

Synergizing AI and ERP for Predictive Supply Chain Management and Quality Assurance in Healthcare

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Abstract

This article explores the transformative potential of integrating Artificial Intelligence (AI) with Enterprise Resource Planning (ERP) systems in healthcare, focusing on applications in predictive supply chain management and quality assurance. The healthcare industry faces increasing pressure to improve efficiency while maintaining high-quality care, and AI-ERP integration offers a compelling solution. By combining ERP's comprehensive data management capabilities with AI's predictive and analytical power, healthcare organizations can enhance operational efficiency, improve decision-making, and ultimately deliver better patient outcomes. The article examines current implementations, case studies, and future projections to provide a comprehensive overview of how this technological synergy can help healthcare providers navigate the complex challenges of modern healthcare delivery, from optimizing inventory levels to ensuring regulatory compliance and proactive risk management.

Keywords: Artificial Intelligence, Enterprise Resource Planning, Healthcare Supply Chain, Predictive Analytics, Quality Assurance



1. Introduction

The healthcare industry stands at the cusp of a technological revolution, with the integration of Artificial Intelligence (AI) and Enterprise Resource Planning (ERP) systems promising to reshape supply chain management and quality assurance processes. This synergy offers unprecedented opportunities for enhancing predictive capabilities, optimizing resources, and ensuring the highest standards of patient care. The global healthcare supply chain market, valued at \$2.2 billion in 2020, is projected to reach \$3.3 billion by 2025, driven largely by the adoption of advanced technologies like AI and ERP [1]. This rapid growth underscores the critical need for innovative solutions to manage increasingly complex healthcare supply chains efficiently.

In an era where healthcare organizations face mounting pressures to improve efficiency while maintaining quality, the convergence of AI and ERP presents a compelling solution. Traditional ERP systems have long been the backbone of resource management in healthcare, integrating various operational aspects such as finance, inventory, and patient data. However, these systems often lack the predictive capabilities necessary to anticipate and respond to the dynamic challenges of modern healthcare delivery.

Artificial Intelligence, with its capacity for advanced data analysis, pattern recognition, and predictive modeling, has already demonstrated significant potential in various healthcare applications. A study by Accenture estimates that key clinical health AI applications can potentially create \$150 billion in annual savings for the US healthcare economy by 2026 [2]. The integration of AI with ERP systems represents a natural evolution, combining the comprehensive data management capabilities of ERP with the predictive and analytical power of AI.

This synergy is particularly crucial in the context of healthcare supply chain management and quality assurance. The healthcare supply chain is notoriously complex, involving numerous stakeholders, stringent regulatory requirements, and the critical need for timely delivery of supplies and medications. AI-enhanced ERP systems can provide real-time insights, predict demand fluctuations, optimize inventory levels, and identify potential supply chain disruptions before they occur.

Moreover, in the realm of quality assurance, the AI-ERP integration offers powerful tools for continuous monitoring, anomaly detection, and compliance management. In an industry where quality directly impacts patient outcomes, these capabilities are invaluable. A report by the World Health Organization highlights that medication errors alone cost an estimated \$42 billion annually worldwide, emphasizing the critical need for advanced quality assurance measures in healthcare [3].

This article explores the transformative potential of AI-ERP integration, focusing on its applications in predictive supply chain management and quality assurance within the healthcare sector. We will delve into the specific ways this technological synergy can enhance operational efficiency, improve decision-making, and ultimately contribute to better patient care outcomes. Through analysis of current implementations, case studies, and future projections, we aim to provide a comprehensive overview of how healthcare organizations can leverage this powerful combination to navigate the challenges of modern healthcare delivery.

Aspect	Traditional ERP Systems	AI-Enhanced ERP Systems	Potential Impact
Predictive Capabilities	Limited	Advanced	Improved demand forecasting and resource allocation

Data Analysis	Basic	Complex pattern recognition	Enhanced decision-making and operational efficiency
Supply Chain Management	Reactive	Proactive	Real-time insights and disruption prevention
Quality Assurance	Manual monitoring	Continuous automated monitoring	Reduced errors and improved patient safety
Cost Savings	-	Up to \$150 billion annually by 2026	Significant reduction in healthcare costs
Market Growth	-	\$2.2 billion to \$3.3 billion (2020-2025)	Rapid adoption of advanced technologies

Table 1: Comparative Analysis: Traditional vs. AI-Enhanced ERP Systems in Healthcare [1-3]

2. The Convergence of AI and ERP in Healthcare

2.1 Current State of ERP in Healthcare

Enterprise Resource Planning (ERP) systems have long been the backbone of organizational resource management in healthcare. These systems integrate various aspects of operations, including finance, human resources, inventory management, and patient data. The adoption of ERP systems in healthcare has been growing steadily, driven by the need for improved operational efficiency and data management. Traditional ERP systems in healthcare offer several key benefits:

- 1. Centralized Data Management:** ERP systems provide a single source of truth for organizational data, reducing data silos and improving information accessibility.
- 2. Process Standardization:** By implementing best practices across departments, ERP systems help standardize processes and improve operational efficiency.
- 3. Regulatory Compliance:** Many healthcare ERP systems are designed with built-in compliance features to help organizations meet industry regulations such as HIPAA.
- 4. Cost Control:** By providing better visibility into resource utilization and financial performance, ERP systems help healthcare organizations control costs more effectively.

However, traditional ERP systems often lack the predictive capabilities necessary to anticipate and respond to the dynamic challenges of modern healthcare supply chains. They are typically reactive rather than proactive, relying on historical data and predetermined rules to manage resources.

2.2 The AI Revolution in Healthcare

Artificial Intelligence, with its capacity for data analysis, pattern recognition, and predictive modeling, has already begun to make significant inroads in healthcare. From diagnostic assistance to personalized treatment plans, AI is proving its worth across various medical applications. As highlighted by Topol, the convergence of human and artificial intelligence is ushering in an era of high-performance medicine [4]. Key areas where AI is making an impact in healthcare include:

- 1. Diagnostic Imaging:** AI algorithms can analyze medical images to detect abnormalities with high accuracy, assisting radiologists in diagnosis.
- 2. Drug Discovery:** AI is accelerating the drug discovery process by predicting the effectiveness of drug candidates and identifying potential side effects.
- 3. Personalized Medicine:** AI models can analyze patient data to recommend personalized treatment plans based on individual characteristics and treatment history.
- 4. Operational Efficiency:** AI is being used to optimize hospital operations, from patient flow manage-

ment to resource allocation.

2.3 The Synergistic Potential

The integration of AI with ERP systems represents a logical evolution, combining the comprehensive data management capabilities of ERP with the predictive and analytical power of AI. This synergy promises to elevate supply chain management and quality assurance to new heights of efficiency and effectiveness.

Key benefits of this integration include:

1. **Enhanced Decision-Making:** AI can analyze vast amounts of data from ERP systems to provide actionable insights and support data-driven decision-making.
2. **Predictive Analytics:** By incorporating AI, ERP systems can move from descriptive to predictive analytics, allowing organizations to anticipate future trends and challenges.
3. **Automation of Complex Processes:** AI can automate complex, rule-based processes within ERP systems, freeing up human resources for more strategic tasks.
4. **Continuous Improvement:** AI algorithms can continuously learn from new data, allowing ERP systems to adapt and improve over time.

Feature/Benefit	Traditional ERP	AI-Enhanced ERP
Data Management	Centralized	Centralized + Predictive
Process Standardization	Yes	Yes + Adaptive
Regulatory Compliance	Built-in features	Proactive compliance
Cost Control	Improved visibility	Predictive optimization
Decision-Making	Data-driven	AI-powered insights
Analytics	Descriptive	Predictive
Process Automation	Rule-based	Complex + Intelligent
Continuous Improvement	Manual updates	Self-learning
Diagnostic Assistance	Limited	Advanced imaging analysis
Drug Discovery	Not applicable	Accelerated process
Personalized Medicine	Limited	AI-driven recommendations
Operational Efficiency	Improved	Highly optimized

Table 2: The Evolution of ERP Systems in Healthcare: From Traditional to AI-Powered [4]

3. Predictive Supply Chain Management

The integration of AI with ERP systems in healthcare has revolutionized supply chain management, particularly in the areas of demand forecasting, inventory optimization, and risk management. These advancements are crucial in an industry where stockouts can have life-threatening consequences, and overstocking can lead to significant financial waste.

3.1 Demand Forecasting

One of the most significant advantages of AI-ERP integration is enhanced demand forecasting. By analyzing historical data, seasonal trends, and external factors (such as epidemiological data or local health statistics), AI algorithms can predict demand for medical supplies, pharmaceuticals, and equipment with unprecedented accuracy.

Advanced machine learning techniques, such as deep neural networks and ensemble methods, have shown remarkable potential in forecasting healthcare demand. These AI-powered forecasting systems typically

incorporate a wide range of data sources, including:

- Historical usage patterns
- Seasonal disease trends
- Demographic data
- Scheduled procedures and surgeries
- Local and global health events
- Economic indicators

Case Study: Regional Hospital Network

A regional hospital network implemented an AI-enhanced ERP system to forecast demand for critical supplies. The system analyzed historical usage patterns, scheduled surgeries, and regional health trends. As a result, the network reduced stockouts by 35% and decreased overstocking by 28%, leading to significant cost savings and improved patient care.

This case study exemplifies the potential of AI-ERP integration in healthcare supply chain management. By reducing stockouts, the hospital network improved its ability to provide timely care, potentially saving lives in critical situations. The reduction in overstocking freed up capital that could be reinvested in other areas of patient care or hospital operations.

3.2 Inventory Optimization

AI algorithms can dynamically adjust inventory levels based on predicted demand, lead times, and supply chain risks. This optimization ensures that healthcare facilities maintain adequate supplies without tying up excessive capital in inventory.

Inventory optimization in healthcare is particularly challenging due to the diverse nature of medical supplies, varying shelf lives, and critical importance of certain items. AI-powered systems can handle these complexities by:

1. **Implementing multi-echelon inventory optimization:** Considering the entire supply chain from manufacturers to distributors to individual hospital departments.
2. **Factoring in expiration dates:** Ensuring that perishable items are used before they expire, reducing waste.
3. **Prioritizing critical items:** Maintaining higher safety stock levels for life-saving medications and equipment.
4. **Considering space constraints:** Optimizing storage utilization in healthcare facilities with limited space.

3.3 Supply Chain Risk Management

By continually analyzing global supply chain data, AI can identify potential disruptions before they occur. This capability allows healthcare organizations to proactively mitigate risks, whether they stem from geopolitical events, natural disasters, or supplier issues.

AI-powered risk management systems in healthcare supply chains typically involve:

1. **Real-time monitoring:** Continuously tracking global events, supplier performance, and transportation routes.
2. **Predictive analytics:** Using historical data and current trends to forecast potential disruptions.
3. **Scenario planning:** Simulating various risk scenarios to develop contingency plans.
4. **Automated alerts:** Notifying relevant personnel when potential risks are identified.

The importance of robust supply chain risk management in healthcare was highlighted during the COVID-19 pandemic. The World Health Organization emphasized the critical role of data analytics in managing

healthcare supply chains during global health crises [5].

By leveraging AI for risk management, healthcare organizations can:

- Diversify suppliers to reduce dependency on single sources
- Identify alternative transportation routes to avoid delays
- Stockpile critical supplies in anticipation of potential shortages
- Develop rapid response plans for various disruption scenarios

The integration of AI-powered predictive analytics into healthcare ERP systems represents a significant advancement in supply chain management. By enhancing demand forecasting, optimizing inventory levels, and proactively managing risks, these systems are helping healthcare organizations improve operational efficiency, reduce costs, and ultimately provide better patient care.

4. Quality Assurance Enhancement

The integration of AI with ERP systems in healthcare has significantly enhanced quality assurance processes, leading to improved patient safety, regulatory compliance, and operational efficiency. This section explores how AI-powered systems are revolutionizing real-time monitoring, compliance management, and predictive maintenance in healthcare settings.

4.1 Real-time Monitoring and Anomaly Detection

AI-powered systems can monitor supply chain processes in real-time, detecting anomalies that might indicate quality issues. This capability is particularly crucial in healthcare, where even minor deviations can have serious consequences for patient safety.

One of the most notable applications is in cold chain logistics for pharmaceuticals and vaccines. AI algorithms can analyze data from IoT sensors in real-time, detecting temperature fluctuations that could compromise product integrity. These systems offer several key advantages:

1. **Immediate anomaly detection:** AI can identify issues as they occur, allowing for rapid intervention.
2. **Pattern recognition:** AI can detect subtle patterns that may indicate emerging problems before they become critical.
3. **Predictive alerts:** By analyzing historical data, AI can predict potential issues and alert staff proactively.
4. **Continuous improvement:** AI systems can learn from each incident, improving their detection capabilities over time.

4.2 Compliance Management

The healthcare industry is subject to stringent regulatory requirements, including HIPAA, GDPR, and FDA regulations. AI can assist in ensuring compliance by continuously monitoring processes, documenting activities, and alerting management to potential compliance issues before they become problematic.

A report by Deloitte on AI applications in healthcare regulation highlighted that AI-powered compliance management systems could reduce compliance-related costs by up to 30% while improving the accuracy of compliance monitoring [6]. These systems offer several key advantages:

1. **Automated documentation:** AI can automatically generate and maintain compliance-related documentation, reducing the administrative burden on healthcare staff.
2. **Real-time compliance checking:** AI algorithms can continuously monitor operations against regulatory requirements, flagging potential issues immediately.
3. **Risk assessment:** AI can analyze patterns of non-compliance to identify high-risk areas that require

additional attention.

- 4. Regulatory updates:** AI systems can automatically incorporate new regulatory requirements into their monitoring processes, ensuring ongoing compliance.

4.3 Predictive Maintenance

For medical equipment and facilities, AI can predict maintenance needs based on usage patterns and sensor data. This predictive approach minimizes downtime and extends the lifespan of critical assets.

Predictive maintenance in healthcare typically involves:

- 1. Data collection:** Gathering data from equipment sensors, usage logs, and maintenance records.
- 2. Pattern analysis:** Using machine learning algorithms to identify patterns that precede equipment failures.
- 3. Predictive modeling:** Developing models that can forecast when maintenance will be required.
- 4. Automated scheduling:** Integrating predictions with ERP systems to automatically schedule maintenance activities.

The benefits of predictive maintenance in healthcare include:

- 1. Reduced downtime:** By addressing issues before they cause equipment failures, healthcare providers can minimize service interruptions.
- 2. Cost savings:** Predictive maintenance can reduce overall maintenance costs by preventing major breakdowns and extending equipment life.
- 3. Improved patient care:** Ensuring equipment reliability contributes to better patient outcomes and satisfaction.
- 4. Resource optimization:** By accurately predicting maintenance needs, healthcare facilities can optimize their maintenance staff and resources.

The integration of AI-powered quality assurance tools with ERP systems represents a significant advancement in healthcare management. By enhancing real-time monitoring, compliance management, and predictive maintenance, these systems are helping healthcare organizations improve patient safety, reduce risks, and optimize resource utilization.

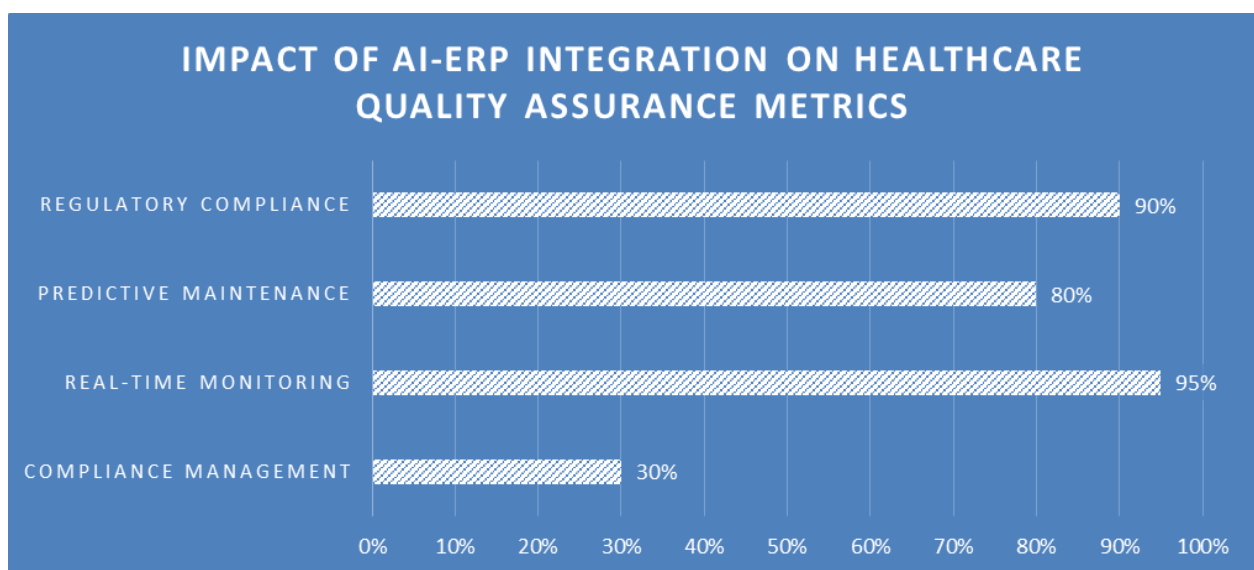


Fig 1: Quantitative Benefits of AI-Powered Quality Assurance in Healthcare [6]

5. Implementation Challenges and Considerations

While the integration of AI and ERP systems in healthcare offers significant benefits, it also presents several challenges that organizations must address for successful implementation. This section explores the key considerations and potential obstacles in deploying AI-enhanced ERP systems in healthcare settings.

5.1 Data Integration and Quality

The effectiveness of AI-ERP systems depends heavily on the quality and integration of data. Healthcare organizations must ensure that data from various sources is accurately collected, cleaned, and integrated. This challenge is particularly acute in healthcare due to the diverse nature of data sources and the critical importance of data accuracy.

Key considerations include:

1. **Data standardization:** Ensuring consistent data formats across different systems and departments.
 2. **Data completeness:** Addressing missing or incomplete data that could skew AI analyses.
 3. **Data accuracy:** Implementing robust data validation processes to minimize errors.
 4. **Historical data migration:** Integrating legacy data into new AI-ERP systems without loss of integrity.
- To address these challenges, healthcare organizations should consider implementing data governance frameworks and investing in advanced data integration tools specifically designed for healthcare environments.

5.2 System Interoperability

Healthcare environments often involve multiple systems from different vendors. Ensuring seamless interoperability between AI components, ERP systems, and existing healthcare IT infrastructure is crucial for success. The lack of interoperability can lead to data silos, inefficiencies, and potential errors in patient care.

To address this challenge:

1. **Adopt healthcare-specific data standards:** Implement standards such as HL7 FHIR (Fast Healthcare Interoperability Resources) to facilitate data exchange.
2. **Use API-first approaches:** Develop and integrate systems using well-defined APIs to enable easier connectivity between different components.
3. **Implement middleware solutions:** Utilize integration platforms that can act as a bridge between different systems and data formats.
4. **Collaborate with vendors:** Work closely with ERP and AI vendors to ensure their solutions are designed with interoperability in mind.

5.3 Ethical and Privacy Concerns

The use of AI in healthcare raises important ethical and privacy considerations, particularly regarding patient data. Organizations must implement robust data protection measures and ensure compliance with regulations such as HIPAA in the United States or GDPR in Europe.

Key ethical and privacy considerations include:

1. **Data anonymization:** Ensuring patient data used in AI training and analysis is properly de-identified.
2. **Informed consent:** Developing clear protocols for obtaining patient consent for data use in AI systems.
3. **Algorithmic bias:** Regularly auditing AI algorithms to detect and mitigate potential biases that could lead to disparities in care.
4. **Transparency:** Providing clear explanations of how AI systems make decisions that affect patient

care.

A study published in PLOS ONE highlighted the potential of machine learning in improving cardiovascular risk prediction using routine clinical data, but also emphasized the importance of addressing ethical concerns and ensuring transparency in AI-driven healthcare solutions [7]. To address these concerns, healthcare organizations should:

1. **Establish ethical review boards:** Create dedicated committees to oversee the ethical implications of AI implementations.
2. **Develop AI governance frameworks:** Implement comprehensive policies that address data privacy, security, and ethical use of AI.
3. **Engage in ongoing education:** Provide regular training to staff on ethical considerations in AI and data privacy.

5.4 Change Management and Training

The introduction of AI-enhanced ERP systems represents a significant change in how healthcare organizations operate. Comprehensive training programs and change management strategies are essential for successful adoption.

Effective change management and training strategies should include:

1. **Stakeholder engagement:** Involve key stakeholders from various departments in the planning and implementation process.
2. **Phased implementation:** Roll out AI-ERP systems in stages to allow for adjustment and learning.
3. **Comprehensive training programs:** Develop role-specific training that addresses both technical skills and the broader implications of AI in healthcare.
4. **Continuous support:** Provide ongoing support and resources to help staff adapt to new systems and workflows.
5. **Feedback mechanisms:** Establish channels for staff to provide feedback and suggestions for system improvements.

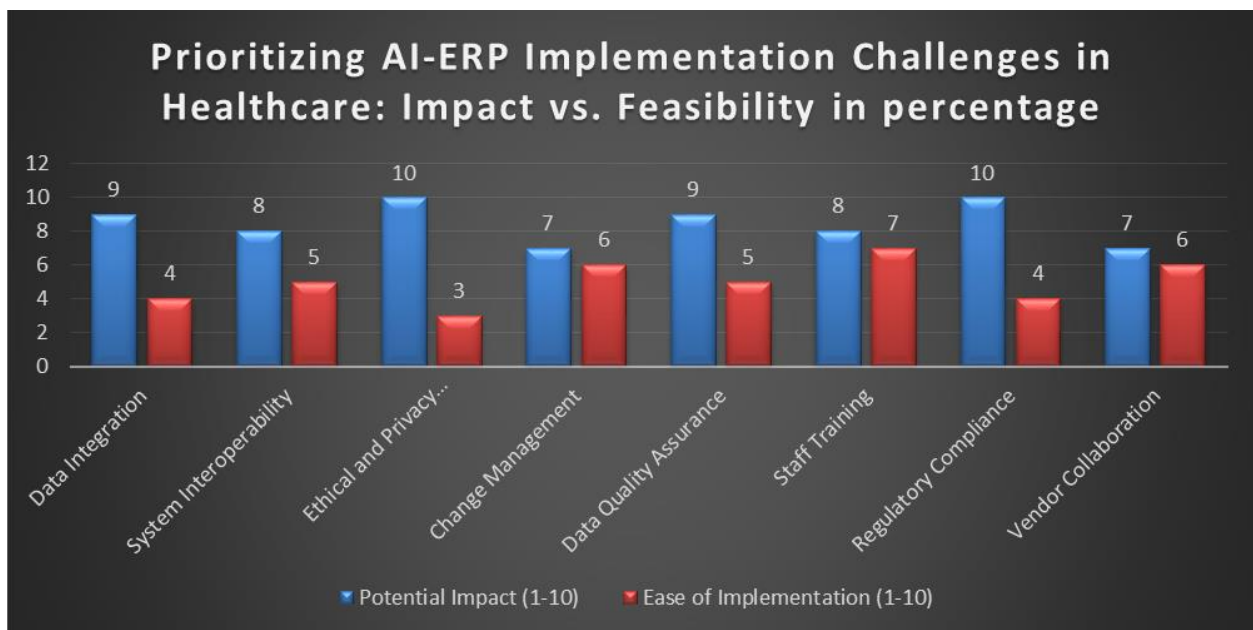


Fig 2: Strategic Focus Areas for Successful AI-ERP Integration in Healthcare Systems [7]

6. Future Directions

As AI and ERP technologies continue to evolve, we can anticipate even more sophisticated applications in healthcare supply chain management and quality assurance. The integration of these technologies promises to revolutionize healthcare operations, leading to improved efficiency, enhanced patient care, and more resilient healthcare systems. This section explores potential future developments in this rapidly advancing field.

6.1 Advanced Predictive Modeling Incorporating Real-time Global Health Data

The future of AI-ERP systems in healthcare will likely see a significant enhancement in predictive modeling capabilities, especially through the integration of real-time global health data. This advancement could dramatically improve supply chain management and resource allocation in healthcare settings.

Key developments may include:

- 1. Global Health Data Integration:** AI systems could potentially tap into global health databases, such as those maintained by the World Health Organization (WHO) and other international health bodies, to predict disease outbreaks and supply chain disruptions more accurately.
- 2. Social Media and Internet of Things (IoT) Data Utilization:** Advanced AI algorithms could analyze social media trends and data from IoT devices to detect early signs of health issues or supply chain disruptions.
- 3. Climate Data Integration:** With the increasing impact of climate change on global health, future systems might incorporate climate data to predict and prepare for health crises related to extreme weather events or changing disease patterns.

A study published in *Physiological Genomics* highlights the potential of AI in global health, suggesting that machine learning models could predict disease outbreaks with high accuracy by analyzing diverse data sources, including satellite imagery, weather data, and population movement patterns [8]. This approach could be particularly valuable in preparing healthcare supply chains for potential pandemics or regional health crises.

6.2 AI-driven Autonomous Supply Chain Management Systems

The evolution of AI technologies is paving the way for increasingly autonomous supply chain management systems in healthcare. These systems could potentially manage entire supply chains with minimal human intervention, optimizing processes in real-time.

Future developments might include:

- 1. Self-optimizing Inventory Systems:** AI algorithms could autonomously adjust inventory levels based on predicted demand, automatically placing orders and redirecting supplies as needed.
- 2. Intelligent Supplier Selection:** AI systems could continuously evaluate and select suppliers based on performance metrics, pricing, and risk factors, ensuring the most efficient and reliable supply chain.
- 3. Predictive Maintenance and Quality Control:** Advanced AI could predict equipment failures and quality issues before they occur, automatically scheduling maintenance or initiating recalls when necessary.

These autonomous systems could significantly reduce human error, improve response times to supply chain disruptions, and optimize resource allocation across healthcare networks.

6.3 Integration with Emerging Technologies

The integration of AI and ERP systems with other emerging technologies promises to further enhance healthcare supply chain management and quality assurance.

Potential integrations include:

- 1. Blockchain for Enhanced Traceability and Security:** Blockchain technology could be integrated with AI-ERP systems to provide an immutable, transparent record of all supply chain transactions. This could significantly enhance traceability, reduce fraud, and improve the security of sensitive healthcare data.
- 2. 5G and Edge Computing:** The rollout of 5G networks and advancements in edge computing could enable real-time data processing and decision-making at the point of care, improving the speed and efficiency of healthcare supply chains.
- 3. Augmented Reality (AR) for Inventory Management:** AR technologies could be integrated with AI-ERP systems to assist in inventory management, providing visual guidance for stock-taking, order picking, and equipment maintenance.
- 4. Quantum Computing:** As quantum computing technology matures, it could potentially be applied to solve complex optimization problems in healthcare supply chains, enabling even more accurate predictive modeling and decision-making.

The integration of these technologies with AI-ERP systems could lead to unprecedented levels of efficiency, transparency, and responsiveness in healthcare supply chains.

As demonstrated by the potential applications of AI in fighting global health crises [8], the future of healthcare supply chain management and quality assurance lies in the intelligent integration of diverse data sources and cutting-edge technologies. By leveraging advanced AI algorithms, real-time data analysis, and emerging technologies, healthcare organizations can build more resilient, efficient, and responsive supply chains that are better equipped to handle the challenges of modern healthcare delivery. These future directions represent exciting possibilities for the continued evolution of AI-ERP systems in healthcare. As these technologies mature and integrate, they have the potential to significantly improve the efficiency, reliability, and effectiveness of healthcare supply chains, ultimately leading to better patient outcomes and more resilient healthcare systems.

7. Conclusion

The integration of AI with ERP systems represents a significant opportunity for healthcare organizations to revolutionize their supply chain management and quality assurance processes. By harnessing AI's predictive capabilities within the framework of ERP, healthcare providers can achieve unprecedented levels of efficiency, responsiveness, and quality in their operations. While implementation challenges exist, including data integration, system interoperability, and ethical considerations, the potential benefits in terms of cost savings, improved patient care, and enhanced operational efficiency make this a compelling area for investment and research. As the healthcare industry continues to evolve, organizations that successfully leverage AI-ERP integration will be well-positioned to lead in delivering high-quality, efficient healthcare services, ultimately contributing to more resilient and effective healthcare systems.

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