Impacts of Automatic Dispensing Cabinets on Efficiency of Telepharmacy Systems

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Abstract

This paper reviews the impact of Automated Dispensing Cabinets (ADCs) on the efficiency of telepharmacy systems. Telepharmacy is emerging as a modern pharmaceutical model. Telepharmacy has emerged as a health care system to access rural and underserved areas. Telepharmacy's success depends on streamlined workflows, right medication dispensing, and accurate inventory management. ADCs provide secure storage, platform for seamless medication workflows and reduce human errors. The integration of ADCs with Telepharmacy Systems enables improving medication safety, reduces delays and reduction in pharmacist's workload. The study evaluates ADCs impact on parameters such as dispensing time, error rates, and workflow efficiency. Using automation, ADCs allow real-time inventory tracking, secure access of medication, and adherence to regulatory standards. This research follows the approach of mixed methods. It combines quantitative data analysis from telepharmacy sites using ADCs with qualitative data taken from pharmacists and technicians. The results show improvements in turnaround times, reduction in dispensing inaccuracies, and overall satisfaction among pharmacy staff. The findings will provide suggestions for integrating ADCs into the process of automating pharmacy. The paper will look at the challenges such as implementation costs, staff training necessities, and technology implementation.

1. Introduction

Telepharmacy has come out as a new method to deliver pharmaceutical care remotely, while addressing issues in healthcare access for rural and underserved populations. Using digital platforms, telepharmacy allows pharmacists to offer services such as medication counseling, prescription verification, and clinical support without physical presence. Efficiency of telepharmacy depends on the integration of advanced technologies that finetune the

medication management. Automated Dispensing Cabinets (ADCs) have emerged as one of the systems that securely store, track, and dispense medications with minimum human interactions. The ADCs are computerized systems. ADC controls inventory, manages user authentications, and ensures accurate dispensing. With these processes in place the risk of medication errors gets reduced and compliance with regulatory standards gets improved.

The integration of ADC with Telepharmacy systems offers several benefits. ADCs reduce turnaround times which allows pharmacists to concentrate on clinical decisions and patient counseling. ADCs enhance medication safety due to manual errors. With ADCs live inventory tracking would be available. ADCs enable operational efficiency by ensuring remote access and this is the central theme for multi-site telepharmacy systems.

ADCs result in difficulties and challenges when implemented for telepharmacy setups. ADC's implementations present questions about overall costs, training the staff, and compatibility with the existing infrastructure. This paper examines the role of ADCs in optimizing telepharmacy systems, thereby focusing on the impact on workflow efficiency, error reduction, and overall quality of service. Quantitative performance metrics and qualitative feedback from healthcare professionals have been analyzed as part of the study. The study aims to insight into how

automation can strengthen telepharmacy as a model for modern healthcare systems.

The evolution of telepharmacy has been linked to advancements in healthcare technologies. As healthcare systems. As healthcare systems attempt to increase efficiency and patient safety, the next generation of ADC will adopt artificial intelligence and machine learning algorithms. These enhancements will help in predicting medication demands, optimize inventory and flag potential drug interactions in advance. These features can bring down the stockouts and wastages leading to focusing on uninterrupted patient health care.

Blockchain technology has been another emerging technology which can be incorporated into Telepharmacy System. With Blockchain technology, immutable secure transaction records get created. Blockchain can enhance the security of medication dispensing. Blockchain resolves concerns pertaining to data integrity and regulatory compliance. This become very prevalent for stringent tracking of controlled substances, which is a mandatory requirement.

Cloud based ADC platforms enable interoperability and integration across multiple telepharmacy sites located at great distances. These systems enable data analytics, allowing administrators to generate and monitor performance metrics in real time. These metrics help to analyze the data and implement corrective actions quickly. Electronic Health

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Record Integration is another aspect which will finetune the workflows, ensuring the pharmacists to have an immediate access to patient health records.

These advantages are accompanied by new challenges. With more systems getting integrated, cybersecurity risks get increased. This would call for extreme security such as robust encryption and multi factor authentication strategies. The cost for implementing AI based ADCs and blockchain technologies may be overwhelming, especially for small or financial constrained pharmacies. These challenges emphasize need for scalable and cost-effective solutions.

Technologies such as Internet of Things (IoT) sensors and real-time monitoring systems are expected to enhance the working of ADC. Integration with IoT can help to track medication storage conditions, such as temperature and humidity. These medical storage conditions ensure compliance with regulatory and pharmaceutical standards. Predictive analytics supported by IoT data can help predict medication shortages, automate the replenishment processes. These predictive mechanisms reduce inefficiencies and improve patient outcomes.

Regulatory considerations will be vital for future of telepharmacies and ADC integration. As these systems get more advanced, health care organizations must follow the guidelines enforced by agencies such as Food and Drug Administration (FDA) and Drug Enforcement Authority (DEA). These guidelines are more stringent for controlled substances and while enforcing cybersecurity protocols. Creating standardized protocols for data privacy, interoperability and audit trails will be necessary to adhere to compliance across multiple healthcare settings.

2. Literature Review

Ref ere nce #	Year	Name of the Paper	Authors	Observations	Application
1	2021	ASHP Guidelines on the Safe Use of Automate	Cello, R and et all.	Guidelines address components of ADC technology implementation and important detailed steps to meet and	Automated dispensing cabinet (ADC) technology is used to improve patient care, enhance the efficiency

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		d Dispensing Cabinets		maintain basic ADC requirements.	
2	2016	Telepharmacy: a pharmacist's perspective on the clinical benefits and challenges	Poundel, A and et all.	For rural hospitals with fewer patients, the issue of costs appears to be one of the biggest barriers to telepharmacy services.	Telepharmacy has many recognizable benefits such as easy access to healthcare services in remote and rural locations, economic benefits, patient satisfaction as a result of medication access and information in rural areas, effective patient counseling, and minimal scarcity of local pharmacist and pharmacy services.
3	2025	Effectiveness of Pharmacy Automation Systems Versus Traditional Systems in Hospital Settings: A	Shbaily, E and et all.	Medication errors (MEs) in hospital settings is a healthcare challenge, resulting in adverse patient results which result in meditational errors and operational efficiency.	Patient outcomes improved through enhanced medication safety and reduced adverse drug events.

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		Systematic Review			
4	2023	Effect of an automated dispensing cabinet system on drug distribution effectiveness in a surgical unit	Liou, J and et all.	The use of the automated dispensing cabinet (ADC) for drug distribution in hospitals has become increasingly common and has numerous benefits.	The implementation of ADC was beneficial for surgical units. To the best of our knowledge, there have been no studies on a similar ADC system.
5	2021	Automation of in-hospital pharmacy dispensing : a systematic review	Batson, S and et all.	The current systematic review (SR) was undertaken to identify and summarize the published literature reporting on the clinical and economic value of automated in-hospital pharmacy services with a primary focus on systems supporting the dispensing of medicines.	The published evidence suggests positive impacts of ADS and should encourage hospitals to invest in automation, with a global strategy to improve reliability and the efficiency of the medication process.

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| 6 | 2025 | Benefits and challenges associated with implementation and ongoing use of automated dispensing cabinet for medicines : A scoping review. | Jung, Y and et all. | Automated dispensing cabinets (ADCs) have been increasingly used in hospitals as a means of streamlining medicines that use workflows, facilitating medicine management, saving costs, and improving patient safety | Differences in settings, distribution models, workflows, and technology infrastructure limit the overall ability to generalize findings. |
| 7 | 2024 | Revolutionizing Pharmacy Practice: The Role of Automation and AI in Enhancing Patient Safety and Efficiency | Al Shahrani M and et all. | Pharmacy automation is emerging as a transformative tool in healthcare systems and improving patient safety outcomes. | This review explores the benefits and challenges of the role of pharmacists in an automated pharmacy environment. |

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| 8 | 2018 | Reducing pharmacy patient waiting time | Alam, S and et all. | Pharmacy services start right from prescribing medicines and continue as the medication's effect is monitored. | The purpose of this paper is to enlist techniques, methods and technological advancements that have been successfully employed to reduce patient waiting time. |
| 9 | 2024 | The workload and satisfaction of pharmacists and pharmacy assistants after installation of an automated tablet dispensing and packaging system in a tertiary university hospital in Malaysia | Ramach andram, D et all. | The aim of this study was to examine the impact of pharmacy automation on the workload and satisfaction of pharmacists and pharmacy assistants in an inpatient setting. | Pharmacists focused mainly on clinical duties with healthcare colleagues, while pharmacy assistants handled various medication orders. |

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10	2020	Evaluation of telepharmacy and the use of a gravimetric technology-assisted workflow system for remote sterile product pharmacist checks	Jean, S and et all.	To evaluate the impact of remote sterile product pharmacist checks when used with a gravimetric-based technology-assisted workflow (TAWF) system on product checking accuracy, pharmacist review time, workload sharing, cost savings, and staff perceptions.	The remote process allows for opportunities for workload sharing and cost savings.
10	2022	Impact of automated drug dispensing system on patient safety	Alanazi, M and et all.	Automated drug dispensing system (ADDs) is an emerging technology that positively impacts drug dispensing efficiency by minimizing medication errors.	ADDs were highly effective in improving dispensing practice and medication review; however, the pharmacists need to emphasize the importance of ADDs to translate the pharmacists freed time towards patient care.
12	2020	Role of telepharmacy in	Ibramhim, O	Remote pharmacist interventions have achieved much	This study aimed to examine differences in rates and types of

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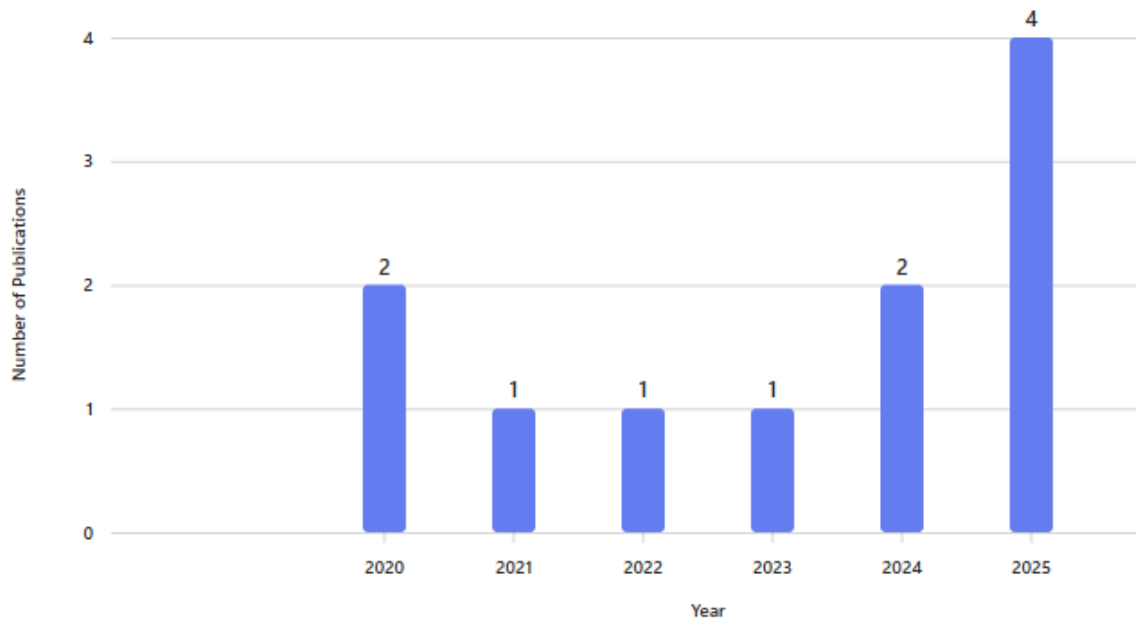**346 |** P a g e

		pharmacist counselling to coronavirus disease 2019 patients and medication dispensing errors	and et all.	more attention during the coronavirus disease 2019 (COVID-19) outbreak, since they reduce the risk of transmission and can potentially increase the access of vulnerable populations, such as patients with COVID-19, to pharmaceutical care.	pharmacist interventions related to COVID-19 and medication dispensing errors (MDEs) across community pharmacies with and without telepharmacy services.
13	2021	Economic evaluation of digital pharmacy platforms in reducing medication errors and operational healthcare costs	Genesis, I. O.	By evaluating financial and clinical outcomes, this study indicates the critical role of digital pharmacy platforms in enhancing safe, efficient, and economically healthcare delivery.	The digital transformation of pharmacy systems presents opportunities to increase medication safety, minimize healthcare costs, and improve overall efficiency.
14	2010	Impact of telepharmacy in a multihospi	Garrelts, J. C and et all.	Telephone calls were automatically routed to the telepharmacies so that handling of	The implementation of telepharmacy services in a multihospital health system expanded

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		tal health system		nursing and other calls would be transparent to staff.	hours of service, improved the speed of processing of physician medication orders, and increased clinical pharmacy services and cost avoidance.
15	2025	Assessment of Automation Models in Hospital Pharmacy: Systematic Review of Technologies, Practices, and Clinical Impacts	Karvannan, R. and et all.	The use of artificial intelligence offers promising prospects for improving the accuracy and operational efficiency of automation systems.	Medication management in hospitals is a complex process that encompasses every step from prescription to administration, involving multiple healthcare professionals.

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Fig No.1. Graphic showing the Number of Publications reviewed year-wise.

The above Graphic shows the Number of Publications on Telepharmacy and Automated Dispensing Cabinets reviewed.
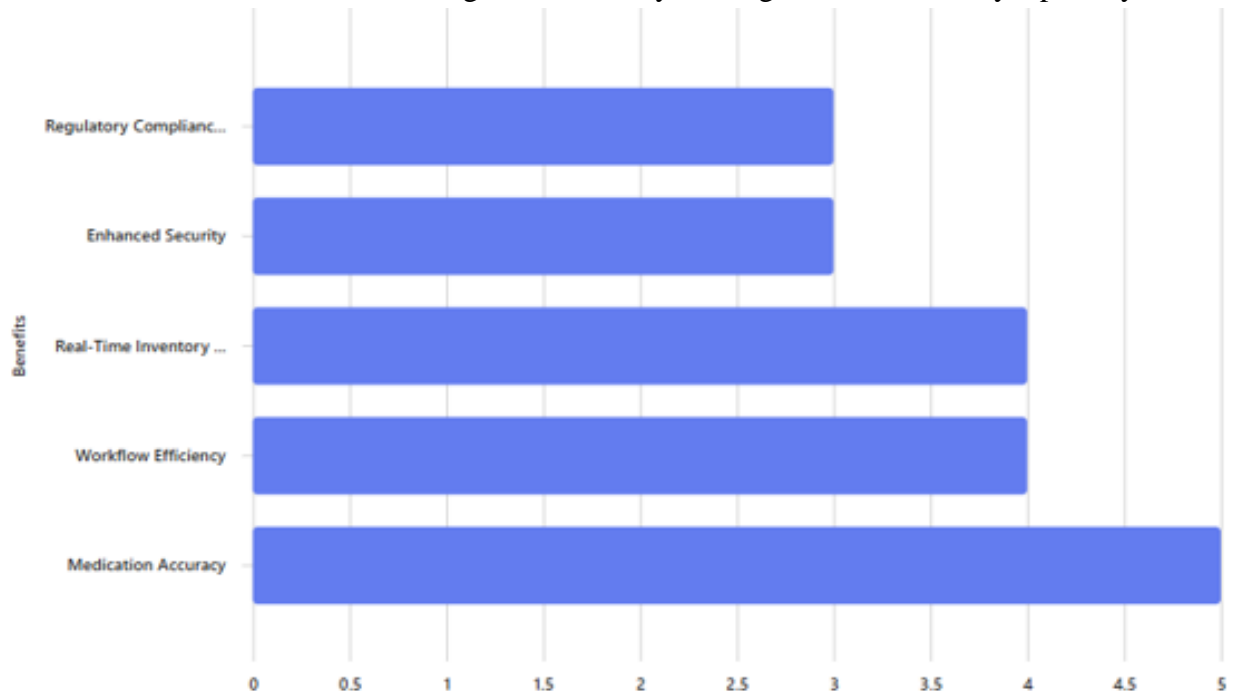
3. Benefits of ADCs in Telepharmacy

Automated Dispensing Cabinets (ADCs) offer numerous advantages that enhance the efficiency and safety of telepharmacy systems. One of the advantages with ADC is improving medication accuracy. ADCs automate the medication dispensing process. This reduces human errors associated with manual processes. With this process in place, patients receive accurate medication and the right dosage. Accuracy becomes extremely important in remote pharmacy setups where pharmacists may not be physically present to supervise every transaction. ADCs streamline medication workflow by minimizing the time required to retrieve them and dispense the medication. This allows the telepharmacists to concentrate on more important pharmacy tasks such as patient consultation and prescription verification. ADCs are set up to provide live inventory access and management. ADCs offer

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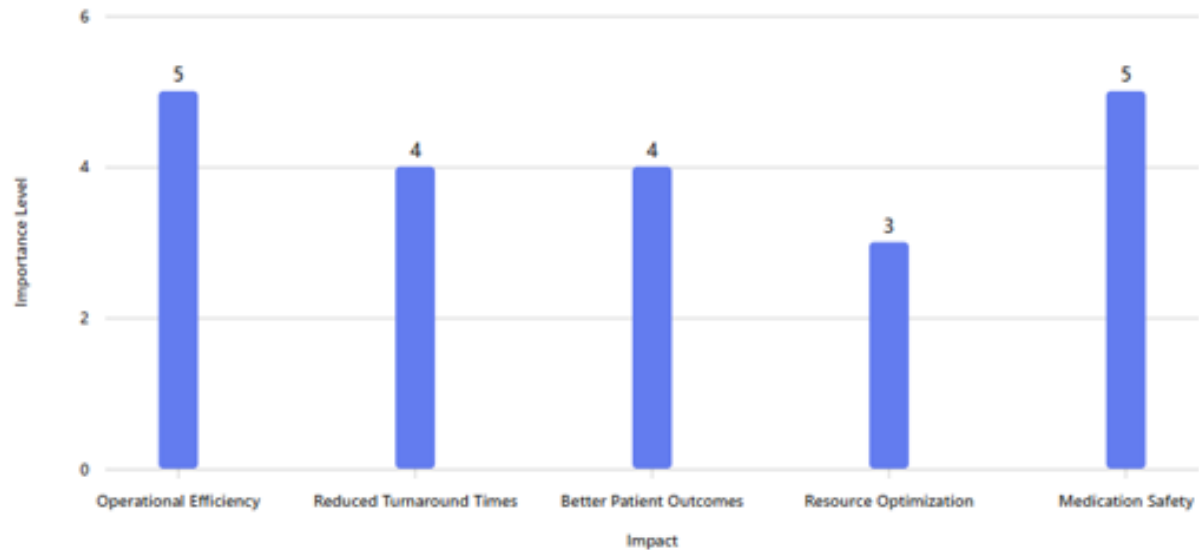
features for constant tracking of stock levels, expiration dates of medication, and usage patterns. By performing these tasks, it would help prevent shortages and overstocking. ADC offers higher level of security and protection. ADCs are set up for using user authentication and access controls to secure medications. This minimizes the chances of theft and unauthorized access. ADCs are designed to be compliant with regulatory standards. ADCs perform compliance by recording audit trails of all activities. In telepharmacy setups, these benefits result in better operational efficiency, reduced processing times, and better patient care. ADC Integration into telepharmacy systems can result in a higher quality of service while maintaining utilization of resources and by making medication safety a priority.

Fig No.2. Graphic showing the Key Benefits of ADCs in Telepharmacy

The above infographic, Fig No.2 shows the five major advantages of Automated Dispensing Cabinets. The Chart clearly shows that Medication Accuracy has the highest score.

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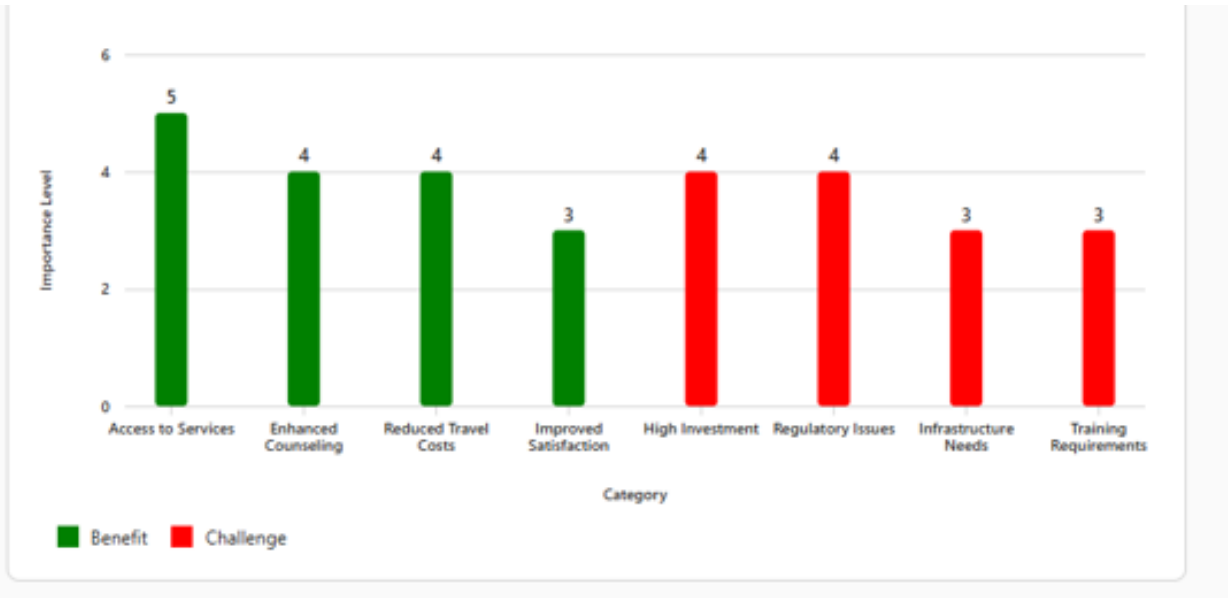*Fig No.3. Impact of ADC Integration*

The graphic, Fig No.3 shows the Impact of ADC Integration depicting five major areas impacting Automated Dispensing cabinets, which are Operational Efficiency, Reduced Turnaround Times, Better Patient Outcomes, Resource Optimization, and Medication Safety. The picture depicts Operational Efficiency and Medication Safety with highest impacts

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4.   Key Findings

Automated dispensing cabinets (ADCs) have become integral   part of medication management. The best practices of ADCs focus on interoperability with electronic health records, real-time diversion monitoring, and security practices such as barcode scanning and biometric authentication. These systems provide the benefits of medication safety,

optimize inventory control, and streamline workflows. However, they require staff training and consistent operational standards to be more effective. Telepharmacy has become a solution to improve access to pharmacy services in rural and underserved areas. Telepharmacy offers benefits such as enhanced patient counseling, reduced commutation costs, and improved patient satisfaction. ADC implementation faces challenges. These challenges include high initial investment, regulatory inconsistencies and the need for technological infrastructure and trained staff. ADCs incorporate technologies such as barcode medication administration, and robotic dispensing. However, successful adoption depends on financial investment, organizational alignment, and comprehensive training programs. These studies emphasize that while technology

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dependent solutions improve safety, efficiency, and accessibility in pharmacy practice, their success depends on strategic planning, regulatory support, and continuous training to staff to ensure sustainability and optimal patient care outcomes.

Fig No.4. Graphic showing the Benefits versus Challenges

The above graphic Fig No.4 shows the Benefits and Challenges, Benefits are shown in green, and Challenges are shown in red. This graph shows that Telepharmacy significantly improves accessibility and patient care. Financial, Regulatory and Operational requirements pose significant challenges.
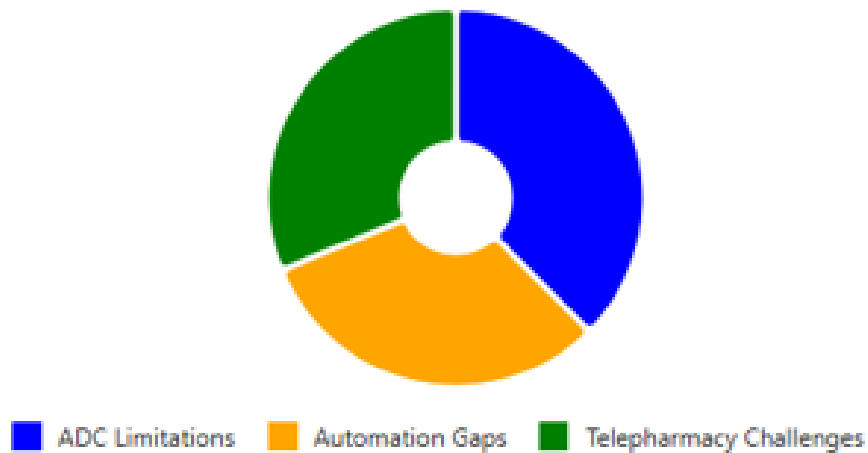
5. Limitations and Gaps

Automated Dispensing Cabinets (ADCs) have been used however they come with several limitations. Override feature, which is designed for usage in   emergencies, is frequently misused. This results in avoiding pharmacist verification which can result in the risk of medication errors. Issues such as incorrect drug selection, stocking mistakes, and administration to allergic patients exist despite barcode scanning and profiling features. Workflow interruptions and increased staff workload during implementation, combined with the need for lot of training, lead to operational challenges. Functioning of ADCs relies on integration with electronic health records and network systems, which comes with downtime and makes the system vulnerable. Most research has been focused on

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large hospitals. This has left a research gap in performance of ADC in smaller or rural healthcare facilities. The American Society of Health System Pharmacists provides comprehensive guidelines about best practices. However, the inconsistent implementation across varied settings provides unclear results. Also, there is limited data to prove that these practices lead to measurable patient safety improvements.

Telepharmacy, even with all its benefits of providing improved access in underserved areas, is accompanied by high financial costs, regulatory inconsistencies, and infrastructure limitations, in regions with poor connectivity. Evidence on long-term clinical outcomes and cost-effectiveness has not been established. The traini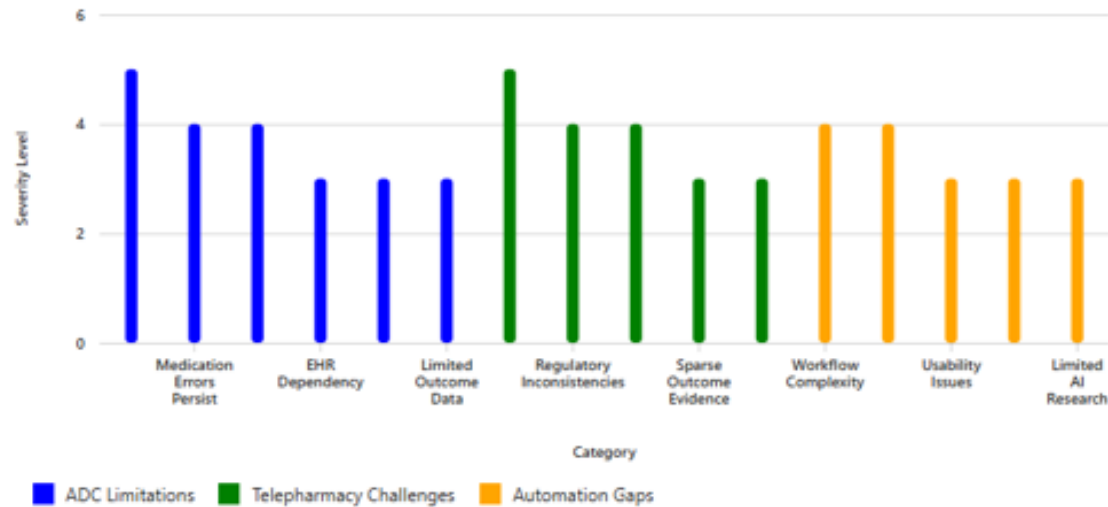ng programs for pharmacists and technicians are yet to be improvised to meet the needs of the Telepharmacy. Automation technologies in pharmacy practice, including ADCs, barcode medication administration, and robotic dispensing, minimize human error and improve efficiency. However, they bring in complexity into workflows, require substantial investment, and rarely get used due to user friendly design. Usage of artificial intelligence and predictive analytics are entering pharmacy automation, however research on the effectiveness remains limited. These disadvantages emphasize the need for more, better understanding of regulatory frameworks, and methods to improve usability and sustainability of technological solutions in pharmacy practice.

Fig No.5. Graphic showing the Challenges Distribution of ADCs in Telepharmacy

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The above graphic Fig No.5 shows the distribution of Challenges Distribution categories for ADCs in Telepharmacy.

Fig No.6. Graphic showing the Challenges and Gaps in ADCs, Telepharmacy and Automation Technologies

The graphic Fig No.6 compares the three limitations. ADC issues cover medication errors and electronic health records dependency. Telepharmacy issues are about regulatory inconsistencies and limited outcome evidence. Automation issues are Workflow Complexity, Usability issues, and Limited AI Research.

6. Conclusion

The integration of technology into pharmacy practice has transformed medication management, patient care, and operational efficiency. Automated Dispensing Cabinets (ADCs) have become the basis in healthcare settings. ADCs offer enhanced medication safety. ADCs support streamlined workflows and improved inventory control. The best practices at pharmacy highlight interoperability with electronic health records, real-time monitoring for diversion, and strong security measures such as barcode scanning and biometric authentication. The challenges such as override misuse, workflow disruptions, and dependency on complex technological platforms indicate the need for constant review and refinement. Telepharmacy offers the advantage of bridging gaps in access to pharmaceutical care for rural and underserved areas. The advantages include better patient counseling, reduced commuting costs, and enhanced patient satisfaction. The disadvantages include high implementation

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costs, regulatory inconsistencies, and restrictions in infrastructure do not allow widespread adoption. Proof of long-term clinical outcomes and the results based on investments remains inadequate. These indicate the need for more extensive research. Automation technologies for pharmacy include ADCs, barcode medication administration, and robotic dispensing. These technologies contribute to reducing human error and allowing pharmacists to focus on clinical activities. Even though the solution presents advantages, there are challenges. Challenges are about usability of the system, investment, and constant medication errors. These indicate that technology by itself cannot remove risk. Innovations such as artificial intelligence and predictive analytics hold promises for future implementation. However, the impact on the actual pharmacy environment needs to be evaluated. In conclusion, these studies indicate that technology-driven solutions are necessary for enhancing pharmacy practice, improving safety, and providing wider access. However, their success would be dependent on planning, compliance with regulatory frameworks, user friendly design, and continuous training. Upcoming research should focus on studying clinical outcomes, addressing implementation difficulties, and using technology for varied healthcare settings. By eliminating these gaps, pharmacy practice solutions can fully use advancements in technology to deliver safer, efficient, and patient-centered care.

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