, computerized alerts, reminders, patient summaries, diagnostic support, and contextual information. These systems minimize medical errors, improve decision-making, quantify performance, and integrate real-time PGHD with EHR for comprehensive monitoring without office visits. The combination delivers a more holistic patient view and optimizes care processes.

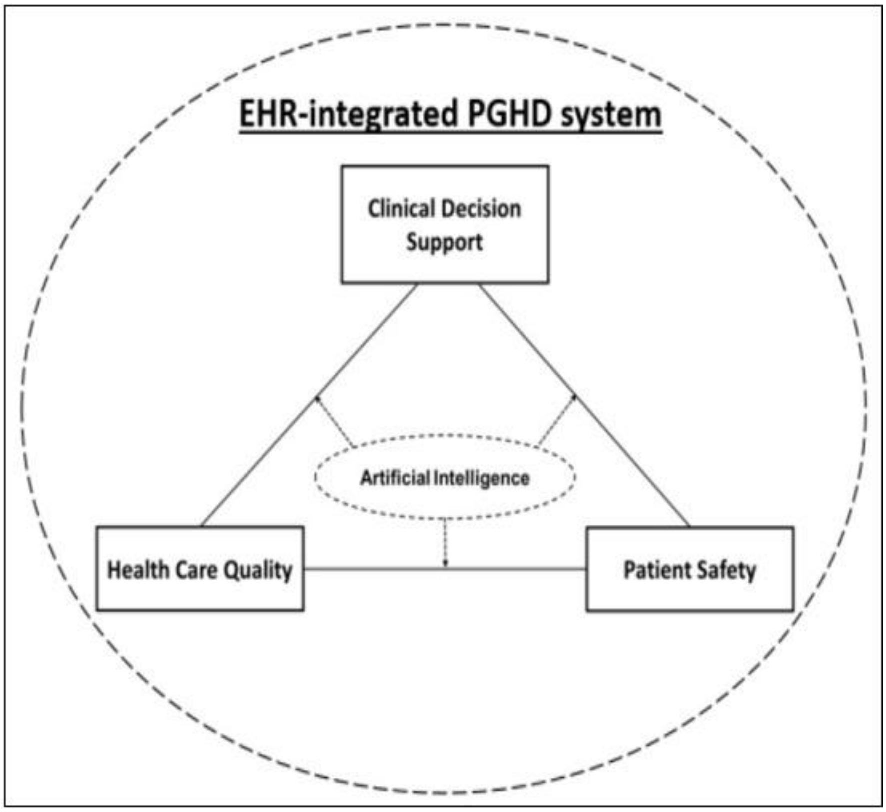

Figure 2: AI-Driven EHR-PGHD Systems Framework

Framework of artificial intelligence applications for EHR-integrated PGHD in decision support, healthcare quality, and patient safety.

3. Methods

A systematic review, compliant with PRISMA standards, drew from six major databases for studies on wearables, mobile health, PROs, and AI from 2000–2022. The search strategy encompassed broad inclusion, supplemented by seminal reviews and white papers.

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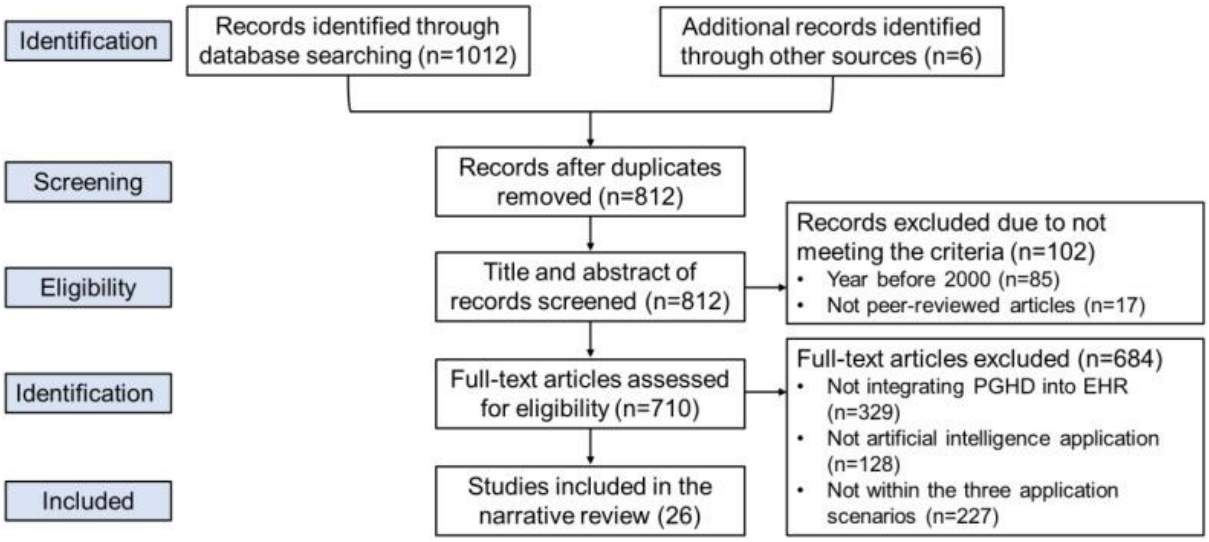

Figure 3: PRISMA Flow Diagram

PRISMA diagram of the study screening process.

Roles of AI in EHR-Integrated PGHD (Table 1 Extract)

Domain	AI Role	Example
Administrative/ Automation	Document automation, scheduled review, knowledge updates	Epic Systems PROs, patient portal
Clinical Management	Adherence monitoring, holistic health view	Retina imaging diagnosis via smartphone and AI (>90% accuracy)
Diagnostics Support	Diagnostic suggestions, equitable information sharing	AI image recognition for cancer/heart disease
Patient Decision Support	Shared decision-making, biomarker identification	ML for deterioration biomarker discovery
Cost Containment	Reducing duplication, cost-effective recommendations	NLP for automated transcription, review, and cost avoidance
Workflow Improvement	Improved workflow, pattern recognition, error reduction	AI helping in diabetic retinopathy diagnosis

Results: Value of PGHD-EHR Integration

Traditional EHR captures episodic snapshots; integrating PGHD offers longitudinal perspectives crucial for personalized diagnosis and interventions. It amplifies patient voices, helps fill gaps between visits, and strengthens patient-provider relationships, broadening research scope and clinical impact.

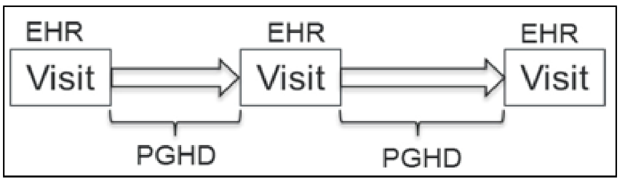

Figure 4: Patient Journeys Between Visits

Shows data collection opportunities between clinical visits.

4. Key Applications and Examples

- Administrative Function: Epic Systems allows scheduled reviews and PROs integration through patient portals.
- Clinical Management: Smartphone-based retina images analyzed by AI can diagnose conditions with high accuracy.
- Diagnostics: AI applies deep learning and NLP for rapid detection of critical illness.
- Patient Support: ML analyzes integrated data for predictive deterioration markers (concussion to coma).
- Cost Containment: NLP automates documentation and assists with cost reduction.
- Workflow Improvement: AI pattern recognition and diagnosis support for diabetic retinopathy.

5. Challenges

- Data Storage & Architecture: Integration requires robust systems for large data volumes.
- Quality & Standardization: Variability in device quality and lack of standards hinder clinical use, especially of home-based devices.
- Interoperability: Fragmented technical infrastructure, nonstandard coding, and limited consensus restrict data exchange and normalization.
- Security & Privacy: PGHD security can be less regulated than EHR, raising breach risks.

6. Recommendations

- AI pre-integration data cleaning and deduplication
- Use APIs for accurate, privacy-conscious data linkage, and authentication
- Apply biometric verification and GPUs for secure, fast processing

- Support FAIR standards (like FHIR, SMART-on-FHIR) for interoperability and visualization
- Promote open sharing of AI algorithms for reproducibility and confidence in results
- Prioritize user-focused design to ensure accessibility and mitigate health disparities

7. Discussion

AI-driven, EHR-integrated PGHD systems have the power to support personalized medicine, shared decision making, and address health disparities. However, ethical issues—particularly around bias and equitable data interpretation—need careful management. Intuitive data visualization and human-centered workflows are critical for widespread adoption.

8. Conclusion

AI and PGHD-EHR integration heralds a new era in clinical decision support, with improved care quality, safety, and individualized treatment. Overcoming challenges in data quality, interoperability, and security is essential for achieving meaningful use in healthcare systems worldwide.

AI-powered, EHR-integrated PGHD systems are essential to the future of personalized medicine and healthcare innovation. They drive holistic clinical decision support, improve care quality, and enhance patient safety. By addressing interoperability, data quality, privacy, and usability challenges, healthcare systems can unlock the transformative benefits promised by integrated digital health technologies. Continued research, standardization, and cross-disciplinary collaboration will be critical for widespread adoption, meaningful use, and sustainable impact.

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