

Integrating Automation in Healthcare: A Review of Applications, Benefits, and Challenges

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Abstract:

Automation is rapidly transforming healthcare by integrating advanced technologies such as artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), robotic process automation (RPA), and sensor-based systems into clinical and administrative practices. This review explores the evolution, benefits, and challenges of healthcare automation, highlighting its potential to improve efficiency, accuracy, and patient-centred care. Applications span from electronic health records (EHRs), clinical decision support systems (CDSS), and robotic surgeries to telemedicine, remote patient monitoring, and automated pharmacy services. Evidence from a systematic literature review (SLR) and meta-analysis demonstrates that automation enhances diagnostic precision, streamlines workflows, reduces operational costs, and strengthens patient engagement. However, barriers such as technical integration issues, resistance to change, ethical concerns, data privacy risks, and regulatory challenges remain significant. The future of automation in healthcare lies in predictive analytics, big data, IoT-driven monitoring, and intelligent virtual assistants, all aimed at enabling personalized and precision medicine. Ultimately, the successful adoption of automation depends on balancing technological innovation with ethical oversight, regulatory compliance, and human-centred care, ensuring that automation complements rather than replaces the healthcare professional's role.

Keywords — Automation, Artificial Intelligence (AI), Remote Patient Monitoring, Predictive Analytics, Patient-Centered Care

I. INTRODUCTION

The progressive integration of automation into industries has significantly enhanced production speed, operational efficiency, and product quality. Over successive phases, technologies have increasingly replaced labour-intensive activities. With recent progress in robotics and information systems, tasks that once required human physical strength or cognitive skills are now being automated (19). Although automation is defined in several ways, most explanations focus on technologies that execute tasks traditionally performed by people. As Parasuraman and Riley explain, the definition of automation will continue to evolve over time. Various industries now

incorporate automation in everyday processes, reflecting technological growth (37). Within healthcare, automation involves employing advanced tools in hospitals and clinics to manage routine, repetitive duties without continuous human input. Since medical practice extends far beyond patient consultations, such tools help in building intelligent environments that support professionals. These smart systems integrate a range of technologies, including artificial intelligence (AI), machine learning (ML), sensor-based networks, robotics, the Internet of Things (IoT), and the Internet of Medical Things (IoMT) (1). Collectively, they are redefining how both workspaces and living environment's function.) As healthcare increasingly incorporates automation, it is essential to address

the ethical and regulatory dimensions that accompany technological advancements. Implementation must not only focus on efficiency but also ensure patient safety and data privacy (23). Innovations such as robotic surgeries and automated pharmacy systems hold promise for higher precision, but they also demand rigorous regulatory oversight to maintain compliance and build trust (56). Hence, balancing innovation with governance is critical for responsible healthcare delivery. Advances in information technology (IT) have notably strengthened healthcare delivery, especially in remote monitoring (26). Similar to industrial fields, gradual adoption of automation has boosted productivity, efficiency, and quality across medical services. Activities that once demanded manual work are increasingly executed through automated systems, while new breakthroughs in robotics and IT have extended automation to tasks that were once solely dependent on human judgment or expertise (19). However, implementing technological innovations in health systems remains complex, given their structured and fast-changing environments. Many improvement initiatives fail to expand organization-wide; a report by Health Quality Ontario revealed that fewer than 40% of such projects scaled successfully after initial adoption (9). A frequent reason is that healthcare leaders overlook how emerging tools align with existing workflows and practices. While AI has gained momentum, clear strategies for its systematic adoption in healthcare are still lacking (41). Broadly, automation is defined as the design and use of technology to supervise and regulate service delivery. Across multiple industries, it has been utilized to improve safety, efficiency, timeliness, and overall value while lowering operational costs. Over time, healthcare automation has advanced significantly: computing devices have become faster and smaller, datasets have grown more complex and diverse, and AI has expanded into solving intricate challenges in science and medicine (2). In data-heavy fields like radiology, ophthalmology, and pathology, AI already supports outcome analysis, diagnostic suggestions, and treatment recommendations. These systems not only enhance medical decision-making but are evolving toward autonomy—progressing from

generating insights to performing tasks independently, such as monitoring closed-loop machines (e.g., ventilators, insulin pumps), screening referrals, or triaging patients (31). Yet, for automation to improve patient care meaningfully, it must integrate seamlessly with healthcare workflows. Trust in these systems—both from patients and professionals—is essential for adoption (37). Clinical settings such as emergency departments, where rapid and accurate assessment is vital, could particularly benefit from automation (37). Likewise, electronic health records (EHRs) and laboratory systems need to be efficiently interconnected with AI tools, as the accuracy and scale of input data directly influence their reliability (31). Digitization of healthcare also enables the vision of personalized and precision medicine, even for hard-to-reach populations. Growing adoption of wearable devices and mobile health applications has the potential to revolutionize service delivery, extending monitoring and treatment beyond traditional hospital settings (28).

II. RESEARCH METHODOLOGY

The study explores how automation can transform healthcare delivery, particularly in clinical and pharmaceutical settings. Automation is reshaping patient care by enabling remote monitoring, personalized treatment plans, and more accurate diagnostics. On the administrative side, it streamlines processes such as appointment scheduling, billing, and claims management. In pharmaceuticals, automation optimizes the supply chain through real-time inventory tracking and predictive analytics, while also accelerating drug discovery using AI-powered tools and virtual clinical trials. Collectively, these advancements reduce errors, save time, and improve efficiency, ultimately benefiting both patients and healthcare organizations. Applications of AI in diagnostics Leveraging image analysis and predictive tools to improve accuracy. Smart patient monitoring – Utilizing devices for early detection of complications and continuous health tracking. Robotic medication delivery – Reducing prescription errors and ensuring timely administration. Patient safety and error reduction – Using EHRs, AI-driven alerts, and automated

dispensing to minimize risks. Operational and economic evaluation – Assessing how automation reduces costs, optimizes resource allocation, and shortens hospital stays. Innovative integration approaches – Exploring RPA for administrative workflows, AI Chabot’s for patient interaction, and automated inventory systems in pharmacy practice. Methodologies: The research methodology relied primarily on secondary data analysis from published studies and followed a structured review process. Systematic Literature Review (SLR): A rigorous approach was used to identify, select, and synthesize relevant studies. The process ensured transparency and reproducibility by applying predefined inclusion and exclusion criteria. Content Analysis: Patterns, themes, and user experiences were extracted from existing literature, providing qualitative insights into automation’s role in healthcare (1). Meta-Analysis: Where possible, statistical techniques were used to combine data from multiple studies, offering broader generalizations and highlighting trends across different healthcare systems.

III. FOUNDATIONAL TECHNOLOGIES IN HEALTHCARE SECTOR

The integration of core technologies is central to the development of intelligent healthcare ecosystems. Collectively, these tools—including the Internet of Things (IoT), Internet of Medical Things (IoMT), Artificial Intelligence (AI), Machine Learning (ML), sensor-based systems, and Robotic Process Automation (RPA)—are transforming healthcare practices and the environments in which they operate. IoT devices enable real-time monitoring of patients, offering continuous updates on their health status (34). Within IoMT, the ecosystem typically includes: AI, one of the oldest fields of computer science, focuses on developing systems capable of simulating human intelligence and problem-solving abilities (5). Its applications include Deep convolutional neural networks for detecting skin cancer and evaluating retinal images for diabetic retinopathy. AI systems for monitoring adherence to direct oral anticoagulants, thereby reducing unnecessary hospital visits (2). Machine Learning

(ML), a subset of AI, uses statistical methods to enable computers to learn from data without explicit programming. In healthcare, ML has improved diagnostic accuracy, clinical trial design, and predictive analytics for patient outcomes. Its impact is potentially transformative, with applications ranging from drug discovery to large-scale patient data analysis (35).

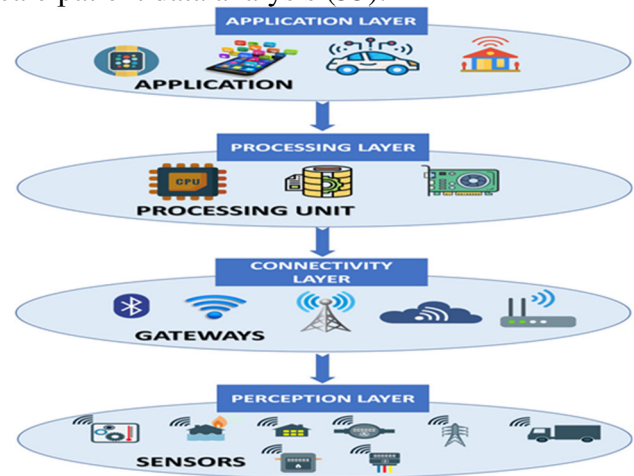


Fig. 1 Showing IoT Architecture in Healthcare.

A. Sensor Networks

Sensor networks serve as the backbone of IoT systems by gathering diverse data such as body temperature, activity levels, and environmental conditions. Beyond data collection, they facilitate communication and coordination among devices, enabling smart healthcare systems to function as interconnected environments. This enhances healthcare safety, monitoring, and patient support (1). Robotic process automation- RPA involves the use of software “bots” that mimic human tasks in digital environments. In healthcare, RPA is especially effective in streamlining repetitive administrative functions such as: Patient scheduling and eligibility checks, Physician credentialing and enrolment, Billing, claims processing, and compliance monitoring, Clinical documentation and coding, Accounts receivable, denial management, and patient self-pay workflows, by reducing manual intervention, RPA minimizes errors, lowers operational costs, and increases efficiency within healthcare organizations (2).



Fig. 2 Pillars of Machine Learning for Healthcare Sector.

B. Benefits of automation

Automation in healthcare brings a wide array of benefits, influencing not only clinical care but also efficiency, safety, and patient experience. Healthcare Improvements – Sensor-based systems continuously track vital signs, identify emergencies, and support independent living, especially for individuals with chronic diseases (9). Energy Efficiency – Real-time monitoring and automated controls optimize energy use, thereby reducing costs and environmental impact. Safety and Security – Intelligent systems detect potential hazards, such as intrusions, fire outbreaks, or other emergencies, and provide immediate alerts. Comfort and Convenience – Automated adjustments based on user preferences and environmental conditions create more comfortable healthcare settings (1). More specifically, automation in healthcare contributes to: Broader access to healthcare services, better patient outcomes, Cost reduction in treatment and hospital operations, Higher efficiency and productivity across healthcare delivery.

Core Features of Automated Healthcare Systems
Wearable Health Sensors – Small, discreet devices that monitor physiological parameters (e.g., heart rate, mobility, and activity patterns) without disrupting daily life (26). Automated Medication Dispensers – Smart systems that organize prescriptions and remind patients to take doses correctly, lowering the chances of medication errors (1). Remote Patient Monitoring (RPM) – Healthcare providers use electronic devices to remotely track patient health. This supports early detection of issues, real-time treatment modifications, and reduces unnecessary emergency visits or hospital stays (38) Smart Home Health Monitoring – Integrated networks of sensors that go

beyond wearable, capturing data on sleep quality, activity levels, and environmental conditions to provide a complete view of patient health. These systems promote independence while enabling timely medical interventions (1). Tele pharmacy Services – Use of telecommunications to deliver pharmacy-related services and manage certain operational functions remotely (59). Assistive Robots – Robots designed to help patients with daily activities, enhancing independence and quality of life (22). Automated Patient Care – Deployment of digital systems to streamline routine care processes, reducing the burden on healthcare staff (37). AI-Powered Health Analytics – Sophisticated tools that analyse large datasets to generate actionable insights for personalized treatments (35). Digital Twin-Based Patient Management – Integration of data from wearable, EHRs, and other devices to create a “digital twin” of the patient. This supports continuous health tracking, early detection of problems, and individualized treatment plans (1). Location-based services play an important role in patient tracking and resource management. Using technologies such as: GPS – For outdoor tracking, detecting positions using satellites. Local Positioning Systems (LPS) – For indoor tracking, relying on signals sent to pre-installed receivers. Indoor Positioning Systems (IPS) – Specialized for indoor navigation, assisting with patient flow, staff guidance, and emergency responses (43, 57). Applications of LBS include: Emergency response – Wearable can automatically send a user’s location during falls or health crises. Medication reminders – Alerts triggered by location ensure that patients follow their prescriptions (5). Geospatial insights – Data used for tracking assets, analysing emergency responses, and understanding healthcare environments (1).

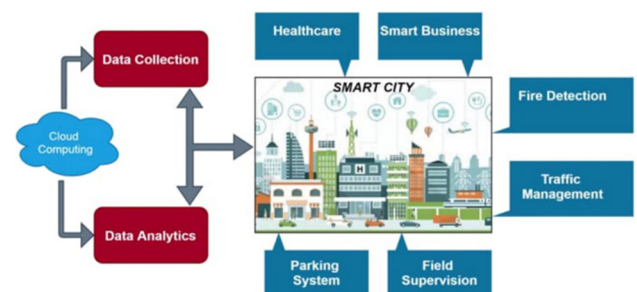


Fig. 3 Smart Healthcare Powered by Cloud Data and Analytics.

C. Review of Comparative Foundational Technologies

The table given below discusses the fundamental technologies needed to integrate with smart environments. It provides a thorough overview of their features, advantages, and disadvantages. The foundation of smart ecosystems is made up of fundamental technologies that offer automation and connectivity, such as IoT, IoMT, AI, ML, and sensors. Interconnected systems are emphasised in smart home features. While home-based care technologies emphasise user independence, real-time monitoring, and emergency responses, telehealth platforms provide connectivity and real-time interactions. AI-driven analytics and interconnected health ecosystems are key components of digital health integration. Automated patient care and real-time data sharing are both examples of smart hospital attributes. LBS uses indoor positioning systems to provide personalised services and quick emergency responses. Connectivity, automation, data analysis, remote monitoring, user independence, real-time communication, emergency responses, integration complexity, privacy and security, interoperability, ease of use, scalability, cost-effectiveness, flexibility, and overall effects are some of the parameters that are compared. (43)

TABLE I
OVERVIEW OF DIGITAL HEALTH TECHNOLOGIES

Parameter	Foundational Tech & Smart Home	Home-Based Care & Telehealth	Smart Hospitals & Digital Health
Key Features	Automation, interconnected devices, user-friendly interfaces	Remote patient monitoring (RPM), teleconsultations, emergency response	AI-driven data analytics, real-time data sharing, automated patient care
Primary Goal	Convenience, independent living, intelligent environments	Managing care at home, virtual visits, safety	Efficient, data-driven care within a hospital
Challenges	High integration complexity, privacy & security	High integration complexity, interoperability	High integration complexity, stringent security needs
General Traits	Scalable, cost-effective, flexible, and adaptive across all areas.		

D. Historical Context of Automation in Healthcare

Early Developments in Healthcare Automation: The early stages of healthcare automation highlight the importance of regulatory frameworks and ethical safeguards in guiding technological adoption. While robotic surgeries, for instance, have enhanced precision and reduced recovery periods, they also introduce accountability concerns when complications arise. This underscores the need for strong guidelines to manage liability and patient safety (56). As automation spread, the necessity for continuous professional education became clear. Healthcare professionals must acquire both technical skills and an understanding of how automation supports compassionate, patient-centred care. Without this balance, technology risks becoming a replacement rather than a support system for human interaction (58). Collaboration between humans and machines is therefore critical to maximize innovation while preserving quality care (9).

1) Evolution of Technology in Healthcare: Over time, technological growth has reshaped clinical practices, but has also introduced ethical and regulatory dilemmas (56). **Early Innovations:** Tools like automated medication systems and hospital management software improved efficiency but raised concerns about depersonalization of care. Over-reliance on machines could weaken patient-provider relationships, highlighting the importance of ethical integration (56). Regulations evolved alongside these tools to ensure safe and effective use, especially for advanced applications like robotic surgeries (46, 14). **Technological Advancements:** The rise of electronic health records (EHRs) revolutionized data management, though they required major workflow adjustments and team coordination. Similarly, decision-support tools enhanced diagnostic accuracy but demanded clinician training to prevent overdependence on machines (23). Training programs that emphasize both empathy and digital skills have been recommended to help healthcare staff adapt while preserving strong patient communication (23, 55). **Key Milestones in Automation Adoption:** Recent Advances in Automation Technologies 1. Integration of Artificial Intelligence (AI) and Machine Learning (ML) 2. Robotics in Surgery and Patient Care 3. the Internet of Things (IoT), the Internet of Medical Things (IoMT) 4. Sensor Networks. As automation continues to evolve, the integration of AI and machine learning into healthcare presents new opportunities for enhancing patient outcomes and operational efficiency. These technologies not only streamline administrative tasks but also assist in clinical decision-making by analysing vast amounts of data at unprecedented speeds (46). Furthermore, advancements in robotic systems are revolutionizing surgical procedures, allowing for greater precision and reduced

recovery times, thus shifting the paradigm of traditional medical practices toward more innovative approaches (47). However, the adoption of these technologies is met with challenges, including concerns over data privacy, ethical implications, and the need for comprehensive training programs for healthcare professionals to effectively utilize automated tools (38). This shift towards automation necessitates a critical examination of both potential benefits such as increased precision and reduced operational costs and challenges, including ethical concerns surrounding patient privacy and autonomy. (58)

2) Types of Automation in Healthcare: Administrative Automation: Automation has streamlined administrative functions by enhancing patient engagement and back-office operations. Tools such as mobile health apps and telemedicine platforms empower patients by granting them easier access to their medical information and treatment plans. However, disparities in digital literacy could limit accessibility, potentially widen healthcare inequality if not properly address (10, 18). Scheduling and Patient Management – Automated scheduling systems ensure smoother patient flow and reduce human error in appointment handling. However, successful implementation requires adequate training for both healthcare workers and patients to overcome barriers related to usability (51) Scheduling and Patient Management Systems: Furthermore, as the field of healthcare automation advances, the confluence of technology and patient engagement underscores the imperative for the establishment of comprehensive training programs tailored for both healthcare providers and patients. Such initiatives possess the potential to mitigate the digital literacy divide, thereby ensuring that diverse demographic groups are adequately prepared to proficiently navigate these innovative tools, ultimately enhancing their overall experiences and outcomes in healthcare (51). Moreover, although automated systems confer substantial advantages, including increased efficiency and diminished error rates, they concurrently introduce ethical considerations pertaining to patient autonomy and data privacy that necessitate resolution through the implementation of stringent regulatory frameworks (16). As institutions adopt these technological advancements, a collaborative strategy that encompasses stakeholders from various sectors—including technology developers, healthcare practitioners, and policymakers—will be essential in fostering an ecosystem that emphasizes not only innovation but also the core tenets of patient-centred care (15). Billing and Claims Processing: Automation simplifies revenue cycle management by: Collecting patient demographics and insurance details, Coding services with ICD-10 or CPT systems, and Submitting claims electronically through EHR platforms. These systems reduce delays, minimize coding errors, and improve reimbursement processes. Still, incorrect data input can result in claim denials, requiring oversight and follow-up (24, 53, 54).

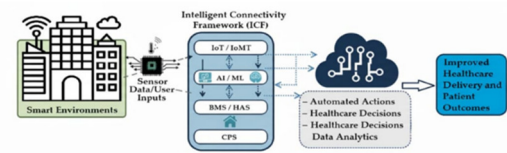


Fig. 4 Showing Benefits of Automation in Healthcare.

3) Clinical Automation: Technologies like Electronic Health Records (EHRs) and Clinical Decision Support Systems (CDSS) are at the core of clinical automation. HER Systems – Act as centralized patient data repositories, improving coordination and enabling real-time access to medical history, lab results, and treatment plans. They also include decision-support features like drug interaction alerts, enhancing patient safety (45, 49). Electronic Health Records (EHR) Systems: Clinical automation involves the use of technology in healthcare to enhance efficiency, accuracy, and patient outcomes, with Electronic Health Records (EHR) being significant advancement in this field. EHR systems act as centralized repositories for patient data, providing real-time access to medical histories, treatment plans, and test results. This improves collaboration among healthcare teams and facilitates informed decision-making, allowing clinicians to spend more time on patient care instead of administrative tasks (49). EHR are equipped with clinical decision support tools that offer evidence-based recommendations at the point of care, such as alerts about drug interactions and abnormal lab results, thereby enhancing patient safety. Additionally, clinical automation streamlines processes like appointment scheduling and prescription management, reducing reliance on paper-based methods and minimizing errors (45). Overall, clinical automation and efficient billing and insurance processing are critical components of the healthcare ecosystem, enabling providers to improve their financial health while delivering high-quality patient care (58). Clinical Decision Support Systems (CDSS): Advanced tools that analyse patient data against medical guidelines to provide clinicians with recommendations for diagnosis and treatment. These systems reduce errors, enhance diagnostic precision, and support preventive care. CDSS applications range from reminders to AI-driven predictive analytics for population health (30, 39, 40) Telemedicine and Remote Monitoring: Telemedicine has revolutionized healthcare access by enabling patients to consult providers via digital platforms, overcoming geographical and physical barriers (26). Remote Patient Monitoring (RPM) tools, such as wearable and mobile health apps, continuously track metrics like heart rate and blood pressure. The collected data is transmitted to clinicians for real-time analysis, allowing for early detection of complications and timely treatment adjustments (27, 28). This combination strengthens chronic disease management (e.g., diabetes, hypertension), reduces hospital readmissions, and lowers costs while improving patient engagement. Robotic Process Automation (RPA): RPA employs software bots to handle repetitive tasks such as data entry, claims management, and patient on boarding. This allows medical staff to devote

more time to direct patient care. While RPA enhances efficiency, it raises concerns regarding potential job displacement and the need for reskilling programs to adapt the workforce (19, 52). Ensuring human oversight in critical functions remains essential to protect patient safety. Artificial Intelligence and Machine Learning Applications: Analyse electronic medical records (EMRs), Improve diagnostic accuracy, support predictive modelling in clinical research, Enable personalized medicine (20, 32). For instance, machine learning algorithms can identify biomarkers, predict disease progression, and optimize treatment strategies by analysing large, diverse datasets. These capabilities enhance decision-making across public healthcare, clinical trials, and personalized care (1).

4) Operational Cost Reduction: Automation helps cut down expenses related to staffing, training, and resource utilization. By simplifying workflows and reducing reliance on manual processes, healthcare organizations can allocate resources more efficiently. This not only supports financial sustainability but also allows institutions to invest in patient care innovations and advanced technologies. Moreover, cost savings free up healthcare workers to spend more time on direct patient care, improving both outcomes and satisfaction (34, 58). **Increased Patient Satisfaction:** When healthcare professionals are relieved from administrative burdens, they can dedicate more time to meaningful patient interactions. This strengthens the patient provider relationship, leading to higher satisfaction and improved treatment adherence. Patients who feel supported are more likely to engage actively in their care, which further enhances outcomes. **Training programs that help clinicians use automation effectively can amplify these benefits, ensuring seamless integration into daily practice (31, 36, 44).** **Improved Efficiency and Productivity:** Automation minimizes waste by streamlining repetitive processes, enabling healthcare systems to operate with greater efficiency. Productivity also increases as organizations achieve higher output relative to input, often supported by tools like project management software and AI-driven task management. This fosters a culture of continuous improvement, innovation, and teamwork, driving long-term competitiveness and better patient services (2, 7). **Enhanced Data Management and Analytics:** Data has become a strategic asset in healthcare, and automation plays a central role in managing it effectively. Advanced systems support data governance, ensure integrity, and integrate multiple sources into unified platforms. Using predictive and prescriptive analytics, these systems extract actionable insights for clinical and administrative decision-making. Beyond improving efficiency, these insights enable personalized medicine, early detection of complications, and more effective resource allocation (22, 34). **Streamlined Communication and Coordination among Care Teams:** Automation enhances collaboration between healthcare teams by ensuring timely data sharing, predictive analysis, and patient-centred interventions. This fosters a patient-centric approach, enabling providers to respond promptly to health risks and customize treatment pathways. In the long run, automation improves

health outcomes and satisfaction by aligning medical care with individual patient needs. AI and machine learning further strengthen this by enabling predictive modelling and decision support that enhance clinical judgment (44).

E. Challenges and Barriers to Automation

Technical Challenges and Integration Issues: Introducing automation in healthcare requires advanced infrastructure and seamless integration with existing systems. Technical barriers often arise due to compatibility issues, data quality concerns, and limited interoperability between platforms. Overcoming these hurdles demands strong cross-functional collaboration, clear strategies, and ongoing investments in infrastructure. At the same time, organizations must remain vigilant against risks such as cyber attacks, compliance failures, and skill gaps among staff. A structured roadmap with defined goals and risk-mitigation strategies is essential to achieve smooth adoption (80). **Resistance to Change Among Healthcare Professionals:** Healthcare professionals may be hesitant to embrace automation, fearing disruption of established workflows or loss of control. This resistance can be reduced through inclusive training programs, open communication, and involvement of staff in the design and implementation process. By engaging professionals early, institutions can build trust, foster ownership, and create a culture of continuous improvement. Feedback mechanisms are equally important, enabling workers to share their experiences and suggest refinements, which increases acceptance and overall system effectiveness (56). **Ethical and Privacy Concerns:** While AI and automation offer immense benefits, they raise sensitive issues related to bias, privacy, and job displacement. The use of vast patient datasets introduces vulnerabilities to hacking and unauthorized access. Patients may also remain unaware of how their information is processed, leading to mistrust. To address these challenges, healthcare systems must implement strict data protection measures, ensure algorithm transparency, conduct regular audits. Involve patients in decision-making about data usage. Strong ethical frameworks and continuous staff education are necessary to ensure that automation is used responsibly, protecting both patient autonomy and trust (3, 22). **Regulatory and Compliance Issues:** As

AI systems grow more autonomous, accountability in medical decision-making becomes a pressing issue. Questions such as “Who is responsible if an AI-driven decision causes harm?” highlight the urgency of clear regulations. Stakeholders—including clinicians, technologists, and ethicists—must collaborate to create standards that prioritize patient welfare while encouraging innovation. Training healthcare professionals on evolving compliance requirements is equally important, ensuring they stay updated on ethical guidelines while using automation responsibly. Striking this balance between innovation and regulation will help maintain trust and improve patient outcomes (12, 23, 51).

F. Future Trend in Automation in Healthcare

Artificial Intelligence and Machine Learning Applications: AI and ML are set to redefine healthcare by supporting advanced medical imaging, personalized treatment plans, drug discovery, and remote monitoring. For example, AI-assisted robotic surgery allows for minimally invasive procedures with greater precision, reducing complications and recovery time. Machine learning tools are also improving clinical trial research by enabling advanced predictive analytics, which can shorten evaluation timelines and cut costs. These developments collectively enhance patient outcomes, healthcare efficiency, and decision-making (2, 32).

G. Predictive Analytics and Big Data in Healthcare

The use of predictive analytics, fuelled by big data, is transforming healthcare delivery. By analysing massive patient datasets, healthcare providers can forecast disease outbreaks, individual risk factors, and treatment responses with higher accuracy. Applications include early diagnosis, resource optimization, personalized treatment, and even fraud detection. Such predictive tools not only reduce costs but also improve care quality by enabling preventive and proactive interventions (1) IoT-enabled devices such as wearable sensors and smart medical tools are revolutionizing continuous patient monitoring. These devices provide real-time updates on vital signs, empowering healthcare providers to intervene promptly. IoT-driven

monitoring supports personalized care, early detection of illness, and reduced hospital dependency, making healthcare more efficient and cost-effective while improving overall patient safety (34).

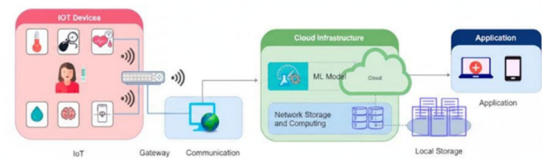


Fig. 5 Showing Intelligent Healthcare Assistants Working.

H. Intelligent Healthcare Assistants and Virtual Nurses

Advancements in conversational AI and natural language processing (NLP) are paving the way for digital assistants and virtual nurses. These tools can: Interact with patients meaningfully, Answer common health-related queries, Assist in medication management by reminding patients of schedules and possible interactions, Monitor vital signs remotely and provide feedback in real time, By extending care beyond hospital walls, virtual assistants enhance safety, continuity of care, and patient empowerment (55)

IV. CONCLUSIONS

The study emphasizes the transformative potential of automation in reshaping healthcare delivery. By combining evidence from a systematic literature review (SLR) and meta-analysis, the research establishes a strong foundation for understanding how automation enhances clinical care, streamlines administrative operations, and accelerates pharmaceutical innovation. Patient care can be significantly improved through real-time monitoring, personalized treatment strategies, and more accurate diagnostics. Administrative processes such as scheduling, claims processing, and documentation can be automated, allowing providers to focus more on direct patient interaction. Pharmaceutical services benefit from automated drug discovery, robotic dispensing, and optimized inventory management. However, successful integration depends on carefully addressing ethical issues, data security, and regulatory frameworks.

Safeguarding patient privacy, ensuring accountability in automated decision making, and building public trust are essential. Ultimately, the study concludes that automation, if balanced with appropriate governance and ethical oversight, has the potential to create a more efficient, accessible, and patient-centred healthcare system.

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