JAASP http://www.aaspjournal.org
Journal of Asian Association of Schools of Pharmacy 2025; 14: 36–49
doi: https://doi.org/10.62100/jaasp.2025.14105

Research Paper

A cross-sectional study on the perceived usefulness and acceptance of automated dispensing cabinets in the Emergency Department of a Philippine tertiary hospital

Ma. Lourdes Concepcion D. Jimenez[1,2,3,*], Mark B. Carascal[4], Anthony Aldrin C. Santiago[5] and John Q. Wong[6]

[1]*Ateneo School of Medicine and Public Health, Ateneo de Manila University, Pasig City, Philippines*
[2]*Department of Emergency Medicine, Acute and Critical Care Institute, The Medical City, Pasig City, Philippines*
[3]*Department of Emergency Medicine, Philippine General Hospital, Manila, Philippines*
[4]*Clinical and Translational Research Institute, The Medical City, Pasig City, Philippines*
[5]*Department of Pharmacy, The Medical City, Pasig City, Philippines*
[6]*Epimetrics Inc, Makati City, Philippines*

Received May 8, 2025
Revised August 6, 2025
Revised September 9, 2025
Revised October 14, 2025
Accepted October 20, 2025

*Corresponding author
Ateneo School of Medicine and Public Health, Ateneo de Manila University, Pasig City, Philippines
E-mail: mjimenez@ateneo.edu

ABSTRACT

Automated dispensing cabinets (ADCs) are pharmacy-related healthcare technologies that provide easy, secure, and controlled management of medications in hospitals. In the Philippines, only two hospitals employed ADCs; however, no technology assessment studies are available, particularly regarding users' perceptions of its utility. Our research aims to determine the perceived usefulness and acceptance of using ADC in the Emergency Department (ED) of a private tertiary hospital in the Philippines. A prospective questionnaire survey was conducted among the ED healthcare professionals (n = 123) using a previously validated tool, measuring their perceptions on the ADC based on usefulness and acceptance indices. Chi-square tests were performed to determine the predictors of usefulness and acceptability, while Fisher's exact test was employed for bivariate analyses involving categorical variables. Respondent socio-demographic and ADC experience variables were used as predictor variables, while the usefulness and acceptance variables were treated as outcome variables. Our results showed an overall high perception of usefulness (mean usefulness index of 0.79 ± 0.10) and acceptance (mean acceptability index of 0.68 ± 0.68) of ADC usage in the ED among confirmed users. Further analysis revealed that nurses are generally more accepting of ADC (p-value < 0.001), while younger (p-value = 0.032) and less experienced staff (p-value = 0.010) encountered more frequent problems and non-acceptability in using the technology. In summary, our study showed the promising utility of ADC in hospital pharmacy management, with a high level of acceptance among most end-users.

Key words: automated dispensing cabinet, emergency department, Philippines

1. Introduction

Hospitals are increasingly transitioning from manual to digital systems, driven by the belief that information technology (IT) and automated control systems can enhance service efficiency and improve patient outcomes. The Technology Acceptance Model (TAM) and the Theory of Reasoned Action (TRA) offer frameworks for understanding how user perceptions influence the adoption of technology. TAM outlines the causal relationships between system design features, perceived usefulness, perceived ease of use, attitudes toward technology use, and actual usage behavior (Davis, 1989). This model suggests that a technology's perceived ease of use has a significant impact on its perceived usefulness. Despite the potential of IT to substantially improve performance, user reluctance often hinders these gains (Edelman, 1981; Sharda et al., 1988). This issue has been a long-standing focus of research on management information systems (MIS).

One notable advancement in healthcare technology is the

Automated Dispensing Cabinet (ADC), a computerized, secure, and biometrically controlled medicine cabinet. ADCs are designed to store and dispense medications close to the point of care, providing control, tracking, and inventory management (Metsämuuronen et al., 2020). This technology aims to improve organizational efficiency by refining workflows, enhancing nurse medication access, and reducing staff workload through computerized physician order entry (CPOE). Additionally, ADCs support cost-efficiency measures by improving inventory management and reducing staff and maintenance costs, and shifting pharmacist roles from technical tasks to more clinical roles (Johnson, 2022; Smith & Brown, 2023). Studies have shown that ADCs reduce medication errors during prescription, dispensing, and administration, enhancing patient safety (Fung et al., 2009). ADCs are increasingly utilized worldwide; their adoption in the Philippines has been limited. Only two Philippine healthcare institutions currently use them, and no local studies are available.

In the Philippines, medication dispensing remains largely manual and centralized. Pharmacists typically process handwritten or electronic medication orders using paper-based tools such as prescription forms, stock cards, and patient medication profiles. The use of automated dispensing systems, particularly ADC, has been limited to a few tertiary institutions, primarily due to high implementation costs, limited integration with hospital information systems (HIS), and inadequate technical infrastructure (Castrillo et al., 2022).

Most hospitals continue to rely on traditional dispensing models, including centralized pharmacy units and floor-stock systems, with medications dispensed manually by licensed pharmacists, as mandated by the Philippine Pharmacy Act (Republic Act 10918, 2016). This law underscores professional accountability and provides the regulatory framework for the safe and ethical practice of pharmacy.

A critical component of hospital medication management in the Philippines is the adherence to a hospital formulary system, which ensures that only clinically appropriate and cost-effective brands are stocked based on the institution's burden of disease (Department of Health, 2019). The successful implementation of ADCs is closely tied to this system. Due to limited storage capacity within ADCs, noncompliance with the formulary, such as stocking multiple brands of the same drug, can compromise inventory efficiency and space optimization. A robust formulary system, supported by an active Therapeutics Committee, is therefore essential to enable the rational use of medicines and maximize the operational benefits of dispensing automation.

For oral solid dosage forms, unit-dose or blister packaging is widely used, especially in outpatient settings. This practice reflects both regulatory standards and socioeconomic factors, particularly as many patients in the Philippines rely on out-of-pocket payments, with only limited government coverage for inpatient and outpatient medications. The law also permits partial refills, which are commonly practiced in both public and private healthcare facilities (Republic Act 10918, 2016).

While pharmacy automation has made significant progress in other parts of the Asia–Pacific region, the Philippines continues to face key barriers to widespread adoption. These include financial constraints, fragmented digital infrastructure, and limited workforce training in emerging pharmacy technologies. Several previous studies highlighted the potential advantages of ADCs in hospitals. However, in the Philippines, contextual gaps in its utility and limitations remain unknown. These gaps are attributable to the lack of literature from low- and middle-income countries (LMICs), and consequently, the lack of baseline information on the local experience of using ADC. Additionally, many papers do not consider the nuanced perceptions of end-users shortly after implementation, especially in environments where the adoption was mandated rather than voluntary. Finally, inconsistencies in prior findings highlight the need for context-specific evaluations. Our study contributes to filling these gaps by offering a local perspective that complements the global body of evidence on ADC.

The Medical City (TMC), a for-profit tertiary hospital in Pasig City, Philippines, with more than 500 inpatient beds, implemented an ADC in the pediatric section of its Emergency Department (ED) on January 11, 2023, followed by the Adult Main ED on February 2, 2023. Before the ADC implementation, physicians' prescriptions were sent to the ED satellite pharmacy for dispensing through Computerized Prescription Order Entry (CPOE), integrated into the electronic medical record (EMR). Then, ED nurses collect the prescribed medications that have been dispensed and validated by the ED pharmacist. With ADC implementation, the workflow was refined, increasing nurses' access to medicines in their treatment areas and eliminating the need for manual dispensing and pharmacist validation. Currently, in the ED, ADC is utilized by a multidisciplinary team, each playing a distinct yet interconnected role in the medication management process. Nurses serve as the primary users of the ADC. They are responsible for retrieving medications from the cabinet for patient administration, often under time-sensitive conditions. Their routine interaction with the system includes logging in, selecting the appropriate patient and medication, and ensuring accurate documentation, making their experience central to evaluating the system's usability and efficiency. Pharmacists, although not directly involved in medication retrieval at the point of care, play a crucial role in maintaining the ADC system. They oversee the stocking of medications, monitor inventory levels, and ensure compliance with safety protocols, including the handling of controlled substances. Their responsibilities ensure that the ADC remains a reliable and secure source of medications for clinical staff. Physicians, on the other hand, interact with the ADC system indirectly through the prescribing process. By entering medication orders into the electronic medical record

(EMR), they initiate the workflow that enables nurses to access medications via the ADC. Although they do not dispense medications themselves, physicians rely on the system's accuracy and responsiveness to ensure that prescribed treatments are administered promptly and safely.

Given the fast-paced nature of ED activities, ADC integration with EMR aimed to streamline processes and enhance nurses' access to medications for safe administration. Our study aimed to evaluate the perceived usefulness and acceptability of ADCs among end-users, including nurses, doctors, and pharmacists. The conceptual framework for this study examines the relationships between sociodemographic factors, occupational characteristics, perceived usefulness and acceptance of ADCs. By eliminating manual and repetitive tasks, which could cause delays and higher costs, the project highlighted the importance of technology in promoting efficient and safe treatment. The findings from this project could inform the replication of ADC implementation in other healthcare areas.

2. Methodology

2.1. Study Design and Setting

This study employed a cross-sectional design, using a validated questionnaire survey to assess ADC user experience. This study was guided by a conceptual framework informed by the Technology Acceptance Model (TAM) and the Theory of Reasoned Action (TRA). TAM posits that perceived usefulness and perceived ease of use are key determinants of technology adoption, while TRA emphasizes the influence of individual attitudes and social norms on behavioral intentions (Davis, 1989; Fishbein & Ajzen, 1975). In applying these models to the ED context, the framework linked healthcare providers' sociodemographic and occupational characteristics, such as age, profession, and years of experience, to their perceptions of ADC usefulness, which in turn influenced their acceptance of the system. This structured approach informed the selection of variables for analysis and provided a lens through which to explore how these factors interact in a fast-paced clinical environment. By doing so, the study offers insights into the real-world integration of ADCs and highlights the importance of user-centered evaluation in technology implementation. The study was conducted in TMC-ED, a tertiary private hospital in the Philippines with the highest pre-pandemic census nationwide (Jimenez et al., 2021). The data collection was administered through an online questionnaire survey from April 26 to July 5, 2024, to all ED nurses, physicians, and pharmacists who have used the ADC system for at least three months. The protocol for the study has been reviewed and approved by the TMC Institutional Review Board in January 2024, with a research registry number of GCS ED 2023-181.

2.2. Description of the ADC and Medication Dispensing

The ADC installed at TMC-ED is XT Automated Dispensing Cabinet (Omnicell, USA; Figure 1). The ADC is accessible to healthcare workers at TMC-ED through biometric access. At its full capacity, the ADC houses around 250 medications and supplies, which are configured based on the most frequently requested ED medications, including oral medications, injectables, intravenous, emergency, and pro re nata (as needed) medications. Medication dispensing begins with physicians ordering the medicine through a computerized physician order entry (CPOE) system. The orders are viewed and verified by the nurse through accessing the patient's electronic medical records. Once confirmed, the medications are selected by the nurse in the ADC after biometric authentication and confirmation of the patient's identity. The nurse then retrieves the medications by following the guide light in the cabinet (indicating the locations of the medicines), and the ADC logs the transactions (Figure 2). The pharmacists conduct the monitoring and restocking of the ADC at scheduled intervals or upon request from TMC-ED (i.e., when the stock levels are already low).

Figure 1. Automated dispensing cabinet (ADC) setup at The Medical City Emergency Department (TMC-ED).

2.3. Study Participants

Potential participants were identified through the ED department's staffing records, which listed all full-time personnel eligible based on their roles and duration of ADC exposure. An invitation to participate in the study was sent via institutional email, which included a brief description of the study, eligibility criteria, and a secure link to the online questionnaire survey. Eligible participants were full-time healthcare professionals, nurses, physicians, or pharmacists

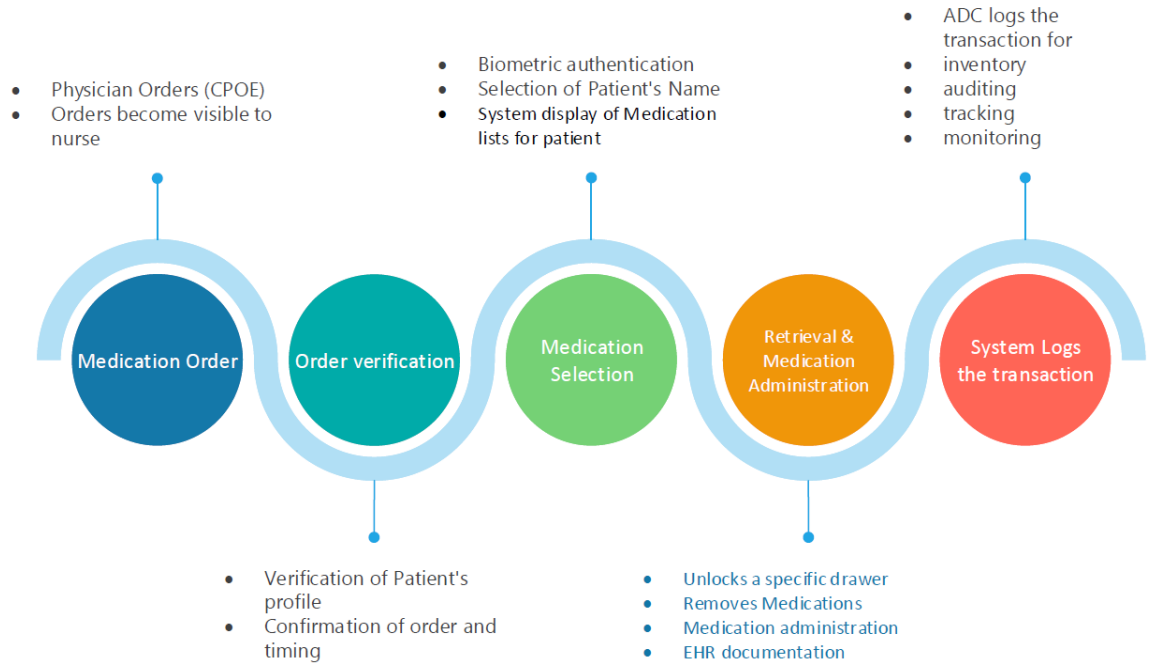

Figure 2. General workflow of medication dispensing using the automated dispensing cabinet (ADC) at The Medical City Emergency Department (TMC-ED).

assigned to the Emergency Department (ED) of The Medical City (TMC). Although physicians are not the primary users of the Automated Dispensing Cabinet (ADC) and do not directly dispense medications, they were included in the survey because they are integral to the medication management process in the Emergency Department. Physicians interact with the ADC system indirectly through prescribing practices and rely on its efficiency and accuracy to ensure timely medication administration. Their insights are valuable in assessing the system's impact on workflow coordination, patient safety, and overall care delivery. To be included in the study, individuals must have had at least three months of continuous experience using the ADC system before the start of the survey period. This threshold was established to ensure that participants had sufficient exposure to the system to provide meaningful feedback on its usefulness and overall acceptability. Staff members who were on extended leave, not actively practicing in the ED during the data collection period, or had less than three months of ADC experience were excluded from the study. Additionally, only those who voluntarily provided informed electronic consent were allowed to continue responding to the questionnaire survey. These criteria helped ensure that the data collected reflected the perspectives of experienced and actively engaged end-users of the ADC system. Participation was entirely voluntary. Before accessing the questionnaire survey, participants were presented with an informed consent form on the first page of the survey platform. This form outlined the study's purpose, procedures, confidentiality measures, and the voluntary nature of participation. Only those who provided electronic consent were able to proceed with the survey. No personal identifiers were collected to ensure anonymity.

2.4. Data Collection

User experience data is collected based on a previously validated questionnaire survey (Metsämuuronen et al., 2020). The questionnaire survey included questions on the demographics of ED staff, their level of experience with the ADC, and end-user perceptions of the ADC system's usefulness and acceptance. The questionnaire survey was administered to the eligible and consenting ED staff through an online questionnaire survey. Given the exploratory nature of this initial assessment of ADC user experience within a single institution, a formal a priori power calculation for all bivariate analyses was not conducted. Instead, we aimed to include all eligible full-time ED staff who had used the ADC for at least three months and consented to participate, resulting in a sample of 123 participants (98 confirmed users). This approach allowed us to capture as much data as possible from the target population. The observed effect sizes (odds ratios) and p-values presented in Table 3 provide an empirical indication of the statistical power achieved for the identified significant relationships within our study sample.

2.5. Questionnaire Survey Instrument

The questionnaire survey instrument was adapted from the study of Metsämuuronen et al. (2020) and included questions designed to capture various aspects of the ADC system. These include staff's demography (gender, age, profession,

ED tenure), experience in using ADC (frequency, operational involvement), perceived usefulness (impact to work, problems in usage, ease of use), and user acceptance (usage satisfaction, adequacy of training, recommendation to use in other units). Other comments were captured verbatim. To ensure relevance and rigor, we adapted the original survey and supplemented it with items informed by the Technology Acceptance Model (TAM) and expert consultations. The expanded questionnaire included items that captured perceived usefulness and acceptance, which were analyzed as composite indices, each normalized to a 0–1 scale. This allowed for a structured and quantifiable assessment of user perceptions across multiple dimensions. On average, participants completed the online questionnaire in approximately 10 to 15 minutes, depending on the depth of their responses to open-ended items.

2.6. Data Analysis

All collected data were checked for completeness and coded appropriately. Although no a priori power calculation was performed, we analyzed all consenting participants, thereby maximizing representativeness. Observed effect sizes (odds ratios) and corresponding p-values in our bivariate analysis provide empirical indicators of achieved power within the available dataset. Descriptive statistics were used to summarize the results of the questionnaire survey. Additionally, summary indices for usefulness and acceptability were also computed to provide a comprehensive overview of their experiences with the ADC system. Chi-square tests were performed to determine the predictors of usefulness and acceptability. Fisher's exact test was employed for bivariate analyses involving categorical variables, especially when expected cell counts were less than five. Respondent socio-demographic and ADC experience variables were used as predictor variables, while the usefulness and acceptance variables were treated as outcome variables. For all bivariate analysis, the health professionals were grouped into just two categories: Nurses vs Others (combined Pharmacist, Pharmacy Assistant, and Physician). This grouping was chosen since "Nurses" alone make up almost half of the daily users of the ADC (Nurse = 49.2%, Pharmacist = 27.9%, Pharmacy Assistant = 0.0%, Physician: 23%). The effect measure computed was the odds ratio with 95% confidence intervals. Missing values for the bivariate analysis were handled via listwise deletion.

2.7. Usefulness Index

The Usefulness Index (UI) was developed using twelve variables: frequency of ADC use, frequency of daily ADC use, impact of ADC, problems with ADC, log-in and identification to access ADC are time-consuming, medicines are easy to find in the ADC, ADCs are easy to use, necessary medicines are missing from the ADC, spent less time ordering and preparing medicines than before, ADCs reduce unnecessary movement out of the ED, restocking service worked well, and ADC made the medication process more difficult. All variables were dichotomized and coded so that higher values indicated greater usefulness. The index was computed by averaging the score across all twelve variables and normalizing the values to a range from 0 to 1, where 0 represents low usefulness, and 1 represents high usefulness.

2.8. Acceptance Index

The Acceptance Index (AI) was developed using five variables: adequate training on using ADCs, belief that ADCs are a good concept, preference to return to the old stock system, satisfaction with the ADC, and belief that expanding the ADC is beneficial. All variables were dichotomized and coded so that higher values indicated greater acceptability. The index was computed by averaging the score across all five variables and normalizing the values to a range of 0 to 1, where 0 represents lower acceptance and 1 represents higher acceptance. For the bivariate analysis between the AI, the UI, and SI, AI was dichotomized using the median into low and high acceptance.

3. Results

3.1. Staff Sociodemographic and Occupational Characteristics

A total of 126 participants initially accessed the survey, but only 123 consented and completed the survey (with the remaining three not consenting to proceed). Out of the 123 respondents, there were 24 non-users, one non-response, and 98 confirmed ADC users. In the analysis, only the responses of the confirmed users were further investigated (n = 98). The study included a diverse group of healthcare providers (Table 1), consisting mostly of female (75.5%) and young workers under 29 years old (63.3%). The majority were pharmacists or pharmacy assistants (53.1%), followed by nurses (31.6%) and physicians (15.3%). In our subsequent analysis, nurses were categorized separately from other healthcare professionals due to their distinct operational role and high-frequency interaction with the ADC in ED. Statistically, nurses represented nearly half of the daily ADC users in our study population. Grouping them separately allowed us to preserve the integrity of their responses, avoid dilution of their experiences in aggregate analyses, and identify profession-specific predictors of perceived usefulness and acceptance. Over half of the confirmed users (56.1%) had more than 12 months of experience in the ED, and 67.4% had worked in the ED before the implementation of the ADC.

3.2. User Perceptions

User perceptions were categorized into indices, including usefulness and acceptance. Analyses in Tables 2, 3, and 4 were applied only to the respondents who were confirmed ADC users. User perceptions were summarized in Table 2.

Table 1. Sociodemographic, occupational, and Automated Dispensing Cabinet (ADC) usage data collected from the Emergency Department (ED) healthcare professional questionnaire survey participants (n=98).

Questionnaire Survey data		n (%)
Gender	Female	74 (75.5)
	Male	24 (24.5)
Age Bracket	20–29	62 (63.3)
	30–39	29 (29.6)
	40–49	6 (6.1)
	50–59	1 (1.0)
Profession	Pharmacist/ Pharmacy Assistant	52 (53.1)
	Nurse	31 (31.6)
	Physician	15 (15.3)
Work Experience in the ED	Less than three months	17 (17.4)
	3–6 months	18 (18.4)
	6–9 months	4 (4.1)
	9–12 months	3 (3.0)
	More than 12 months	55 (56.1)
	No response	1 (1.0)
Worked in ED prior to ADC	Yes	66 (67.4)
	No	32 (32.6)
Average Usage Times per Day	1–5 times	26 (26.5)
	6–10 times	11 (11.2)
	11–15 times	7 (7.1)
	>15 times	34 (34.7)
	No response	1 (1.0)
	Not applicable	19 (19.4)

Table 2. User perceptions on usefulness and acceptance relating to the use of the Automated Dispensing Cabinet (ADC) in the Emergency Department (ED) among confirmed users (n=98).

User index	Aspects identified	Frequency, n (%)
Usefulness	Easy to find medicines	65 (66.3)
	Easy to use	60 (61.2)
	Restocking worked well	55 (56.1)
	Spend less time ordering/ preparing medicine	51 (52.0)
	Reduced unnecessary movement in ED	50 (51.0)
	Positive impact of ADC	47 (48.0)
	Encountered problems with usage	46 (46.9)
	Frequently missing medicines	40 (40.8)
	Process of patient medication became difficult	19 (19.4)
	Time-consuming log-in and identification	6 (6.1)
Acceptance	Conceptually good	76 (77.6)
	Return to previous satellite pharmacy	66 (67.4)
	Expanded ADC usage to other units	66 (67.4)
	Satisfied (overall)	58 (59.2)
	Adequate training provided	56 (57.1)

3.3. Usefulness Index (UI)

The respondents perceived the ADC as useful. Nearly half (47.5%) felt that the ADC made their work easier. The ADC also streamlined specific processes, with 56.6% indicating they spent less time ordering and preparing medicines than before the ADC system was installed. Furthermore, 55.6% agreed that the ADCs reduced unnecessary movement within the ED, and 62% felt that the restocking service offered by the Pharmacy worked well. The UI had a mean ± standard deviation (SD) of 0.79 ± 0.10 and a median of 0.79 (range 0.50–0.96).

3.4. Acceptance Index (AI)

Healthcare providers widely accepted the ADC. Most respondents (56.6%) felt that they received adequate training on how to use it, and 76.8% believed that the concept of

ADC is good. Despite a preference for the previous satellite pharmacy system among some users (28.3%), the majority (58.6%) were satisfied with the ADC in the ED, and 66.7% supported expanding its use to other hospital units. The AI had a mean ± SD of 0.68 ± 0.68 and a median of 0.6 (range 0.50–1.00).

3.5. Bivariate statistics

The study further explored the predictors of usefulness and acceptance of the ADC among healthcare staff. The findings revealed significant differences based on age, profession, and experience (Table 3).

Table 3. Bivariate analysis of the significant predictors and outcomes for each of the user indices relating to the usage of Automated Dispensing Cabinet (ADC) in the Emergency Department (ED) among confirmed users (n = 98).

Index/ Aspect	Predictors	Outcomes, n (%)		p-value*	Odds ratio (confidence intervals)
USEFULNESS					
Problems with ADC	Profession	More frequent	Less frequent		
	Nurse	11 (35.5)	20 (64.5)	0.016	0.33 (0.13–0.82)
	Others	35 (62.5)	21 (37.5)		
Impact of ADC	Profession	Made work easier	Made work difficult/neutral		
	Nurse	24 (75.0)	12 (25.0)	<0.001	0.19 (0.072–0.48)
	Others	26 (35.9)	51 (64.1)		
	Work Experience				
	>1 year	21 (38.2)	34 (61.8)	0.010	0.33 (0.14–0.78)
	<1 year	28 (66.7)	14 (33.3)		
	Worked in ED prior ADC				
	No	20 (64.5)	11 (35.5)	0.035	2.56 (1.06–6.21)
	Yes	28 (41.5)	38 (58.5)		
	Age				
	20-29 years old	34 (57.6)	25 (42.4)	0.032	0.40 (0.17–0.93)
	30-59 years old	13 (35.1)	24 (64.9)		
Frequent use of ADC	Profession	Daily	Not daily		
	Nurse	30 (96.8)	1 (3.2)	<0.001	0.029 (0.0037–0.22)
	Others	31 (46.3)	36 (53.7)		
	Age				
	20–29 years old	34 (54.8)	28 (45.2)	0.047	2.47 (1.00–6.11)
	30–59 years old	27 (75.0)	9 (25.0)		
Frequency per day	Profession	<15×/ day	>15×/ day		
	Nurse	9 (29.0)	22 (71.0)	<0.001	7.13 (2.58–19.7)
	Others	35 (74.5)	12 (25.5)		
ADC is easy to use	Profession	Agree	Disagree		
	Nurse	27 (84.4)	5 (15.6)	0.018	0.28 (0.093–0.83)
	Others	33 (60.0)	22 (40.0)		
Medications are easy to find	Work Experience	Agree	Disagree		
	>1 year	28 (66.7)	14 (33.3)	0.022	0.28 (0.089–0.86)
	<1 year	36 (87.8)	5 (12.2)		
Missing necessary medicines	Work Experience	Disagree	Agree		
	>1 year	21 (42.0)	29 (58.0)	0.003	0.27 (0.11–0.65)
	<1 year	29 (58.0)	21 (42.0)		
ACCEPTANCE					
Preference to return to the previous system	Profession	Disagree	Agree		
	Nurse	25 (86.2)	4 (13.8)	0.024	0.27 (0.085–0.88)
	Others	41 (63.1)	24 (36.9)		
	Worked in ED prior ADC				
	No	24 (85.7)	4 (14.3)	0.032	3.43 (1.06–11.10)
	Yes	42 (63.6)	24 (36.4)		
Beneficial to expand ADC to other units	Profession	Yes	No		
	Nurse	26 (83.9)	5 (16.1)	0.042	0.33 (0.11–0.99)
	Others	40 (63.5)	23 (36.5)		

*p-value from Fisher's exact test

Note: Row totals of predictor variables differ across outcomes because of nonresponse. Association between the predictor and outcome variables was determined with Chi-square and Fisher's exact test (where appropriate) with 95% confidence intervals. Effect size was estimated using odds ratio with 95% confidence intervals.

Table 4. Bivariate analysis between acceptance and usability indices among confirmed users (n = 98).

Outcome Variable	Level of Acceptance	n	Mean	SD	p-value*
Usefulness index	High	45	0.90	0.10	<0.001
	Low	25	0.71	0.14	

*p-value from independent sample t-test

3.6. Usefulness

The odds of younger staff, aged 20–39 years old, encountering frequent problems with the ADC are 5.8× that of their older counterparts ages 40–59 years old. The odds of nurses using the ADC daily are 58× that of other professions and of them using it more than fifteen times daily are 7.3× that of others. Additionally, nurses reporting that the ADC made their work easier are 5.9 times more likely than others; they were also less likely to experience frequent problems. The odds of nurses finding the ADC easy to use are 4× that of others. The odds of staff with over a year of work experience saying the ADC made their work easier are 2.6×, and of them finding medicines are 3.2× that of those with less experience. Furthermore, they were less likely to agree that necessary medications were missing from the ADC. However, the odds of staff who had worked in the ED before the ADC implementation believing that the ADC made their work easier are lower than those who had not. Finally, the odds of experiencing frequent problems are 2.4 times higher for those who had not worked in the ED before ADC implementation.

3.7. Acceptance

Acceptance of the ADC varied among staff. The odds of nurses agreeing not to return to the previous system are 4.8 times higher, and those supporting the expansion of the ADC to other departments or networks are 3.5 times more likely than those in other professions. Conversely, the odds of staff who had worked in the ED before the ADC implementation preferring the old system are 2.5× that of those who had not. Those with high acceptance of the ADC had higher mean (SD) scores on the usefulness index (0.83 (0.08) vs. 0.70 (0.10)) than those with low acceptance (Table 4).

4. Discussion

As hospitals increasingly adopt digitalization, technology plays a crucial role in modernizing healthcare by enhancing safe and timely care through automated systems (Keen & Muris, 1995). The complexity and high volume of ED activities demand precise medication management. ADCs have transformed this process, ensuring accuracy, security, and safety (Mandrack et al., 2012). This study explored the perceptions of ED staff regarding the implementation of ADCs. Specifically, we conducted a targeted survey on ADC implementation in the ED, focusing on user perceptions and technology acceptance. The investigation is systematic as it followed the technology acceptance framework and inferred the ADC's acceptability through carefully developed composite indices. Findings suggest that ADCs were generally perceived as useful and acceptable for integration into ED workflows. Notably, participants reported that ADCs may help reduce medication errors and improve access to medications. However, it is essential to clarify that this study did not directly assess medication error rates or other objective safety outcomes. As such, while these perceptions are valuable for understanding user experience and guiding implementation strategies, they do not establish a causal relationship. Furthermore, the cross-sectional design limits the ability to infer temporal or causal effects.

Overall, the findings of this study are consistent with existing literature, highlighting the perceived benefits of ADCs in the hospital setting. Similar to previous studies conducted in high-income countries, our results show that healthcare professionals, particularly nurses, view ADCs as useful tools that support workflow efficiency (Ahtiainen et al., 2020; Fung et al., 2009; Metsämuuronen et al., 2020). These perceptions align with global evidence suggesting that ADCs can streamline medication access, reduce delays, and potentially minimize human error (Ahtiainen et al., 2020; Metsämuuronen et al., 2020). What distinguishes our study, however, is its focus on a middle-income country context, specifically within a high-volume ED in the Philippines. To our knowledge, this is the first systematic investigation of ADC implementation in this setting. Unlike studies conducted in more technologically advanced environments, our research captures the experiences of healthcare workers operating under different resource constraints, infrastructure limitations, and organizational dynamics. This context-specific perspective adds a valuable dimension to the global discourse on the adoption of health technology. Another unique aspect of this study is the inclusion of multidisciplinary perspectives. While nurses are the primary users of ADCs, we also gathered insights from physicians and pharmacists, recognizing that medication management is a collaborative process. This broader approach enabled us to examine how ADCs impact interprofessional workflows and communication, which are crucial components of patient safety and care quality. The practical implications of our findings are significant. First, the perceived usefulness of ADCs underscore the importance of investing in adequate training and support systems to ensure the successful adoption of these technologies. Second, the integration of ADCs with existing EMRs was seen as a key factor in enhancing efficiency, highlighting the need for seamless system interoperability. Third, the study emphasizes the

value of involving end-users in the evaluation process, even in top-down implementations, to identify barriers and opportunities for improvement.

While pharmacist practitioners advocate for ADCs to improve safety and efficacy (Fung et al., 2009), our findings indicate that ED nurses, especially younger staff, are the primary users, making their insights particularly valuable (Ahtiainen et al., 2020). Some respondents, particularly ED nurses with pre-ADC experience, reported mixed impressions, noting that while ADCs simplify workflows, they also encountered frequent issues. Understanding the transition from manual to automated systems is crucial, as this shift is expected to enhance overall operational efficiency. Research emphasizes the need for end-user involvement in the design and execution (Robey & Farrow, 1982). However, reluctance among end-users to adapt to computer-based systems has hindered the realization of these benefits (Davis et al., 1989). This skepticism towards new technologies has been documented in several studies (Arinal et al., 2014; Metsämuuronen et al., 2020; Zaidan et al., 2016).

Despite these obstacles, our research indicates a generally positive perception of ADCs, particularly in medication preparation and reducing movement within the ED. However, this perceived usefulness is lower than that reported in other studies (Ahtiainen et al., 2020; Metsämuuronen et al., 2020), underscoring the need for strategic planning and effective communication when implementing ADCs (Burton et al., 2019). Collaboration among nurses and pharmacists, expert guidance, self-assessment tools, adherence to best practices, and ongoing education are critical for safety and productivity (Mandrack et al., 2012).

A more in-depth analysis of the usefulness and acceptance indices provides comprehensive insights into healthcare providers' experiences using ADCs within the ED. Each index captures distinct dimensions of the ADC implementation, contributing to a nuanced understanding of its overall impact on medication management. The UI, based on twelve variables, yields a mean value of 0.79, indicating a high perception of usefulness among users. This suggests that ADCs effectively enhance the medication management process, with variability ranging from 0.50 to 0.96, influenced by factors such as years of work experience and specific ED roles. Given the nurses' elevated level of ADC engagement and years of experience, the study found that their previous exposure to ADC led to a positive response regarding their preference for ADCs over the previous system. Key advantages include reduced time spent ordering and preparing medications, minimized unnecessary movement within the ED, efficient pharmacy restocking, and a streamlined ADC dispensing process. However, challenges related to daily and weekly reports of missing necessary medications highlight areas needing continuous improvement through a review of the medication list.

The AI, developed from five variables, reveals varying levels of user acceptance. By dichotomizing scores, we gain more precise insights into user sentiment regarding the ADC system. High acceptance correlates with adequate training, satisfaction, and positive beliefs about ADC benefits. Conversely, reluctance to return to traditional stock systems indicates a commitment to ADC improvements. Ensuring comprehensive training programs and fostering an environment conducive to open feedback will enhance user confidence and satisfaction with ADCs. Hence, change management plays a crucial role in successfully implementing ADC systems, as introducing new systems frequently encounters resistance to change. The primary challenges in adopting new systems are often more behavioral than technical, highlighting the importance of addressing human factors to ensure a smooth transition and effective utilization.

This study has several important limitations that should be acknowledged. First, the cross-sectional design limits the ability to assess changes in user perceptions over time or to establish causal relationships between ADC implementation and outcomes such as workflow efficiency. Longitudinal or experimental designs would be more appropriate for evaluating sustained effects and behavioral adaptation. Second, the study was conducted in a single tertiary institution, which may affect the generalizability of the findings. While TMC-ED is a high-volume and technologically advanced setting, its infrastructure and staffing may differ from other hospitals in the Philippines, particularly in public or rural contexts. Third, the timing of data collection conducted approximately one year after ADC implementation may have introduced recall bias, as participants were asked to compare their experiences before and after the system was introduced. This reliance on retrospective self-assessment may have influenced the accuracy of responses. Fourth, although the ADC implementation was a top-down decision by hospital management, the study focused on frontline healthcare workers' perceptions. While this approach is valuable for understanding user experience, it does not capture the perspectives of administrators or IT personnel involved in system integration and maintenance. Fifth, the study relied on self-reported data collected through an online questionnaire. While the instrument was adapted from a validated tool and supplemented with context-specific items, the absence of objective performance metrics such as actual medication error rates, dispensing times, or inventory discrepancies limits the ability to draw definitive conclusions about the ADC's operational impact. Additionally, the authors acknowledge that the survey tool used was originally or exclusively used for nurses, not pharmacists or doctors. This may present biases in the gathered data. Hence, future studies should assess the reliability and validity of the survey in other professions involved in operating ADCs. Finally, while bivariate analyses were used to explore associations between

user characteristics and perceptions, the study did not employ multivariate regression models to control for potential confounding variables. Future research should consider more advanced statistical techniques to strengthen causal inferences and explore interaction effects. Despite these limitations, the study provides valuable baseline data on ADC user experience in a Philippine ED setting and highlights areas for improvement in future implementations and evaluations.

5. Conclusion

In summary, the UI suggests that ADCs are mainly viewed as useful for improving medication management. However, variability in user experiences and acceptance levels remains. It is essential to address concerns such as ongoing training, frequent ADC occurrences, and missing medications to maximize the effectiveness of the technology. Strategies that foster collaboration between nursing and pharmacy staff, along with regular user feedback mechanisms, can provide valuable insights for refining the implementation of ADC. These factors should also be considered before expanding the use of ADC to other units. Future research should encompass a larger sample size and longitudinal studies to observe changes in perceptions over time as users become more familiar with the technology, ultimately ensuring that ADCs continue to improve efficacy and user satisfaction within the ED environment. Additionally, future research should also incorporate objective outcome measures, such as actual medication error rates, dispensing times, and inventory accuracy, using longitudinal or experimental designs to more rigorously evaluate the impact of ADCs on patient safety and operational efficiency.

Acknowledgement

The authors acknowledge the contribution of Ms. Ma. Andrelee Jimenez and Ms. Geronie Federigan for their assistance in administering the questionnaire survey.

Author contributions

MLC Jimenez- conceptualization, data analysis, critical review and evaluation of results, primary authorship, review and editing of the paper, study supervision, procurement of grant. MB Carascal- conceptualization, data analysis, critical review and evaluation of results, primary authorship, review and editing of the paper. AAC Santiago- conceptualization, review, and editing of the paper. JQ Wong- critical review and evaluation of results, data analysis, review, and editing of paper.

Statements and declarations

Not applicable

Ethical consideration

The protocol for the study has been reviewed and approved by TMC Institutional Review Board in January 2024, with a research registry number of GCS ED 2023-181.

Consent to participate

All study participants provided an electronically captured informed consent prior to participating in the questionnaire survey.

Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

Funding statement

The study received partial funding from The Medical City through the Research Award, Recognition and Dissemination Program, awarded in 2023 to the Acute and Critical Care Institute where MLD Jimenez is affiliated.

Data availability

All data related to this research are available from the authors upon reasonable request.

ORCiD ID

Ma. Lourdes Concepcion D. Jimenez- https://orcid.org/0000-0001-9451-611X

Mark B. Carascal- https://orcid.org/0000-0002-8414-644X

References

Ahtiainen HK, Kallio MM, Airaksinen M and Holmström AR. Safety, time and cost evaluation of automated and semi-automated drug distribution systems in hospitals: a systematic review. Eur J Hosp Pharm. 2020; 27(5): 253-262.

Arinal MF, Cohn T and Avila-Quintana C. Evaluating the impact of medication cabinets in patients' rooms on a medical-surgical telemetry unit. Medsurg Nursing. 2014; 23(2): 77-83.

Burton JK, Bottino D and Secomb TW. A systems pharmacology model for drug delivery to solid tumors by antibody-drug conjugates: Implications for bystander effects. AAPS J. 2019; 22(1): 12.

Castrillo AI, Perez IL and Tecson MD. Prospective acceptability of automated dispensing machines in a tertiary hospital in Cavite: a case study. [Bachelor's thesis, De La Salle Medical and Health Sciences Institute]. GreenPrints. 2022. https://greenprints.dlshsi.edu.ph/bsp/60

Davis FD, Bagozzi RP and Warshaw PR. User acceptance of computer technology: A comparison of two theoretical models. Management Science. 1989; 35(8): 982-1003.

Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly. 1989; 13(3): 319–340.

Department of Health. Philippine national formulary: Essential medicines list. 2019; 1(8). https://www.philhealth.gov.ph/partners/providers/pdf/PNF-EML_11022022.pdf

Edelman F. Managers, Computer systems, and productivity. MIS Quarterly. 1981; 5(3): 1-19.

Fishbein M and Azjen I. Belief, attitude, intention and behaviour: An introduction to theory and research. 1975. Reading, MA: Addison-Wesley.

Fung EY, Leung B, Hamilton D and Hope J. Do Automated Dispensing Machines Improve Patient Safety? Can J Hosp Pharm. 2009; 62(2):

516-519.

Jimenez MLC, Manzanera R, Carascal MB, Figueras MD, Wong JQ, Moya D, et al. Factors affecting the non-urgent consultations in the emergency department of a tertiary hospital in the Philippines: A cross-sectional study. Emerg Med Australas. 2021; 33(2): 349-356.

Johnson R. Cost Analysis of ADC Implementation in Healthcare Settings. Health Care Manag Rev. 2022; 40(4): 567-574.

Keen J and Muris N. Information strategy in the NHS: issues and challenges. J Manag Med. 1995; 9(2): 57-62.

Mandrack M, Cohen MR, Featherling J, Gellner L, Judd K, Kienle PC, et al. Nursing best practices using automated dispensing cabinets: nurses' key role in improving medication safety. Medsurg Nurs. 2012; 21(3): 134-144.

Metsämuuronen R, Kokki H, Naaranlahti T, Kurttila M and Heikkilä R. Nurses' perceptions of automated dispensing cabinets - an observational study and an online survey. BMC Nurs. 2020; 19: 27.

Republic Act 10918: An act regulating and modernizing the practice of pharmacy in the Philippines, repealing for the purpose Republic Act numbered five thousand nine hundred twenty-one (RA no. 5921), otherwise known as the Pharmacy Law. Rep Act 10918 (July 17, 2016) (Phil). https://elibrary.judiciary.gov.ph/thebookshelf/showdocs/2/70354

Robey D and Farrow D. User Involvement in Information System Development: A Conflict Model and Empirical Test. Manage Sci. 1982; 28(1): 78-85.

Sharda R, Barr SH and McDonnell JC. Decision Support System Effectiveness: A Review and an Empirical Test. Manage Sci. 1988; 34(2): 139-159.

Smith J and Brown L. Decentralization of Automated Dispensing Cabinets: Impacts on Pharmacist Roles. J Pharm Pract. 2023; 35(2): 123-130.

Zaidan M, Rustom F, Kassem N, Al Yafei S, Peters L and Ibrahim MI. Nurses' perceptions of and satisfaction with the use of automated dispensing cabinets at the Heart and Cancer Centers in Qatar: a cross-sectional study. BMC Nurs. 2016; 15: 4.

Appendix A. Questionnaire survey used for the study.

1. Gender
   ____Female (1) ____Male (2)

2. Age
   ___20–29 years (1) ___30–39 years (2) ___40–49 years (3) ___50–59 years (4) ___60 years or over (5)

3. Profession
   ____Nurse (1) ____Pharmacist (2) ____Physician (3) ____Others (4)

4. Work experience ED
   ____Less than three months (1)
   ____Three to six months (2)
   ____Six to nine months (3)
   ____Nine to twelve months (4)
   ____More than twelve months (5)

5. Did you work in your current unit before the ADC system?
   __-__Yes ____No

6. How often do you use ADCs?
   ____Every workday
   ____Weekly but not every workday (skip question 7)
   ____Less than weekly (skip question 7)
   ____I do not use ADCs (skip question 7)

7. How many times per day do you use ADCs?
   ____On average 1–5 times per day
   ____On average 6–10 times per day
   ____On average 11–15 times per day
   ____On average over 15 times per day

8. Have ADCs had an impact on your work?
   ____Yes, they have made my work much easier.
   ____Yes, they have made my work a little easier.
   ____No, they have not made my work easier or more difficult (skip question 10)
   ____Yes, partly they have made my work easier and partly more difficult.
   ____Yes, they have made my work a little more difficult.
   ____Yes, they have made my work much more difficult.

9. How have ADCs made your work easier or more difficult?
   _____

10. Have you had problems with ADCs?
    ____Yes, daily
    ____Yes, weekly
    ____Yes, monthly
    ____Yes, less than monthly
    ____No, I have not (skip question 11)

11. What kind of problems have you had with ADCs?
    _____

12. Estimate, in how many cases out of ten you are logged in with your own identification when you use the ADC

Never Always

1	1	1	1	1	1	1	1	1	1	1
0	1	2	3	4	5	6	7	8	9	10

13. Estimate, in how many cases out of ten you use the barcode when you take a medicine from the ADC

Never Always

1	1	1	1	1	1	1	1	1	1	1
0	1	2	3	4	5	6	7	8	9	10

14. Estimate, in how many cases out of ten you record the removal of a medicine

Never Always

1	1	1	1	1	1	1	1	1	1	1
0	1	2	3	4	5	6	7	8	9	10

15. Do you agree with the following statements? Please, select the option that best describes your opinion. 1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, 4 = somewhat agree, 5 = strongly agree.

Statement	Score
The log-in and identification to access the ADC are time-consuming	
Medicines are easy to find in the ADC.	
I often have to wait to access the ADC while another user accesses it.	
It occurs daily in our unit that nurses take medicines from the ADC when someone else is logged in.	
ADCs are easy to use.	
Some necessary medicines are missing from the ADC daily.	
It is common in our unit that the medicines removed from the ADC are not always documented in the system.	
I now spend less time ordering and preparing medicines than before the ADC system was installed.	
Pass-through ADCs reduce unnecessary movement into and out of the operating theatre and patient rooms.	
Adequate training is given on how to use the ADC.	
The restocking service offered by the Pharmacy has worked well.	
ADCs reduce medication selection errors.	
Neglecting to record the removal of a medicine poses a risk to patient safety.	
Using a barcode when taking medicines from the ADC improves patient safety.	
The concept of ADCs is good.	
I would rather return to the old stock system.	
The process of patient medication has become more difficult.	
ADCs reduce the risk of medication misuse by staff.	

Patient safety

16. How do ADCs affect patient safety?
____ ADCs improve patient safety significantly (skip question 19)
____ ADCs improve patient safety a little (skip question 19)
____ ADCs have no effect on patient safety (skip question 18 and 19)
____ ADCs partly improve and partly adversely affect patient safety
____ ADCs weaken patient safety a little (skip question 18)
____ ADCs weaken patient safety significantly (skip question 18)

17. Which factors of ADCs improve patient safety?
_____

18. Which factors of ADCs weaken patient safety?
_____

19. How could ADCs be improved?
--------_____
-----

20. How satisfied are you with ADCs overall?
___Completely dissatisfied
___Somewhat dissatisfied
___Neither satisfied nor dissatisfied
___Somewhat satisfied
___Completely satisfied

21. Free comments
----------_____