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A REVIEW OF A PHARMACY AUTOMATION STUDY

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ABSTRACT

Automation is the process of using different control systems to perform a range of jobs in industries with little or no human interaction. Automation has moved into the pharmaceutical industry in recent years. Automation has been applied in the production, packing, labelling, and warehousing areas. The manufacture of specialised drugs is now possible because to the use of automated machinery. Utilising the most recent technologies has affected the R and D industry as well. The QA department's conventional responsibilities were limited to writing SOPs, carrying out audits and certifying and validating machinery and processes. The primary subjects of this study are the implementation of automated technology in the pharmaceutical industry and its implications for the division in charge of pharmaceutical quality assurance. This article covers the Raman probe along with other topics. Automation has been applied in the production, packing, labelling and warehousing areas. With the advent of automated machinery, the production of personalised drugs has become possible. Therefore, it's possible that automated systems could replace human inspectors. You can achieve greater repeatability and flexibility for less money with this technology.

KEYWORDS

Automation, Human interaction, Automated machinery and Standard operating procedure.

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INTRODUCTION

Automation is the process of replacing human labour in a production process with machinery and other devices that carry out mental and physical tasks[1-7]. Pharmaceutical automation includes the mechanical processes used in production, packing and material handling as well as the distribution of pharmaceuticals. The organisation discovered how crucial it is to safeguard the accuracy of data produced and that, in a controlled setting, process irregularities must be looked into and eliminated. The March 2017 event at the microtherapeutic

research facility brought to light the need for pharmaceutical companies to make sure all data related to them, including data generated by third parties, complies with industry standards. Automation, which translates to "self-dedicated," is the use of a computer or other control system to operate industrial machinery and processes while minimising the need for human intervention. Automation can also be used to automate processes and systems, which significantly minimises the need for human sensors and mental requirements[8,9]. For example, answering machines and automated telephone switchboards have essentially replaced telephone operators. Automation is the process of replacing human labour in a production process with machinery and other devices that carry out mental and physical tasks.

It's a method of working where the production process for material handling and product designs are combined through a mechanism of ideas and work to create a predetermined regulating and controlling system.

It is the outcome of industrialisation, which was motivated by the desire to produce consistently high-quality goods and boost productivity.

It can be carried out at different manufacturing system levels.

Managing semi-finished, finished and raw material items.

Throughout the production process, productive machinery is employed.

Quality control procedures and inspections.

The liquid's temperature is periodically measured by the system and the operator. For instance, he might slightly adjust the wall to enhance the steam flow if the temperature is lower than required. A temperature-sensitive gadget is used to generate a signal proportionate to the temperature measurement for an automatically regulated system. The controller receives this signal and compares it with the predetermined intended value[10-15]. The controller adjusts the steam control valve's opening to rectify the temperature if the disparity disappears.

What is automation and how it is used in Pharmaceutical Industries

Automation is the use of machines to execute the majority of the significant and repeated tasks in the pharmaceutical industry, replacing human labour in both mental and physical processes during the production process[16-24]. The development of industries has been accelerating, and the pharmaceutical sector is no exception. Regulations are becoming more stringent than they formerly were. In fact, enterprises can save time by using machines. Automated processes can assist Industrial Management in adhering to the constantly shifting regulatory requirements. Automation significantly lowers the requirement for human sensors. Over many years, it has been a global practice in numerous industries to replace human labour with modern technologies for a variety of purposes.

Since the newest technology can always have a significant impact on job chances in businesses, certain worker unions and other groups have always been against this tradition due to the replacement of humans. Automation is a group of technologies that enable systems and machines to operate with little to no human involvement and to perform better than when they are operated manually. Computer vision systems have been used for quality assurance purposes much more recently. As a result, systems may eventually take the role of human inspectors. Both computer hardware and software are advancing.

Numerous noteworthy advancements have resulted from the development of computer hardware and software technologies. For a comparatively little price, this technology offers more flexibility and repeatability. This allows for larger plants all along without sacrificing product quality[25-31]. These technologies are now being developed to be an essential component of online and real-time quality evaluation systems for pharmaceutical manufacturing plants.

Pharmaceutical firms have begun using automation into certain processes, such as anti-counterfeiting, sterilisation, and medication research. Enhancing an organization's workflow is the primary goal of

process automation. Automation helps us control all business processes in real time, cut down on errors, and enhance productivity while saving money, time and waste[32,33].

Impact of pharmacy automation technologies

Our findings imply that, despite the paucity of data, pharmacy automation does have some advantages across a range of metrics. The majority of research[34-38] agreed that pharmacy automation has reduced drug mistakes. This result was consistent with research from other settings, including the intensive care unit (ICU), where automation led to a decrease in medication preparation errors[39] and an inpatient setting where automation-more specifically, the unit dose dispensing system-prevented administration errors when used in conjunction with the proper monitoring[40]. The additional discovery that transcription was the most prevalent time for prescription errors to occur[41] implies that we should think about automating the transcribing process and utilising technology to improve medication safety.

Furthermore, even though it was discovered that automating the prescription filling process increased efficiency and decreased the amount of labour needed for the same task, pharmacy employees did not experience a decrease in their workload following automation[34,36,38,42,43]. This might be explained by moving workers to jobs related to automation that weren't previously needed. Despite this, employees reported in other research that their work/life balance had improved and their stress level had decreased after automation[44,34].

Therefore, even if the workload did not decrease, this seeming contradiction may indicate that staff members have benefited indirectly or intangibly from the deployment of automation. Patients may benefit from the cost savings reported by the studies, but there is not enough information available to say whether the reported marginal benefits outweigh the hidden costs associated with implementing and maintaining these systems because neither the capital costs nor the operating costs of the automation systems were routinely disclosed.

Therefore, more research will be required to determine the true total cost of implementing these pharmacy automation systems and to provide a more accurate picture of the financial sustainability of such implementations by integrating anticipated cost avoidance analyses from errors saved. Furthermore, our research showed that post-automation, there were time savings in terms of patient waiting, pharmaceutical preparation time, and stock-taking time[35,42,45,46]. However, even after automation was put in place, pharmacy employees noticed no decrease in the amount of time needed to fill prescriptions[43].

It seems unlikely that even a tiny amount of time saved may result in any noticeable advantages, such higher patient satisfaction or more staff time for other pursuits. This is consistent with the ambiguity around the effects of automation on workload and productivity, as previously discussed and makes it challenging to defend time savings as the primary consideration when considering whether to install automation systems in pharmacies. Finally, the implementation of automation did not generally have an impact on the job happiness of pharmacy staff[44,35], though one study did note an increase in satisfaction levels after automation[43].

These findings imply that, despite the fact that filling prescriptions by hand is linked to stress and overwork, staff satisfaction is not significantly impacted by it, and that automation solutions could not be the answer to raising employee contentment. As job satisfaction is easily influenced by a variety of factors, including the working environment, compensation, and corporate policy, it may not be a reliable indicator to assess the benefits of automation.

According to a poll that was previously conducted in Singapore[47], the top three pharmacy services that patients believe are most important are:

Prescriptions that are filled accurately and quickly (less than 30 minutes)

Correct medication administration

Fair prices.

Our results demonstrate that automation has reduced pharmaceutical errors, even though it is unclear how automation will affect labour productivity and time savings. With the scant information available, we can only suggest that ADM implementation would be more advantageous in public hospitals or sizable community pharmacy chains that strive to give consumers access to inexpensive healthcare through economies of scale and cost savings. We looked for ways to automate many facets of outpatient pharmacy operations as a whole in our search method. Still, much of the research that could be found concentrated only on automating the prescription filling procedure.

In order to compare the many robotic systems and choose the best system for the job, additional research on novel ways to use automation in this setting is required. This is especially true in light of more recent, cutting-edge inventions like the "drug vending machine." Analysing later works revealed efforts to push boundaries in this area. ADM was used in conjunction with extra features including automated transcription of prescription orders via an e-prescribing system in one study each from 201131 and 201328.

This is consistent with the growing global adoption and integration of various electronic prescription systems, indicating that additional pharmacy process segments may be automated in the future to increase workflow efficiency and productivity through the use of additional technological systems in conjunction with ADM. For example, a study has demonstrated the synergistic effects of ADM and bar coding systems, which further reduced medication errors[48].

The Pharmacy Automation Process

A system must take into account a number of important aspects when determining if automation is necessary[49]. Administrators want to ascertain how automation fits into the hospital's and pharmacy's strategic plans. That can be achieved by filling out a computer needs assessment checklist and performing an automation needs assessment. Administrators are required to review the current technology and decide which elements should be incorporated into the new system as part of the needs assessment process. Technology integration, both present and future, should be given top emphasis. Particular focus should be given to the technology enabling automated data transfer, profile-based billing, the pharmacy, and other software systems.

The presence of a pre-made interface is a reliable sign that, if the early bugs are fixed, everything will function as intended. Next, the administrator must evaluate the vendor's system configuration skills, raising concerns about the system's flexibility, adaptability to the hospital's changing needs, and potential for system upgradeability. The system's access methods are essential to its security. Possession of a valid ID is mandated in Ohio and several other states. It is advisable to consult local, state, and federal laws prior to utilising barcode, thumbprint, or card scanning access for automated drug distribution systems. For additional system tests, the administrator should also make sure the system is capable of reading bar codes. In order to determine which choices best suit the institution, we also recommend looking into whether the system can support a real-time drug administration record (MAR). The system's upkeep and servicing are of utmost importance, so the administrator must carefully examine how quickly the vendor responds to concerns. In addition, a computer needs assessment that examines the departmental interfaces as well as the gear and software already in use must be completed by the pharmacy personnel.

They must assess the screening options available to them through the system. Does it, for instance, highlight medications with a restricted therapeutic index, problematic pharmaceuticals, or other products that can have a negative impact on patients' outcomes? The pharmacy has to evaluate how easy it is for personnel to become educated on the system and how user-friendly the order entry process is. Does the system allow doctors to enter orders using a palm pilot? Any system under consideration must have MAR capabilities, which the pharmacy must also examine. To what extent is

the system adaptable? Is it possible to alter it? What is the system's price? What reporting features does it have? How is the usage of a therapeutic class of medications or target drugs observed by the system?

Can I exchange my old equipment for new? To what extent can the conditions and prices of a purchase or lease be negotiated? To determine how a healthcare institution will move forward when choosing whether system to buy or lease, the chemist must answer all of these issues.

Selection Procedure for an Automated Drug Dispensing and Monitoring System

The managers of a healthcare system must assess how automated dispensing devices (ADDs) may impact the medication management system prior to acquiring an automated drug dispensing and monitoring system[50]. Because of the associated costs, the decentralised nature of the facilities, and the requirement to cross-use personnel across all sites, Holzer decided to investigate decentralised ADDs as an alternative to centralised dispensing devices.

The choice of an automated system vendor is the next stage in automating the drug distribution process. AcuDose Rx, Diebold Medselect Systems, MedServe, Omnicell, Pyxis, and SureMed are a few popular automation systems. The following crucial elements must be taken into account while assessing a vendor:

The new system offers a two-way interface and is pre-established for the system already in use.

The new system can deliver appropriate medications to the right place at the right time.

The system contains security controls that are unique to the purchaser's facility.

Vulnerabilities to inedication errors must be identified and eliminated, if possible.

The system is linked to the wholesaler to ensure a comprehensive medication management system.

Flexibility in pricing is an important factor to be analyzed. Are there group purchasing organization discounts or volume discounts? What is the best price that can be obtained? Does the company offer an "out" clause for leases if the technology fails to produce items that are strongly desired?

Service and maintenance agreements must be reviewed. Does the company offer preventive maintenance with routine inspections or only crisis maintenance? Are repair or troubleshooting personnel always available?

A healthcare facility must assess per-unit pricing and service agreement pricing after deciding which system best meets its needs. Service is typically extra expensive and offers a variety of choices. Another crucial choice is whether to buy or lease a system. Given how quickly technology is developing, renting is frequently a better choice. If a facility decides to lease, it needs to consider how long the lease will last in order to guarantee best value and flexibility. Targeted labour reductions need to be carefully examined as well.

Without significantly decreasing labour, ADD systems can pay for themselves in less than five years by recovering misplaced charges and decreasing prescription theft. They might also offer a means of reducing the number of full-time staff. The administrator is responsible for evaluating the vendor's assumptions, reviewing the fine print in the contract and estimating the costs and necessity of training.

Challenges Experienced during Pharmacy Automation

Medication errors significantly burden healthcare systems, providers, and patients. The most severe outcome of medication errors is death, with an estimated 7,000 to 9,000 deaths occurring annually in the United States; other outcomes include permanent disabilities, extended hospital stays and increased healthcare costs estimated at $21 billion per year[51-55]. The National Coordinating Council for Medication Error Reporting and Prevention defines a medication error as any avoidable occurrence that may lead to inappropriate medication use or harm to the patient while the medication is controlled by healthcare professionals or the patient[56]. Medication errors hit three categories: system, healthcare provider, and patient. The first category (system) includes but is not limited to prescribing,

communicating orders, labeling the products, packaging, terminology, compounding, supplying, delivering, administration, tutoring, monitoring, and usage[57,58]. The second category involves healthcare personnel, such as less experienced staff, stressed staff, and many others[59]. The last category (the patient's condition) includes but is not limited to impaired cognition, polypharmacy and adherence[60,61]. As a result of the previous, the automated dispensing system (ADS) was approved by the American Society of Health-System Pharmacists in 2010 as a step towards reducing medication errors and stress and saving time and effort[60,61].

ADS has been observed to reduce workload and work-related stress by around 21.8% in outpatient pharmacies[62] and decrease drug errors while increasing patient safety by 37% in pharmacies[63,64]. The use of robotics in healthcare facilities was proposed as a must. The Audit Commission for Local Authorities and the National Health Service (NHS) in England and Wales recommended it in 2001. In addition, in ''A Spoonful of Sugar," the Audit Commission's paper examined the status of pharmaceutical services and their operations. It highlighted that innovation could tackle staff shortages, especially in pharmacies using information technology and automation. Nevertheless, another study comparing workforce requirements between manual, and ADS found that ADS only reduced the burden of pharmacy technicians while increasing the workload of pharmacists. When combined with computerised ADS, chemist participation in the work process can enhance the effectiveness of the medication distribution system while also indirectly improving hospital patient care[65], [66]. The "A Spoonful of Sugar" research states that in order for chemists to give patients better treatment and highlight their value, workflows or services must be redesigned. This could entail going over the responsibilities of chemists and automating basic duties like dispensing[65,66]. By automating these chores, staff members may spend more time delivering patient-centered care and lower the possibility of errors during dispensing. Furthermore, jobs for pharmacy technicians and assistants might be extended in the ADS plan if suitable competency tests are developed and adhered to[67]. Because of this, ADS has a number of advantages, such as cutting down on patient wait times and prescription filling times[68,69]. Failure Mode and Effects Analysis, or FMEA, is a methodical process that is used to pinpoint any weak areas in the creation, production, or delivery of a good or service. It describes potential failure modes and draws attention to potential defects, particularly ones that can endanger the customer[70-74]. Determining the impact of these failures and ranking which failures need the greatest attention are two other uses for FMEA. FMEA templates are frequently employed by business analysts and healthcare facilities to finalise their evaluations[71-74].

FMEA scoring is a risk assessment technique with a range of 1 to 10. A number of one denotes minimal danger, whereas a score of ten denotes significant risk[70-74]. FMEA is not without risks and restrictions, though. It depends on the team's experience, and improper identification could lead to failure modes being overlooked[72]. It can be labour-intensive, time-consuming, challenging to calculate the likelihood of failure, or even challenging to create workable preventive measures. Setting priorities aids in concentrating on important problems, but it is not a complete fix. Scope and detail must be balanced in FMEA[72]. Lastly, for FMEA to be effective, organisations must be dedicated to putting suggested steps into practice[72].

Prioritising failure modes during an FMEA will help you determine which ones are most essential and need attention. To eliminate the failure mode, action must be performed and assessed for effectiveness; prioritising them alone will not suffice. There may be situations where further action beyond the FMEA's purview is required. It takes a team effort to identify failure modes and it takes time and attention to detail to analyse the process or design completely. If the team does not undertake a thorough analysis, significant failure modes may go unnoticed, which could lead to

problems in the future. It is not advisable to rush the process because it requires time to go over the specifics and make sure everyone on the team has enough time to contribute. Additionally, a failure mode or consequence that is unrelated to the team's experiences could go unnoticed. To enhance the rating process, meaningful rating scales should be used and made clear to all members of the organisation. In addition to being confusing, generic grading systems make it difficult for management to compare risks and assign tasks to different teams in an efficient manner.

All things considered, it is imperative that FMEAs be carried out early on in the design phase and that the team thoroughly looks into likely failure mechanisms[75]. Our research attempts to assess the dangers connected with Employing the conventional Risk Priority Number (RPN) FME, determine the underlying reasons of reported issues with the pharmacy's present manual workflow and put corrective measures in place for long-term profitability and high-quality execution.

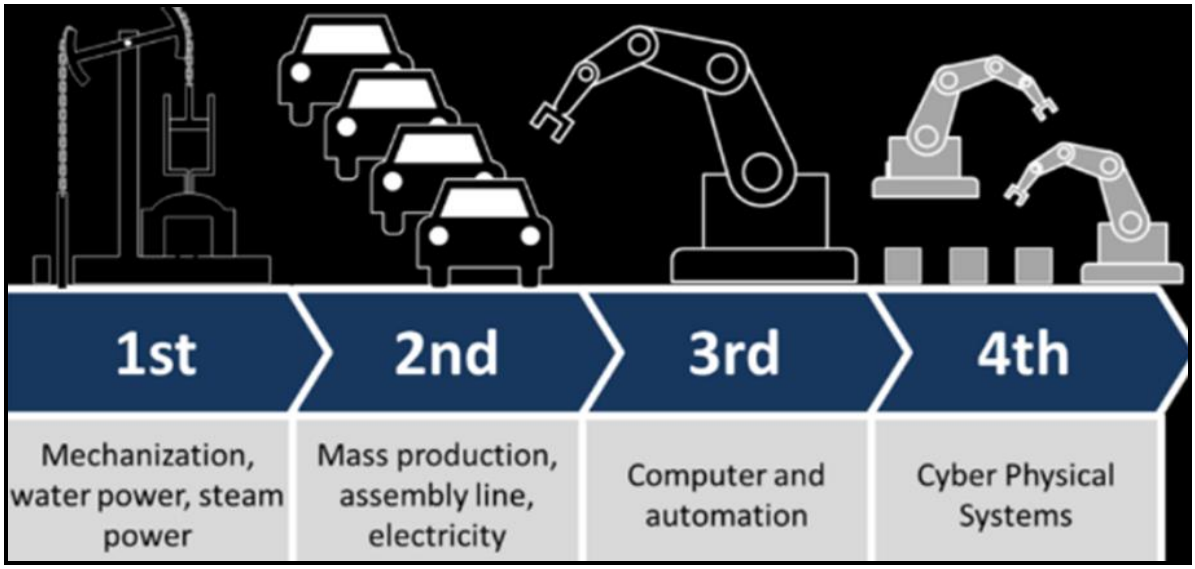

Figure No.1: Automation used in Pharmaceutical Industries four stages of manufacturing

Figure No.2: Automation launches an industrious new era in Pharmaceutical industries

CONCLUSION

The pharmaceutical industry can potentially gain from automation in a number of ways, including better overall image quality, reduced radiation exposure and more productivity for technologists. Using computer-based QA algorithms to detect and measure QA flaws, gathering QA data to establish international QA standards and building structured databases will all increase the efficacy of the QA department. Taking into account the short- and long-term effects of automation, paper trails in the industries will disappear, and drug development will shift to the virtual realm. This will, however, improve the quality assurance department by reducing the window of opportunity for errors and oversight of defects. The QA division will be essential to the development of automated technology as their specialised knowledge will be required by the engineers to create an effective automated system without compromising the quality of the final output.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

BIBLIOGRAPHY

1. Thomas George P. Impact of automation in pharmaceutical industry on roles and responsibilities of quality assurance: A review, *Inter Jour of Pha Qua Ass,* 11(01), 2013, 74-82.
2. HQ I, HQ, I. The growing role of automation in the pharmaceutical industry – IDBS, *IDBS*, 2019.
3. Gandla Kumaraswamy, Penke Vijaya Babu, Rajinikanth Sagapola, Peta Sudhakar. A Review of artificial intelligence in treatment of COVID-19, *Jour of Pha Nega Res,* 13(1), 2022, 254-264.
4. The Engineer. The benefits of automation in pharmaceutical manufacturing, 2019.
5. Process optimization and automation in pharmaceutical manufacturing, *Rscal.com,* 2019.
6. Rogers P. Robotic process automation' is the answer to digital transformation, *Intelligent CIO,* 2019.
7. Popovic D. Automation and control in production processes, control systems, robotics and automation, *Industrial Appl Control System,* 19, 2009, 1-10.
8. Sravanthi Gandu, Kumaraswamy Gandla, Kavitha Pingili, Julluru Bhasker. A review on vaccine safety surveillance in pharmacovigilance, *World Journal of Pharmaceutical and Life Sciences,* 8(8), 2022, 93-98.
9. Petrova E, Ding M, Eliashberg J, Stremersch S. Innovation and marketing in the pharmaceutical industry, *S. l: Springer-Verlag, New York,* 7, 2014, 19-81.
10. Bansal P, Gill S, Christopher A, Gupta V. Emerging role of bioinformatics tools and software in evolution of clinical research, *Perspect Clin Res,* 7(3), 2016, 115-122.
11. Leuenberger H, Leuenberger M N. Implementing virtual R and D reality in industry: In silico design and testing of solid dosage forms, virtual R and D reality/proof of concept, *Swiss Pharm,* 31(7-8), 2009, 18-21.
12. Markarian J. Using robotics in pharmaceutical manufacturing, equipment and processing report, *PharmTech.com,* 2014.
13. Ranganathan S. Digital marketing in the Indian pharmaceutical industry: A study to assess views of pharmaceutical marketing professionals in using digital marketing as a brand promotional lever, *World J Pharm Pharm Sci,* 89(5), 1970, 2278-4351.
14. Mahnaz S, Ahmadi M, Sadoughi F, Garavand A. A comparative review of electronic prescription systems: Lessons learned from developed countries, *J Res Pharm Pract,* 6(1), 2017, 3-11.

15. Acemoglu D, Linn J. Market size in innovation: Theory and evidence from the pharmaceutical industry, *Quart J Econ,* 119(3), 2004, 1049-1090.
16. Saxena S, Devi P, Soni V. Identification of novel inhibitors against mycobacterium tuberculosis L-alanine dehydrogenase (MTB-AlaDH) through structure-based virtual screening, *J Mol Gra Model,* 47, 2014, 37-43.
17. Kumaraswamy Gandla, Sravanthi Gandu, Juluri Bhasker, Pingili Kavitha. A Validated UV- visible spectrophotometric method for simultaneous estimation of zolpidem tartrate and sibutramine hydrochloride in pharmaceutical dosage form, *International Journal of Innovative Research in Technology,* 9(2), 2022, 848-865.
18. Kumaraswamy Gandla, Sravanthi Gandu, Parameshwari, Simultaneous estimation of metoprolol and telmisartan in combined tablet dosage form by using RP-HPLC and UV spectrophotometry, *Asian Journal of Pharmaceutical Research and Development,* 10(4), 2022, 22-33.
19. Kumaraswamy Gandla M. Bindu, Kumaraswamy Gandla, Swapna Vemireddy, Sashmitha Samuel, Yalamanchili Praharsha. A validated stability indicating RP-HPLC method for the determination of molnupiravir in pharmaceutical dosage form, *World Journal of Advanced Research and Reviews,* 15(01), 2022, 580-590.
20. Kumaraswamy Gandla, Juluri Bhaskaer, Kavitha P, Sravanthi Gandu. Method development and validation for the simultaneous estimation of empagliflozin and linagliptin in bulk and pharmaceutical dosage form by reverse phase-high performance liquid chromatography, *International Journal of Current Science,* 12(3), 2022, 630-642.
21. Kumaraswamy Gandla G, Swapna, Ragidi Padma, Prasanth Kumar D, Pavan Kumar G. Synthesis and evaluation of 4-nitro chalcones: Exploring antibacterial activity, *Rasayan Journal of Chemistry,* 2022, 255-260.
22. Zerhouni E A. Clinical research at a crossroads: The NIH roadmap, *J Investig Med,* 54(4), 2006, 171-173.
23. Chang J, Zhu X. Bioinformatics databases: Intellectual property protection strategy, *J Intellect Property Rights,* 15, 2010, 447-454.
24. Liu Y, Hu B, Fu C, Chen X. DCDB: Drug combination database, *Bioinformatics,* 26(4), 2009, 5878.
25. Yelampalli, Suresh Reddy, Kumaraswamy Gandla, Konatham Teja Kumar Reddy, Adel Ehab Ibrahim, Sami El Deeb. Determination of sodium, potassium and magnesium as sulfate salts in oral preparations using ion chromatography and conductivity detection, *Separations,* 10(2), 2023, 99.
26. Konatham Teja Kumar Reddy, Kumaraswamy Gandla. Novel vesicular drug delivery systems proniosomes, *Pharm Res,* 6(3), 2022, 000272.
27. Kumaraswamy Gandla, Vyshali Veerareddy. A review on bioanalytical method development and validation by hyphenated techniques, *Journal of Pharmaceutical Negative Results,* 13(1), 2022, 1843-1846.
28. Liu X, Wang S, Meng F, Wang J, Zhang Y, Dai E, *et al*. SM2miR: A database of the experimentally validated small molecules' effects on microRNA expression, *Bioinformatics,* 29(3), 2013, 409-411.
29. Raviteja M, Gupta N. A review on electronic data management in pharmaceutical industry, *Asian J Pharm Clin Res,* 6(2), 2013, 38-42.
30. Richard C, Bairu M. Global clinical trials: Effective implementation and management, *Elsevier Academic Press,* 24(7), 2011, 471-522.
31. Peter Guilfoyle. Pharma 4.0: Industry 4.0 applied to pharmaceutical manufacturing, *Pharmaceutical Processing World,* 2018.
32. Edwards R, Edwards S. A computer-assisted data collection system for use in a multicenter study of American Indians and Alaska Natives: Scapes, *Computer Methods Programs Biomed,* 90(1), 2008, 38-55.

33. Pavlovic I, Kern T, Miklavcic D. Comparison of paper-based and electronic data collection process in clinical trials: Costs simulation study, *Contemporary Clinical Trials, Elsevier*, 30(4), 2009, 300-316.
34. James L, Barlow D, Bithell A, *et al*. Role conflict: occupational stressors versus patient safety, The effect of workload and pharmacy staff stressors on prevented dispensing incidents in hospitals with manual and automated dispensing systems, *Int J Clin Pharm*, 17(S2), 2009, B2-B3.
35. Franklin B D, O'Grady K, Voncina L, *et al*. An evaluation of two automated dispensing machines in UK hospital pharmacy, *Int J Pharm Pract*, 16(1), 2008, 47-53.
36. Beard R J, Smith P. Integrated electronic prescribing and robotic dispensing: A case study, *Springer Plus*, 2, 2013, 295.
37. James K L, Barlow D, Bithell A, *et al*. The impact of automation on workload and dispensing errors in a hospital pharmacy, *Int J Pharm Pract*, 21(2), 2013, 92-104.
38. Ysp O, Chen L L, Wong J A, *et al*. Evaluating the impact of drug dispensing systems on the safety and efficacy in a Singapore outpatient pharmacy, *Value Health*, 17(7), 2014, A791-792.
39. Chapuis C, Roustit M, Bal G, *et al*. Automated drug dispensing system reduces medication errors in an intensive care setting, *Crit Care Med*, 38(12), 2010, 2275-2281.
40. Pelayo S, Hassler S, Bernonville S, *et al*. Safety-oriented usability test of a semiautomated unit dose system: Role of task allocation between human and machine, *Stud Health Technol Inform*, 194, 2013, 103-109.
41. Cheung K C, Van Den Bemt P M, Bouvy M L, *et al*. Medication incidents related to automated dose dispensing in community pharmacies and hospitals-a reporting system study, *PLoS One*, 9(7), 2014, e101686.
42. Mobach M P. The merits of a robot: A Dutch experience, *J Pharm Pharm Sci*, 9(3), 2006, 376-387.
43. Humphries T L, Delate T, Helling D K, *et al*. Impact of an automated dispensing system in outpatient pharmacies, *J Am Pharm Assoc*, 48(6), 2008, 774-779.
44. James K L, Barlow D, Bithell A, *et al*. The impact of automation on pharmacy staff experience of workplace stressors, *Int J Pharm Pract*, 21(2), 2013, 105-116.
45. Lin A C, Huang Y C, Punches G, *et al*. Effect of a robotic prescription-filling system on pharmacy staff activities and prescription-filling time, *Am J Health Syst Pharm*, 64(17), 2007, 1832-1839.
46. Ruhle F, Braun R, Ostermann H. Impact of robotic dispensing machines in German pharmacies on business performance indicators, *Libyan J Med*, 4(4), 2009, 146-151.
47. Vhy T, Lim M M. Patients' perceptions and expectations of outpatient pharmacy services in a teaching hospital, *Int J Pharm Pract*, 5(3), 1997, 128-132.
48. Oldland A R, Golightly L K, May S K, *et al*. Electronic inventory systems and barcode technology: Impact on pharmacy technical accuracy and error liability, *Hosp Pharm*, 50(1), 2015, 34-41.
49. Wong B J, Rancourt M D, Clark S T. Choosing an automated dispensing machine, *American Fournal of Health-System Pharmacy*, 56(14), 1999, 1398-1399.
50. ECRI. Automated decentralized pharmacy dispensing systems, *Health Devices*, 25(12), 1996, 436-473.
51. Borges Da Silva R, Brault I, Pineault R, Chouinard M C, Prud'homme A, D'Amour D. Nursing practice in primary care and patients' experience of care, *J Prim Care Community Health*, 9, 2018.
52. Giannetta N, Dionisi S, Tonello M, Di Simone E, Di Muzio M. A worldwide bibliometric analysis of published literature on medication errors, *J. Patient Saf*, 18(3), 2022, 201-209.

53. Jaam M, Naseralallah L M, Hussain T A, Pawluk S A. Pharmacist-led educational interventions provided to healthcare providers to reduce medication errors: A systematic review and meta-analysis, *PLoS One,* 16(6), 2021, e0253588.
54. Tariq R A, Vashisht R, Sinha A, Scherbak Y. Medication dispensing errors and prevention, *Stat Pearls,* 2018.
55. Whittaker C F, Miklich M A, Patel R S, Fink J C. Medication safety principles and practice in CKD, *Clin. J. Am. Soc. Nephrol,* 13(11), 2018, 1738-1746.
56. NCCMERP. About medication errors | NCC MERP WWW document, *National Coordinating Council for Medication Error Reporting and Prevention,* 2022.
57. Trakulsunti Y, Antony J, Ghadge A, Gupta S. Reducing medication errors using LSS Methodology: A systematic literature review and key findings, *Total Qual. Manag. Bus. Excell,* 31(5-6), 2020, 550-568.
58. World Health Organization. Medication errors Technical Series on Safer Primary Care, *WHO, Geneva,* 2016.
59. Ambwani S, Misra A K, Kumar R. Medication errors: Is it the hidden part of the submerged iceberg in our health-care system? *Int. J. Appl. Basic Med. Res,* 9(3), 2019, 135-142.
60. Ganio M C, Jerry C. Use of automation and technology in sterile preparations: A call to action, *Am. J. Health Syst. Pharm,* 79(10), 2022, 711-712.
61. Iredell B, Mourad H, Nickman N A, Dieu H, Austin G, Goradia R, Wade J S, Goette J, Ezekiel T O, Begnoche B R, Liu A, English S. ASHP guidelines on the safe use of automated compounding devices for the preparation of parenteral nutrition admixtures, *Am. J. Health Syst. Pharm,* 79(10), 2022, 730-735.
62. Coombs C, Hislop D, Taneva S K, Barnard S. The strategic impacts of Intelligent Automation for knowledge and service work: An interdisciplinary review, *J. Strateg. Inf. Syst,* 29(4), 2020, 101600.
63. Hohmeier K C, Desselle S P. Exploring the implementation of a novel optimizing care model in the community pharmacy setting, *J. Am. Pharm. Assoc,* 59(3), 2019, 310-318.
64. Kechagias E P, Papadopoulos G A. Applying a system dynamics approach for the pharmaceutical industry: Simulation and optimization of the quality control process, *Wseas Transactions on Environment and Development,* 17, 2021, 983-996.
65. Ahtiainen H K, Kallio M M, Airaksinen M, Holmstrom A R. Safety, time and cost evaluation of automated and semi-automated drug distribution systems in hospitals: A systematic review, *Eur. J. Hosp. Pharm,* 27(5), 2020, 253-262.
66. Audit commission for local authorities and the National Health Service in England and wales, *A Spoonful of Sugar: Medicines Management in NHS Hospitals: Briefing,* 2001.
67. Kiran D R. Total quality management: An overview, *Total Quality Management. Butterworth-Heinemann,* 2017.
68. Rodriguez-Gonzalez C G, Herranz-Alonso A, Escudero-Vilaplana V, Ais Larisgoitia, M A, Iglesias-Peinado I, Sanjurjo-Saez M. Robotic dispensing improves patient safety, inventory management and staff satisfaction in an outpatient hospital pharmacy, *J. Eval. Clin. Pract,* 25(1), 2019, 28-35.
69. Sng Y, Ong C K, Lai Y F. Approaches to outpatient pharmacy automation: A systematic review, *Eur. J. Hosp. Pharm,* 26(3), 2019, 157-162.
70. Huang J, You J X. Failure mode and effect analysis improvement: A systematic literature review and future research agenda, *Reliab. Eng. Syst. Saf,* 199, 2020, 106885.
71. Liu H, Zhang L. Failure mode and effects analysis for proactive healthcare risk evaluation: A systematic literature review, *J. Eval. Clin. Pract,* 26(4), 2020, 1320-1337.

72. Ouyang L, Yan L, Han M, Gu X. Survey of FMEA methods with improvement on performance inconsistency, *Qual. Reliab. Eng. Int*, 38(4), 2022b, 1850-1868.
73. Simsekler M C E, Gurses A P, Smith B E, Ozonoff A. Integration of multiple methods in identifying patient safety risks, *Saf. Sci*, 118, 2019, 530-537.
74. Strauch B. John senders, human error and system safety, *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 65(5), 2021, 766-778.
75. Cho S W, Lee H S, Kang J. A study on the common RPN model of Failure Mode Evaluation Analysis (FMEA) and its application for risk factor evaluation, *J. Korean Soc. Qual. Manage*, 50(1), 2022, 125-138.
76. Blaker K, White L, Poyser W. Dispensary assistants' attitudes and perceptions regarding automated dispensing machines in community pharmacies, *Int J Healthc Technol Manage*, 14(1-2), 2013, 90-109.
77. Walser L, Skinner J, Chisholm A. Early impact of a decentralized automated dispensing system in a small regional hospital, *Can J Hosp Pharm*, 64, 2011, 81.

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