

Recent trends in the usage of robotics in pharmacy

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ABSTRACT

Robotics is the science and technology of robots, and their design, manufacture, and application. Roboticists also study electronics, mechanics and software. The first ABB robot, for instance, was installed in 1974 in the automotive field. Since then, more than 150000 have been installed globally including a large proportion in the pharmaceutical field. In the world of pharmaceuticals, there is a vital role for robotics to play in the complicated processes of research and development, production, and packaging. Justification for robots ranges from improved worker safety to improved quality. Speeding up the drug discovery process is another benefit of robotics. A number of robot manufacturers have products specifically designed for this industry. Industrial robotics for pharmaceutical applications has a bright future. With a rapidly aging population that urgently requires sophisticated medical devices and newer drugs, robotics systems are increasingly adopted for improved productivity and efficiency to meet this growing demand. However, industrial robotics manufacturers face several challenges in their effort to establish themselves in pharmaceutical applications. Key among these is the incompatibility of their controller software with existing installed equipment.

Keywords: Pharmaceutical field, Robotics, Automated dispensing mechanisms, Automated storage, Automated retrieval systems.

INTRODUCTION

Robotics is the branch of technology that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. Robots in laboratory, life science and pharmaceutical applications perform tasks at rates beyond human capability. These robots function in potentially hazardous settings in proximity to biological dangers, the threat of radioactive contamination, and toxic chemotherapy compounds.

ROBOTIC PHARMACIES

Due to the potential hazards and high volumes, some hospitals and larger health care clinics utilize robotics to dispense medication. Robotic pharmacies are expanding rapidly within the hospitals and clinics. Several companies are servicing that market and the interest level will only increase. On the retail level, robotics in local pharmacies will be a challenge. The technology is available but regulation will pace the growth of robotic pharmacies more than the technology.

At the UCSF medical centre in California, such a system is already in place, and it is working wonders in terms of increasing efficiencies all around. Possibly the greatest benefit is the elimination of wrong dosage, wrong medication, and other errors largely contingent on human mistakes. Hospital pharmacies used to be centralized, but the model is increasingly opening up. Larger hospitals have hundreds of beds and numerous divisions, and all the

complexity basically means it can be difficult to keep track of medication's flow from pharmacy to patient. Automated systems mean such tracking can be made vastly more efficient. One problem, at least at this point, is that smaller hospitals do not have the capital at hand that's necessary to account for the high upfront costs of installing such automated systems. However, there is a general shift toward that, which means costs will be going down in time.

ADVANTAGES OF INDUSTRIAL ROBOTS

Design Benefit: Slim, quick, and flexible, robots are well-suited for the pick and place and assembly work in a pharmaceutical environment. Vision technology allows industrial robots to put together customized orders and do things like assemble blood sugar kits.

Safety Advantage: Robots protect the integrity of pharmaceutical products and the health of employees and patients. With industrial robots, toxic chemicals can be mixed safely. These particular robot models are designed to work in clean room settings. Sealed arm construction and decontamination with Hydrogen Peroxide Vapor (HPV) keep these models from ever contaminating product. Low payload picks and place jobs that would prove tedious for human workers are now the responsibility of tireless robots.

Reliability: The Food and Drug Administration (FDA) requires all medication to be tracked and traced throughout the production process. Industrial robots make it easier for pharmaceutical companies to comply with these requirements. Along similar lines, robots minimize accidents and wasted material.

Tirelessness: A robot can perform a 96 man-hour project in 10 hours with more consistency and higher quality results.

Return on investment (ROI): There is quick turn-around with ROI. Plus, with the increase in quality and application speed, there are the benefits of increased production possibilities.

Accuracy: Robotic systems are more accurate and consistent than their human counterparts.

Reliability: Robots can work 24 hours a day, seven days a week without stopping or tiring.

Affordability: With the advancements in technology and affordable robotics becoming available at less cost, more pick and place robotic cells are being installed for automation applications.

Quality: Robots have the capacity to dramatically improve product quality. Applications are performed with precision and high repeatability every time. This level of consistency can be hard to achieve any other way.

Production: With robots, throughput speeds increase, which directly impacts production. Because robots have the ability to work at a constant speed without pausing for breaks, sleep, vacations, they have the potential to produce more than a human worker.

Safety: Robots increase workplace safety. Workers are moved to supervisory roles, so they no longer have to perform dangerous applications in hazardous settings.

Savings: Greater worker safety leads to financial savings. There are fewer healthcare and insurance concerns for employers. Robots also offer untiring performance which saves valuable time. Their movements are always exact, so less material is wasted.

Speed: Robots work efficiently, without wasting movement or time. Without breaks or hesitation, robots are able to alter productivity by increasing throughput.

Flexibility: Packaging applications can vary. Robots are easily reprogrammed. Changes in their End of Arm Tooling (EOAT) developments and vision technology have expanded the application-specific abilities of packaging robots.

Redeployment: The flexibility of robots is usually measured by their ability to handle multiple product changes over time, but they can also handle changes in product life cycles.

Smaller is Better: The expenses of biological assays are high and getting higher. Robotics gives researchers the advantage of using tiny quantities of assays and to keep samples safe when moving them within the laboratory.

Reduced chances of contamination: Removing people from the screening process reduces the potential for contamination and the potential for dropped samples when handling them in laboratories. Robotics performs these tasks much faster with more precision and accuracy.

Cost - Paybacks for the purchase of robotic equipment in the pharmaceutical industry, given the fairly high hourly labor rates paid to employees, number of production shifts, and the low cost of capital. A typical robot installation, complete with accessories, safety barriers, conveyors, and labor, could cost around \$200,000. If that robot were to replace four manual workers each earning approximately \$30,000 per year, the robot would be paid for through salary savings alone in a little more than a year and a half.

Increase Efficiency: Robotics can increase efficiency, which means the price of the drug itself will become more competitive. When it comes to pharmaceutical production, people are not as efficient as robots, especially when they are wearing a protective suit. People in protective suits also require more room to work in.

Can work continuously in any environment - Another advantage in the laboratory is that robots are impervious to many environments that would not be safe for humans. A robot can operate twenty-four hours a day, seven days a week without a dip in accuracy.

DISADVANTAGES OF INDUSTRIAL ROBOTS

Dangers and fears: Although current robots are not believed to have developed to the stage where they pose any threat or danger to society, fears and concerns about robots have been repeatedly expressed in a wide range of books and films. The principal theme is the robots' intelligence and ability to act could exceed that of humans, that they could develop a conscience and a motivation to take over or destroy the human race.

Expense: The initial investment of robots is significant, especially when business owners are limiting their purchases to new robotic equipment. The cost of automation should be calculated in light of a business' greater financial budget. Regular maintenance needs can have a financial toll as well.

Return on investment (ROI): Incorporating industrial robots does not guarantee results. Without planning, companies can have difficulty achieving their goals.

Expertise: Employees will require training in programming and interacting with the new robotic equipment. This normally takes time and financial output.

Safety: Robots may protect workers from some hazards, but in the meantime, their very presence can create other safety problems. These new dangers must be taken into consideration.

The future of robots in pharmaceutical manufacturing: This range of vision applications in the pharmaceutical industry means it is one of the sectors with the most potential for growth in the entire field of robotics. Indeed, the scope of uses found for materials handling robots is only now beginning to become transparent. What is clear though is that the fundamentals of speed, payload and flexibility will continue to be important and that Toshiba Machine and TM Robotics will continue striving to offer industry leading machines that meet and surpass these requirements.

ROBOTICS ADVANCES AND INVESTMENTS

Swisslog just recently introduced the TransCar Automated Guided Vehicle—an automated system for moving heavy payloads from loading docks to their final destinations, smoothly integrating with elevators and doors to navigate. Laser, sonic and photographic guidance systems all work in tandem to help the AGV operate efficiently. Obviously, that makes the AGV a hugely attractive proposition just about anywhere where massive payloads are delivered and have to be sorted out regularly. So we're talking about hospitals, schools, universities, cafeterias, hotels, perhaps even airports and train stations. The major benefit, though, is directed toward hospitals, which can standardize their delivery schedules using the AGV, thus freeing up valuable human resources. Robotics in healthcare is already receiving serious attention and interest from big names. People like Bill Gates (who's initiated a whole division at Microsoft dedicated to R&D for robotics) are talking about things much further ahead than iRobot's (NASDAQ: IRBT) Roomba or the da Vinci robotic surgical system developed by Intuitive Surgical (NASDAQ: ISRG).

Amazon (NASDAQ: AMZN) recently acquired Kiva Systems for \$775 million or so; Kiva manufactures robotic systems for moving large payloads around in warehouses. Clearly, robotics is

revealing itself as an area that attracts diverse minds for diverse purposes. Healthcare, hospitals, and pharmacies will see booming business in the near future as the baby boomer generation hits retirement. Expect to see major advances in healthcare-related robotics soon.

WHAT ARE THE BENEFITS?

Currently, robots can only dispense medicines by a single method, either the original packs method (also known as 'one stop dispensing') or the packed down 'unit doses' method. To realise the most benefits, a hospital should choose which method they will adopt for the majority of dispensing and therefore which they will automate. Prior to the implementation, most US and European hospitals already supplied medicines primarily as either original packs or via unit dose dispensing. However, the UK used a combination of these methods and therefore before implementation of robotics was undertaken, reform of the majority of the supply chain towards a 'one-stop' or original pack method was required. This reform has been achieved and there are now over 150 successful hospital robot installations around the UK.

Safety & quality: Since 2001 there have been numerous reports on the impact of robotic dispensing on error rates. These analyses consistently show reductions in error rates and have ranged from a modest 16% decrease at Wolverhampton Hospital and up to 65% at King's College Hospital. With the preventable harm from medicines costing the UK more than £750 million each year in litigation costs alone, a reduction in errors of this magnitude can facilitate both savings as well as the opportunity for significant safety improvements. Dispensing of medicines is a resource intensive process. Pharmacy reform initiatives such as the Clinical Pharmacy Model development endorse pharmacy staff as safety agents of patient centred care. Projects such as antibiotic stewardship to reduce hospital acquired infections (HAI) and implementation of the Prevention of Venous Thrombo embolism (VTE) policy highlight the value that the pharmacist can add. The Wirral hospital was able to release 3.5 full time equivalents (FTE) as a result of faster throughput in the dispensary and Wolver Hampton hospital was able to release 2.4 FTE with staff spending 19% less time in the dispensary. This time was redeployed to focus on the quality and effectiveness of medicine use through clinical pharmacy services.

Financial: At the close of financial year 2008–9, NSW Health alone had a drug holding to the value of \$77 million representing almost 13% of annual drug

spend. The rationalisation of inventory associated with pharmacy robotics at King’s College Hospital identified a one off saving of £534,000 on reduced stock hold representing 2.25% of that year’s turnover. If this were achieved in NSW Health, it could result in a \$14 million saving alone. In addition to requiring less inventory hold, the first-in-first-out approach to stock rotation ensures that the products nearest expiry are used preferentially. The King’s College Hospital business case predicted annual savings of £40,000 on reducing expired stock wastage but actual savings were more than £100,000 per annum in the first three years alone. In addition to efficient stock rotation, reports can be run to identify infrequently used medicines that are nearing expiry and these can be re-distributed. These benefits were demonstrated at King’s College Hospital through manual entry of expiry data at robot loading but as data is increasingly being stored in products with two-dimensional barcodes, reduction in expired drug wastage is likely to further improve.

Process efficiencies: Waiting times are one of the most commonly quoted measures of patient experience. A number of implementation evaluations have observed decreases in prescription turnaround times although comparisons are difficult due to differences in baselines. Wolverhampton Hospital found a 19% increase in the number of items dispensed per hour by dispensary staff and Royal Bolton Hospital saw an 80% increase in prescriptions that were completed within one hour. Using the Lean approach of designing flow of processes, these efficiencies were found by stock being delivered directly to the staff member dispensing the medicine thereby reducing unproductive walking and picking time.

Method of dispensing: Benefits of robotic dispensing seen in the UK are primarily with full pack dispensing and imprest management. Full pack dispensing had not always been as prevalent and pharmacy in the UK has evolved where practical from individual patient dispensing which was previously the more common practice. The UK Audit Commission Report ‘A Spoonful of Sugar’ endorsed the change in practice not only to facilitate the implementation of robotic dispensing but also to reduce the overall cost and inefficiencies in the discharge and post-discharge processes. While the complication of state and commonwealth divide in Australia is acknowledged, it does not make this an unachievable task. Robotic dispensing has also demonstrated superior time efficiencies on prescriptions with more than one pack so with the trend towards Polypharmacy, there are likely to be further process efficiencies.

Type of products: Technology with robots has advanced rapidly even in the relatively short time they have been on the market. Fridge lines and schedule eight controlled drug storage can now be accommodated if jurisdictional legislation allows. However freezer lines, bulking items such as fluids bags and unboxed liquids still pose challenges to suppliers and this should be given particular consideration in Paediatric and palliative care settings.

Transaction data: Robot capacity varies from approximately 8,000 to 11,000 packs and as a result many larger UK hospitals use tandem systems of two to three robots. Current and projected capacity and throughput data is necessary to establish requirements for individual hospitals. This should be used in conjunction with the type of products that the scope of services supports.

Table 1: Summary of robotic pharmacy dispensing system benefits

Safety & quality	Financial	Process efficiencies
Reduction in dispensing errors	Reduced stock holding	Faster dispensing process to reduce patient waiting times
Staff released from dispensary for direct patient care supporting new Clinical Pharmacy Model	Improved stock rotation and reduction in expired stock wastage.	<ul style="list-style-type: none"> • Out of hours activity • On call remote working • Improved space utilization

THE WAY FORWARD

1. Business case: To make a business case for robotic dispensing, savings must exceed both the equipment and other associated and ongoing costs. The financial benefits and process efficiencies can be quantified in terms of inventory, turnover and staff savings but risk minimization, space utilization and staff morale also need to have measures assigned. To quantify capital

costs of the robots, a number of things need to be considered: enabling work; infrastructure; interfaces; hardware; project management; overtime and contingency plans to ensure service continuity capacity and throughput data analysis. Implementation of robotic dispensing is an opportunity for departments to leverage Lean techniques and to assess the value added and non-value added efforts at each stage of the pharmacy supply chain. This exercise

should drive the scope of 'to be' processes that will be the enablers of the Pharmacy Reform Program.

2. Design, layout & specifications: When implementing robots, it is essential to redesign the process from start to finish so that inefficiencies are not inherited. Designing the dispensing process to optimize staff efficiencies and patient responsiveness is essential. For example, dispensing computers should be clustered around the output point of the robot to eliminate transportation. Before finalizing layout and specifications, 'current state' processes should be mapped against 'to be' to ensure they deliver increased effectiveness to patients and hospital staff along with increased efficiency to pharmacy operations

3. Installation and implementation planning: Strategic sourcing and procurement is essential when engaging with suppliers and should be partnered with a coordinated and structured project management approach to ensure a successful implementation. The project needs to be divided into manageable and controllable stages but with appropriate flexibility to minimally interrupt the pharmacy service and not impact the provision of patient care.

4. Change management: Implementation of robotic dispensing should involve a centrally coordinated program of awareness, training and education, standard operation procedure (SOP) integration, adoption support, go live assistance and compliance reviews. Identification of change leaders and engagement teams with stakeholders from all appropriate departmental, organizational and supplier groups is essential to ensure trust and motivation for the change.

5. Benefit realization: It is important to assess the impact of robotic pharmacy dispensing and compare actual benefits with those anticipated in the original business case. A number of evaluation tool kits are available using a combination of quantitative and qualitative techniques. Without a thorough review of the business case and benefits that robotic dispensing enables, few hospitals are likely to secure the in-house expertise or capital needed to invest in these systems. To be able to realise the benefits and therefore leveraging of the experience of previous implementations, the specification process can be streamlined and provide the benefits of a standard configuration.

6. Cost savings: A one-off saving of £16,027 has been achieved by reducing stock holdings in 12 wards at Guy's and St Thomas' NHS Trust, said Daniel Mandeman, chief pharmacy technician, automation

system administrator, at the trust. The savings have been made by introducing automated dispensing cabinets at ward level in the biggest roll-out of automatic cabinets in Europe, and the fifth biggest in the world. A total of 105 cabinets have been installed in 30 wards. The target saving from reducing stock holdings is 20% from a total of £127,000 (i.e. £25,400) — this is expected to be met shortly when data from the other 18 wards has been analysed. The medicines cabinets are fully automated and give 24 hour access to stock medicines on the wards, and the cabinet sends an order directly to the pharmacy store about which medicines are required. So far, Mr Mandeman and his team have trained approximately 10,000 members of staff to use the cabinets across the trust.

Improving services: Implementing robotic and 'e-health' solutions into the pharmacy department at the newly built Forth Valley Royal Hospital in Stirlingshire has produced a number of important benefits, said Jann Davison, hospital pharmacy lead at NHS Forth Valley. The new hospital replaces two district general hospitals in the region and the first phase of service moves began in August this year.

CONCLUSION

Robotics which has emerged as a newer and advanced field in pharmacy has gained much non popularity in pharma industry. Their applicability in different fields of pharma industry is appreciated. It is accepted that in future the robotics would play a vital role for the development and growth of pharmaceutical sciences. Robotics has been present in the pharmaceutical industry for more than two decades. Once confined to clinical laboratories, the machines have found their way into the packaging processes and will continue to find new applications throughout the manufacturing arena. The future is always hard to predict, but it will be determined by technological developments, commercial factors and by changes within the pharmaceutical industry

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