Current Developments and Prospects in Automated Medication Dispensing Systems and Pharmacy Robotics

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Abstract

Medication prescribing errors are the main reason for many annual deaths, with errors caused by improper actions of staff. Due to an increase in the number of patients, hospital pharmacies must address difficult tasks because staff doesn't have enough time to focus on single prescriptions. As a result, pharmacies are now relying on robotics to deliver medicines and keep errors to a minimum. The pharmacy robot is considered a major breakthrough in hospital pharmacy technology. The review explores the concept of pharmacy robots and looks at relevant scientific studies featuring their use in pharmacology. Though evidence proves that pharmacy robots positively affect a pharmacy, its employees and its daily tasks, incidents with the machines still occur and must be fixed by employees. The main point is that robots only support the work, making it necessary for humans to remain active in managing both the flow and efficiency of work performed in these systems.

Keywords: ***Pharmacy robot, pharmacy automation, pharmaceutical, robotics, medication dispensing.***

1. Introduction

Hospitals pharmacies aim to deliver medications as directed by a healthcare provider, following the right timing. With an increase in patients and more expansive healthcare systems, the simplicity of recruitment is quickly lost. Although pharmaceutical services are only concerned with patient safety and care, when mistakes happen during medicine distribution, it may lead to significant or even fatal effects. Wrong medicines, incorrect doses, missing treatment times or giving them to the wrong patients can all have serious outcomes.

Supplying medications is not easy because of the complicated logistics involved. Hospital pharmacies ensure that drugs are efficiently delivered by multiple methods to many parts of the hospital simultaneously, all while ensuring that the process stays accurate and prompt. Each action taken in the process such as prescribing and giving drugs, has a chance for mistake(1).

Healthcare institutions have used different technologies to address the challenges found in hospital pharmacies. Thanks to these technologies, there are fewer chances for patients to receive the wrong medicine or run out of their drugs. The pharmacy robot is an example of a breakthrough technology helping to improve hospital pharmacy systems. If properly set up such systems almost never make errors in dispensing medications, since they focus on the five rights of medication administration.

Pharmaceutical companies reap many significant benefits when they employ robotic technology. According to research, the use of robots in both pharmaceuticals and other biological fields lessens how much time is spent, reduces costs and leads to less waste. Robotics allow for faster prescription filling because computerized machines can work with the same efficiency under any number of orders. Particularly, robotics seems to minimize the chances of mistakes in giving medications, making patients safer.

Nevertheless, these robots still need some support from people, as they cannot function entirely by themselves. Even so, these systems still rely on operators, as there is a small chance that machine errors may occur. This makes researchers ask more questions about AI's involvement in healthcare. Even though there are worries about AI replacing humans in the field, research indicates that pharmacies will still rely on human involvement. By relying on these interventions, the whole pharmacy workflow as well as final output is affected(2).

In robotic pharmacy systems, people perform different tasks. It is up to the operator to direct, load and unload any products on the dock. Furthermore, flaws in the machinery are still coming up and must be addressed by people. As a result of these errors, rodents could underdose, overdose or experience human intervention, since vials and fluid bags can be too heavy or too light, some component shapes are off and robotic grips have issues with containers.

If the size of syringes or other pharmaceutical items is modified in the manufacturing process, robots need to be

recalibrated. Robotic systems have trouble when recognizing barcodes and vials, as they may not be well equipped to manage various forms of a single task. Therefore, pharmacists or technicians must help by verifying the data, adjusting how the machine operates or dealing with production issues.

The field of pharmacy greatly benefits from the use of pharmacy robots powered by artificial intelligence. They incorporate the latest algorithms, machine learning and robotics to modernize the way medications are given out. The primary role of pharmacy robots is to do work that usually requires precision and is easy for humans to mess up after a long day of repetition. If these tasks are performed by machines, pharmacists and technicians can rechannel their knowledge to assist patient care.

Robots used in modern pharmacies make use of different tools to accomplish their tasks. Robots can find medications with help from computer vision, as they can examine barcodes, detect pills and verify packages. To handle pharmaceutical items, machines equipped with robotic arms, conveyors and grippers are used. In addition, they are linked to advanced software that monitors the amount of drugs available, tracks if they are near expiration and lets staff know when something needs replenishing. As these innovations are integrated, the entire process from receiving a prescription to dispensing drugs can be done with little assistance from humans.

As healthcare becomes increasingly challenging, the complexity of patient care has led to more use of pharmacy automated tools(3). The more complex and specialized the medicine program becomes, the greater the chance for errors. They make handling and distributing medication more reliable by standardizing each step in the process. The use of these technologies marks an improvement in medication safety systems, working in partnership with electronic health records, support systems for medical decisions and computerized order systems.

I aim to explore the role that pharmacy robot technology plays in pharmacology as a key use of artificial intelligence. Examining the available research will allow us to present the present state of pharmacy automation, assess its value for safety and smooth operations and consider what lies ahead for this area. Being aware of what these technologies can and cannot do is necessary for healthcare organizations who want to provide the best pharmaceutical care to patients.

2. Background

AI has become a significant factor in Pharmacology

Simply put, artificial intelligence enables computers to handle operations that people normally use their brains for. Such systems can function using rules, machine learning or complex networks designed for deep learning. In pharmacology, AI can help make a significant impact on how healthcare services are provided. As pharmacology involves many medications, interactions, dosages and contraindications, it is ideal for using AI to handle and review data much quicker than what humans can achieve.

The Developments of Robots in Medicine

Generally, robots are defined as programs or mechanical devices that operate or are controlled by humans. Automatons or autonomous robots, can take care of several types of work in any environment even without regular human involvement. Recently, automation in robotics has improved a lot and its uses can now be seen in industry, medicine, surgical practice and self-driving vehicles.

Across areas such as transportation, production, healthcare and finance, society is increasing its use of robots. Programming autonomous robots in pharmaceuticals can help ensure efficient and accurate distribution of prescriptions while involving fewer humans. With these new pharmacy robots, handling prescriptions becomes more precise and ensures greater reliability in healthcare(4).

Robots in Pharmacy rely on navigation and knowing their location

They rely on advanced algorithms to draw up accurate maps of their work area. With these algorithms, robots can precisely create environmental maps necessary for them to function well. Just as maps guide humans when we travel, spatial models show robots the layout of their environment and what is around them. Without the accurate information from these environmental maps, pharmaceutical robots could not correctly carry out tasks such as locating, collecting and giving out drugs.

To ensure excellent work, modern pharmacy robots are built with the latest technology. Because of these systems, traditional methods of giving medications can become much more reliable and safe. With automated pharmaceutical robots, productivity goes up, errors in dispensing medicine are almost nonexistent, operations become more

effective and secure, waiting for medicine takes less time and medication is handled in an even cleaner, sterile way.

How Pharmacy Robots Are Put Together

A pharmacy robot's architecture is usually developed in a way that suits the necessary operations. All features of the application environment are taken into account during the development of an automated pharmacy. An easy way to understand this architecture is to review a typical pharmacy robot system that explains the main steps and mechanisms of this type of system.

In a standard implementation, robots communicate and take action on their own with doctors, assistants or other qualified staff members. Upon receiving the details from the doctor, the robot checks its list of available medicines. If the medication is present in the warehouse, the robot grabs and fills the needed container and puts it away until required. The entire process works because the robot can build its own map inside its mind and use it to interact with its environment, often by using SLAM technology for accurate navigation.

The robot needs to validate the identity of anyone who comes to pick up a prescription. Once sure that the prescription is real, the robot gathers the prepared drug and returns it to the patient. The system I mentioned uses AI and SLAM systems to create precise maps and automatically updates them as conditions in the warehouse change.

Structures and security features that exist on a network

Generally, automated pharmacy systems include rooms where patients can use a screen to communicate with the system on their own. They are equipped with internal locks to ensure that only the right people can access the room. Furthermore, the area used to store medicine is typically a secure vault that can be programmed to control factors like lighting and temperature(5). It prevents the degradation of pharmaceuticals that should always be stored in specific conditions like refrigerators. Consequently, multiple patients can be treated at once which improves how efficiently the department handles cases.

Security plays a vital role in the use of pharmacy robots. Usually, patient verification takes place using biometric systems that can scan a fingerprint, recognize a face or check a signature. To ensure only the right individuals get the drugs, multi-factor authentication is used and other security steps are taken if someone's identity is not verified. Putting both types of security measures in place covers both medication and patient safety, ensuring all drugs are dispensed safely.

With the help of robotics, AI, spatial mapping, security and inventory solutions, this system makes it possible for pharmacy robots to handle the different problems in dispensing drugs. Automating everyday work without compromising safety has improved pharmacy operations, helping to be more efficient and secure with medicines.

3. Review Methodology and Rationale for Pharmacy Automation

We chose this approach because it suited what we hoped to achieve in the course.

This in-depth study explores the use of pharmacy robots as advanced AI in the field of pharmacology. When exploring the area, the most significant organizations and publications from the pharmacology sector were the main target. They made sure to access all important databases, including IEEE Computer Society Digital Library, ACM Digital Library, ScienceDirect, SpringerLink and Google Scholar. As of April 2020, these platforms store the most published pharmacology papers.

Studies reporting outcomes related to pharmacy robot technology underwent fine screening and those of any design were considered(6). The content had to be written in English and published after 2010. To find important citations, the researchers examined the titles, abstracts and whole publications in several rounds of review. After thoroughly reviewing all the publications found, the team decided which ones to include in this analysis.

Pharmacy automation is now extremely necessary

Due to the high number of mistakes with medications in hospitals, robotics for pharmacy services are increasingly needed. Data from www.youhaverights.com suggests that in the United States each year, at least 30 million pharmacy errors occur. What makes it worse is that over 7,000 people lose their lives due to healthcare mistakes and many others suffer serious issues. The main reason for such mistakes is that pharmacists sometimes misunderstand the text on the prescription when deciding on the medication or amount to dispense.

Many of these mistakes happen because pharmacy employees are overloaded and work under a lot of stress with their duties increasing constantly. Since more prescriptions must be filled on a daily basis, pharmacy staff now have

less time for individual prescriptions, meaning errors may happen more often. Many pharmacy errors happen when employees give the wrong medication, fail to inform a person how to use a drug or fail to provide proper intravenous medication to patients in hospitals.

In such cases, using robotic technology for distributing medicine can greatly lower the risk of any errors made by humans. Implementing robotics improves accuracy and it also helps with many daily operations.

Pros of Having Automated Pharmacy Systems

Both current medical care and possible profits can be improved, thanks to the use of robots in pharmacies. This technology leads to better handling of pharmacies, allows drugs and patient information to be stored effectively and enhances how managers run the department. With increased productivity, patients spend less time waiting for their prescriptions.

Another benefit is that it enables pharmacy tasks to be distributed, helping establish ward-based drug management. Using this approach, pharmaceutical support reaches patients at their health care center, so they are able to access medicines safely and easily. Perhaps the main advantage of these systems is that they almost completely eliminate mistakes in giving medicine and the risk of contamination. Using barcodes and photos with patient prescriptions enhances safety and also lowers chances of facing litigation for medication errors(7).

The use of robotic systems boosts dispensation and allows hospital pharmaceutical services to be updated using less space. Since extra space is often a challenge, planners need to use efficient logistics when handling increasing stores of medication. Applying artificial intelligence has made a big difference compared to previous ways of dispensing medications, as it ensures all details are correct.

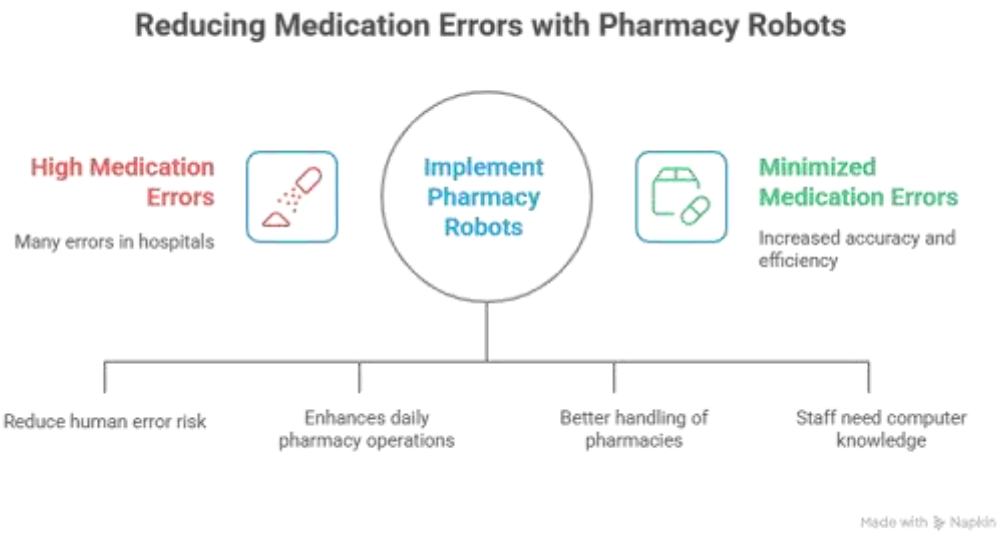

FIGURE 1 Reducing Medication Errors with Pharmacy Robots

Things to Keep in Mind

Improvements and increased efficiency in pharmaceutical systems through technology do not mean that problems and issues with automated systems do not exist. One should consider these disadvantages when introducing robotic systems.

A major issue is that some staff lack the necessary computer knowledge and experience to handle or operate the dispensing robots. Therefore, the system may require extensive and long-running training programs to help people operate it properly(8). Besides, configuring these systems with error-free programming is essential, as otherwise, they can cause errors that are different from those in manual processing.

It is also important to note that finance poses a big obstacle. Automated pharmacy systems require companies to pay a great deal when installing them, budget for stable maintenance and regularly update the software. Pharmacy robots are exposed to the same speed of obsolescence as other tech, so it may be necessary to continually install upgrades or modify existing systems.

While robots improve how efficiently and productively a pharmacy operates, pharmacists are still necessary. It is essential for pharmacists to provide knowledge, advice and care in working with patients. If pharmacist-patient communication is not common, certain patients might opt for speaking to a person instead, rather than use automated services.

A technical issue is that dispensing robots work using programs and networks that may become faulty. It takes careful effort to both maintain the software and handle the integration of dispensing robots with the pharmacy information systems, to avoid issues and ensure no mistakes happen.

Based on these, it is clear that automation should not be valued over the work done by skilled healthcare experts in pharmacy. The best use of pharmacy robotics considers the pros and cons of both machines and humans, joining them together to maximize the positive results and minimize the negative ones(9).

4. Examples of Pharmacy Robot Systems and Comparative Analysis

Modern Technology Advances in the Pharmacy Industry

The pharmaceutical industry has adopted various systems that help fill medications correctly and more efficiently. Most healthcare systems consider the Pyxis and Rowa Speedcase automation platforms to be leading automation tools, though they differ in advantages and disadvantages according to specific healthcare needs. They take the benefits of pharmacy automation from theory and help them become practical enhancements to how work is done.

Pyxis is an automated system

The introduction of the Pyxis MedStation ES System in 2019 made it possible for healthcare workers to have the most advanced turnkey automated dispensing system. Through this plan, decentralized departments at the medical unit can handle more work and place drugs within easier reach of nurses. To ensure that only medical staff who should handle medicines are allowed to do so, it relies on fingerprint verification.

With the Pyxis system, managing drug stocks is simple, even allowing for the generation of detailed reports. The benefit of an automatic medicine dispenser is that it provides drugs at the appropriate time, reducing the need for delays in patient management. As rapidly available medication usually is in an emergency, just-in-time supplies can influence how well patients are treated in critical situations(10).

Yet, there are many constraints within the system's operations. It is unable to monitor drugs at the level of individual pills which may complicate their overall tracking through the system. Handling returned medication should be done carefully, as it presents a risk of possible mistakes. There are risks involved when it is not easy to tell which medications in the same drawer have past their expiration date, allowing old ones to be issued.

Sometimes, issue with transmitting data can interrupt how work is done and patient care within the clinic or hospital. Instead of holding barcode verification for tablets at earlier steps, it is done at the patient's bedside only. Even though the Pyxis system greatly lowers the number of medication errors, it is not possible to eliminate them and people must monitor and fix any unavoidable mistakes.

Rowa Speedcase System.

In 2008, the Rowa Speedcase system was developed with a unique style of automation in mind. Implementing this system has allowed the hospital to spend less on departmental costs, fewer mistakes in providing drugs and even cut down medicine distribution time for patients. With this technology, more prescriptions are processed by the pharmacy department which could reduce the need for extra staff when the department is busy.

With the Rowa system, handling stock is easy, simplifying a task that can be difficult for most pharmacies. Since this approach involves a centralized service for drugs instead of handing them out at the bedside, there are different steps to take when setting up MediMizer rather than Pyxis.

Regardless of these benefits, using the Rowa Speedcase system does have some limitations. Above all else, it cannot put medications into individual units or bring them directly to where they are used in clinics. As a result, manual procedures or systems must be involved in some phases, increasing the likelihood of problems and waste at these stages. To ensure the medication management system runs effectively, facilities implementing it should pay attention to these gaps when designing their procedures(11).

A comparison of robotic and traditional pharmacy operations is made

Traditional methods of dispensing medicines have been replaced by rogue pharmacy robots which execute tasks

with much more accuracy. Such machines perform a series of actions that are inspired by humans, but they can be trusted to do the same thing every time. Since most patients rely on drugs during treatment, it is obvious that precise dispensing is crucial for healthcare facilities.

Many healthcare facilities now use technology-based tools such as CPOE and barcoding, to make sure patients are safe. Documentation, dispensing and medication administration are currently seen as the most risky steps in taking medications, as there is always a chance for errors at each stage.

Because of the dangers of manual processes, many healthcare places have adopted automated methods in their distribution of medicines. Healthcare organizations are also expected to manage expenses by shifting workers from simply handing out supplies to medical duties that are more important. Using resources effectively is a key reason why the automation of pharmacies benefits healthcare by enabling specialist pharmacists to focus more on medical duties.

Van Doormaal and his team studied the effectiveness of different medication systems. According to their study, reviewing drug records by hand allowed them to find 57 cases of taking too much medication and 143 cases of therapeutic errors, of which 46 were drug-drug interactions. Conversely, systems for computerized provider order entry (CPOE) with primary clinical decision support warned 297 times about overdose dangers and 365 times about the potential for drugs to interact. More advanced rules provided 313 safety alerts that brought about around 39% of the detected overdoses and inaccurate treatments(12). Remarkably, a quarter of warnings provided by clinical rule systems required patients to have their medications adjusted which was supported by manual review.

Amodeo and his team looked at how accurate automatic preparation of IV medication can be. The experiment found that, on average, the I.V. Station® made fewer errors and the error ranges were narrower than with manual preparation of medications. As well as improving how accurate the operations were, automation provided additional benefits for the company. Because of these features, the I.V. Station® used less, was more economical, preparations took less time and the workflow simplified even more as more medications needed to be made.

Besides making fewer mistakes, using robotic technology in a pharmacy provides many other advantages. They make managing medicine easy by organizing it, monitoring its expiration and creating prescriptions. Technicians do not need to worry about stocks since automated ordering is in place. The main benefit to patient safety is the decreased chance of drug errors, affecting the results of care and reducing the number of problems that can arise.

Automated systems can be used at main hospital pharmacies or in different hospital departments, adapting to how each hospital prefers to manage them. Staff nurses now have an easier way to provide medicines to patients and can keep medicines safe in optimal conditions. Because of this, errors related to drugs are less likely, drugs are used in the best way possible and there is less time spent handling drug administration and verification, so nurses and pharmacists can concentrate on hands-on work with patients.

5. Technical Capabilities and Obstacle Avoidance in Pharmacy Robotics

Technologies for Environmental Navigation

Many pharmacy robots in the modern age rely on advanced sensory systems to interact and operate properly in healthcare complexes. They should recognize and steer away from objects like tables, walls and moving people as they handle drugs and medicine. Robotic platforms use laser radars (LiDAR), vision instruments, ultrasonic radars and infrared detection devices, each one being ideal for different situations.

Laser radar uses two types of systems: 2D and 3D laser radar. With a 2D LiDAR, you can observe anything horizontally that is at the sensor’s height, but a 3D LiDAR can read the environment vertically and present the data in full 3D, depicting the complete space around the robot. In hospital and clinic settings that include different types of low and high obstacles, 3D perception plays a major role.

Although infrared techniques are useful in certain situations, their detection ranges are too narrow to be helpful for far-advance alerts. Just like ELINT, ultrasonic radar technologies find it difficult to sense threats in front of them due to ultrasonic reflections and their poor ability to direct radio waves. Therefore, engineers have begun using multi-sensor fusion to join the capabilities of different sensors and make the environmental perception of pharmacy robots more trustworthy.

Ways to Detect and Avoid Obstacles

With the help of advanced algorithms, pharmacy robots sense their surroundings and travel without endangering others. The robot uses its lasers to sense both types of objects, whether they are stationary (walls, cabinets, fixed items) or moving (moving equipment, people and patients). The robot’s ability to detect objects supports its

navigation and ability to avoid hitting them.

Using potential field strategies, most advanced systems implement multilayer perception. With this approach, the robot can determine the distance of an obstacle from itself and act accordingly such as moving to one side. These perception layers need to support a wide range of functions depending on parameters such as the robot's current speed, acceleration and braking ability, remaining power and the measurements of the workplace environment.

Pharmacy robot navigation has been significantly improved with the use of SLAM technologies. Robots can create maps of their surroundings and sense their location using SLAM algorithms, all without knowing the area beforehand. It becomes crucial in healthcare systems where the workplace may change with each new patient. With its continuous updates, the robot can easily navigate through any environment and avoid any obstacles that occur as it moves.

Deciding How to Move and Plan the Path

For pharmacy robots to operate smoothly, they must be able to make decisions quickly in real time while moving around. As it journeys between different storage locations and where drugs are dispensed, the robot ought to monitor the environment, recognize dangers and react in the right way. Typically, the process calculates the shortest route to the targeted points as it avoids spotted obstacles.

Since the robot predicts collisions with moving objects in its path, the control system directs it to change its path instead of only preventing crashes when they are about to happen. It makes operating in a healthcare facility more efficient and safe, especially when there are a lot of people transferring within different working spaces.

These advanced pharmacy robots use methods where the bigger task (navigating everywhere in the facility) and smaller tasks (going around objects) are separated. Following this method, a vehicle can travel long distances by responding quickly to any sudden obstacles in its path. Generally, a robotic system plans a main path with a global map, modifies it locally when necessary to avoid obstacles and returns to its original course whenever it can.

The capacity for evolution and learning changes in the environment

These days, pharmacy robots are adapted with artificial intelligence that helps them change and function well over time. These systems shy away from using set strategies and rely on observations in their work environment to modify their navigational approaches. In certain situations, robots can discover busy places and corridors and their scheduling can be altered to avoid disrupting human use in those local areas.

In some advanced cases, reinforcement learning is used to regularly improve the parameters for navigation using gathered data from operations. With each previous navigation task, the robot improves its strategy for following paths and avoiding obstacles in the place in which it is built. For long-term deployment, robots can become more efficient by gradually adapting to new situations they encounter.

As well as helping to navigate, environmental adaptation includes working with shifting products in the store. When inventories in a pharmacy change, it becomes necessary for pharmacy robots to manage different ways of packaging drugs, handling storage and retrieving what is needed. Modern systems rely on computer vision and machine learning to accommodate any new drug types, modifying their activity without needing a complete system adjustment.

Seamless integration of SCS with building infrastructure and methods for maintaining safety.

To use pharmacy robots successfully, they must be appropriately installed with the existing features and safety arrangements in the building. In many advanced situations, facilities are designed so that robot management remains effective and does not put the facility or workers at risk. Some adjustments may be made such as setting up sections in the hallways for robots, adding special charging points that don't hinder human traffic and doors that allow robots to come and go easily from one facility area to another.

Ensuring safety is a major factor when installing pharmacy robots. They usually link up with the facility's fire and emergency response systems and modify their functions during an emergency. So, robots can help by clearing paths out of buildings in case of fire or move to parking spots that are not in the way of those who respond to emergencies. Sometimes, these robots allow certain individuals to take over their movements in cases where the built-in program does not suffice.

When pharmacy robots are connected to the communication network, they can interact with other systems in the healthcare setting. Many systems interact with key platforms such as scheduling, health records and inventory management, to handle changes in operations more effectively. A robot in medicine could be set up to give high priority to delivering crucial medicines depending on real-time updates about patients, meanwhile managing the workflow to keep operations efficient.

Modern pharmacy robots are safe and efficient in healthcare settings due to the integration of complex sensing systems, modern obstacle detection methods, decision-making abilities and proper infrastructure management.

Thanks to these features, systems in automated pharmacies are fit to work smoothly and safely in modern healthcare facilities where demands are often high and the work environment changes frequently.

6.Conclusion and Future work

AI has greatly affected different areas and healthcare and pharmaceutical services are among the fields that see the most impact from technology. With robots in use at the hospital pharmacy, the workflow is enhanced and there are more filled prescriptions, better accuracy in counting, fewer mistakes with medications, increased patient safety and proper adherence to the right drug doses. Furthermore, using these systems makes managing the supply chain automatic, speeding up the release of medications and avoiding medicine stock shortages that could harm patients.

Apart from improving efficiency, pharmacy robots allow the pharmacy to meet staffing requirements by handling the rush on its own, without the need for additional workers. This information allows pharmaceutical companies to better track their activities and help them find ways to improve and optimize their practices. As technology progresses, its use in healthcare is set to help even more with managing medications for patients.

The Modern Pharmacy Field: Working Together with Machines

Even with the many positives of using robots in pharmacies, some question the effects on people working in this field. Because robots can perform certain tasks very well, people should think carefully about the future of those working in the pharmacy sector. Stephen Hawking, a well-known physicist, warned that advanced artificial intelligence might be dangerous for humanity.

According to this view, AI ought to cooperate with human workers instead of being on its own when making decisions. Though robots are outstanding at accomplishing specific duties released by guidelines, the role of human pharmacists still requires considering the big picture, using sound professional knowledge and interacting with others. Strong implementations realize the partnership between automation and pharmacy staff, using technology for simple tasks and allowing pharmacists to focus on key aspects of care and patient interactions.

Working together, humans and AI show great potential in this field. While systems can check for various medication interactions or ways to adjust treatment plans, medical professionals such as pharmacists apply their understanding to determine whether a patient is affected. Collaborative efforts in healthcare produce better results than if either humans or machines worked alone, thus promoting an even greater quality of pharmaceutical care.

Challenges and Issues Presently Faced

Despite the advances in automation in modern pharmacies, some issues and problems are still present. When mechanical problems become detected in robots, material handling challenges, misreads on components and precision concerns are solved by people’s help. Any size changes with medicine-packaging or changes in how medicine appears can make it harder for the machines to operate properly and thus require them to be frequently calibrated.

The software that comes with pharmacy robots can be challenging because it can be hard to use, lack connection in some cases and necessitate updates which could interrupt work. Integrating robots into drugstore information systems often requires skilled people and involves configuring many technical parts. Consequently, encountering these issues can postpone application launch and increase expenses, so the health sector’s poorer regions may not use them as much.

With automation in pharmacies becoming more advanced, the importance of security has also increased. Ensuring these systems are not accessible by people not authorized to access them means additional, complex cybersecurity must be put in place. Since automation in pharmacies is spreading, it is vital to ensure both the security and proper functioning of everything related to digital systems.

Research on the Future and Advances in Technology

Research in pharmacy robotics is progressing faster lately and is bringing about many promising new developments. Better machine learning makes it possible for robots to learn and use new ways of handling medication, update their processes according to efficiency results and respond accordingly to variations in demand. Being able to learn could help reduce the challenges that come with setting up and managing applications everywhere.

In addition, researchers are working on enhanced communication between people and robots which has led to easier collaboration using natural language, hand gestures and new augmented reality tools. As a result, the use of these new methods of interacting with robots would reduce the challenge of training personnel and avoiding errors, allowing robots to be applied in almost any healthcare setting, regardless of a center’s technical skills.

Integrating pharmacy robotics with other healthcare technologies could substantially improve the care given to patients. Connecting these different tools could create a way for better management of patients' medications, even outside the hospital. Collaborating among different care settings could lead to better drug use, less serious side effects and effective treatment results.

Setting Up Healthcare Organizations

Before choosing to automate, healthcare groups should explore many different aspects besides the tech of the systems. If a system is executed thoughtfully and interacts well with the current processes and if staff is properly trained, people's involvement will contribute to the change process. Companies that do not pay attention to those aspects can have difficulties putting automation investments into practice.

All in all, because of the high initial expenses and fixed costs of general upkeep, running such a business can make it difficult to figure out the ultimate cost-benefit results. Even though automation can bring about lasting benefits in operations, handling the initial setup may mean using several systems at the same time and needing more resources which should be handled with care. For a proper evaluation of its ROI opportunity, an organization should develop a detailed model that includes expenses and effects on medication safety, workflow and staff reductions.

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Conflicts of interest

The authors have no conflicts of interest to declare

References

1. Li J, Zhang Y. Advances in robotic dispensing systems: Improving efficiency and patient safety. Int J Pharm Pract. 2022;30(2):101–108.
2. Kumar S, Patel M. Automation in hospital pharmacies: A systematic review. J Hosp Med Pharm. 2021;15(3):203–210.
3. Nguyen T, Han J. Pharmacy robotics and the future of medication management. Technol Health Care. 2023;31(1):55–62.
4. Lee D, Cho H. Integration of AI with robotic dispensers: Emerging trends. J Pharm Innov. 2020;15(4):490–497.
5. Ahmed R, Smith K. Cost-benefit analysis of automated dispensing machines in community pharmacies. Res Social Adm Pharm. 2021;17(6):1024–1030.
6. Yamamoto H, Tanaka T. Smart pharmacy: Implementation and outcomes of robotic automation. Asian J Pharm Sci. 2022;17(3):298–306.
7. Chen L, Wang Y. Enhancing inventory control using robotic systems in hospital settings. Hosp Pharm. 2020;55(5):289–296.
8. Robinson D, Allen P. Impact of automation on pharmacy workflow and medication errors. Pharmacy. 2019;7(4):179–186.
9. Muller C, Hoffman J. Robotics in pharmaceutical logistics: A German perspective. Eur J Hosp Pharm. 2021;28(1):17–22.
10. Kim S, Lee J. The role of automated dispensing in personalized medicine. J Med Syst. 2020;44(9):160–166.
11. Silva T, Borges F. Medication safety improvements through automated systems in long-term care. J Patient Saf. 2022;18(2):134–140.
12. Baker K, Hart A. Evaluating the ROI of pharmacy automation systems. Clinicoecon Outcomes Res. 2021;13(1):205–212.