https://doi.org/10.31925/farmacia.2025.5.1 **REVIEW**

MULTIDOSE DRUG DISPENSING SYSTEMS: A FOCUS ON USER EXPERIENCES, SAFETY, QUALITY AND COST FACTORS

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Manuscript received: May 2025

Abstract

Population aging is one of the most significant social transformations of the 21st century, especially in developed countries. Medication-related behaviour is complex and influenced by multiple factors, requiring diverse strategies to improve adherence. In this context, pharmacists and pharmacy technicians have taken on increasingly important roles in promoting and providing health services. Pharmacy technicians, in particular, can contribute significantly to the implementation of community adherence programs. Individualized medication preparation, such as multiple dose dispensing (MDD) systems, offers an approach that ensures patients receive the correct medication, in the correct dose and at the correct time, improving safety and adherence, particularly among older adults. The study involves identifying current evidence on the implementation and use of MDD systems and exploring possible improvements, particularly for older populations. This assessment analysis follows the Joanna Briggs Institute methodology. The protocol was developed with predefined criteria appropriate for the selected databases and repositories. Article selection, data extraction, and synthesis were performed independently by two reviewers to ensure rigor. In conclusion, MDD systems represent a promising intervention to support medication adherence, tailored to the individual needs of each patient.

Rezumat

Îmbătrânirea populației reprezintă una dintre cele mai importante transformări sociale ale secolului XXI, mai ales în țările dezvoltate. Comportamentul de administrare a medicamentelor este complex și influențat de multiple factori, necesitând strategii diverse pentru îmbunătățirea aderenței la tratament. În acest context, farmaciștii și tehnicienii de farmacie au dobândit un rol tot mai important în promovarea și furnizarea serviciilor de sănătate. Tehnicienii de farmacie pot contribui semnificativ la implementarea programelor comunitare de creștere a aderenței. Prepararea individualizată a medicației, precum sistemele de distribuire a medicamentelor în doze multiple (MDD), oferă o soluție care asigură administrarea corectă a medicamentelor, în doza și momentul potrivit, îmbunătățind astfel siguranța și aderența, în special la pacienții vârstnici. Studiul a presupus identificarea dovezilor actuale privind implementarea și utilizarea sistemelor MDD, precum și a posibilelor soluții pentru optimizarea acestora la populația vârstnică. Această analiză urmează metodologia Joanna Briggs Institute, cu criterii prestabilite și adaptate bazelor de date selectate. Protocolul a fost realizat independent de doi evaluatori pentru a asigura rigoarea procesului. În concluzie, sistemele MDD sunt o soluție promițătoare pentru îmbunătățirea aderenței, în funcție de nevoile fiecărui pacient.

Keywords: multidose drug dispensing, dose administration aids, polypharmacy, medication adherence

Introduction

Multi-dose medication dispensing (MDD) systems, also referred to as multi-compartment medication compliance aids (MCCAs) or dose-administration aids (DAAs), have become more widely used due to their potential benefits in improving health outcomes and also reducing healthcare costs [1-2]. These systems facilitate the management of medication regimens for patients, ensuring adherence to prescribed therapies and reducing medication errors.

Individualized medication preparation (IMP) has emerged as a complementary service to MDD, offering patients, caregivers, and healthcare professionals a way to optimize medication administration and adherence [3-5]. Medications will be reassembled in blister or pouch units according to physician prescriptions, facilitating correct use while excluding inappropriate dosage forms such as liquids and effervescent tablets [6-8]. This structured approach to medication organization aims to ensure that patients receive the right drug, at the right dose, at the right time [3, 9].

MDD and IMP services require interprofessional collaboration, promoting constant communication between pharmacists, physicians, and caregivers. These systems contribute to patient safety, treatment comfort and better disease control [3, 10]. As a result, they are particularly recommended for chronic disease management and for patients with polypharmacy, helping to reduce medication mismanagement and associated complications [11]. Community pharmacy-based MDD services are expected to minimize medication-related hospitalizations and medication-related adverse events through improved medication monitoring and adherence support [2].

Concerns persist about the accuracy of MDD systems, widespread implementation, and potential medication errors [2, 9]. As pharmacies and healthcare institutions integrate these systems, technological advances have emerged to support automated dispensing and monitoring, offering new opportunities to improve medication adherence and reduce human error. However, the actual impact of these innovations on medication safety and dispensing efficiency remains unclear and further investigation is needed [6, 12-14].

The stability of medicines once they are removed from the manufacturer's original packaging is a main preoccupation [15-16]. Manufacturers design packaging to protect drug products from light, air (oxygen, carbon dioxide and other gases) and moisture, ensuring minimal interactions between the drug and its container [2, 15, 17]. However, once drugs are repackaged in an MDD system, these stability guarantees may no longer apply, thus compromising drug efficacy and safety [2, 15-16].

Studies have demonstrated variations in stability between different brands of drugs containing the same active pharmaceutical ingredient [11]. Although manufacturers are responsible for ensuring the stability of drugs in their original packaging, this responsibility does not extend to repackaged drugs; this critical concern falls to pharmacists and pharmacy technicians [2, 16, 18]. When choosing to repackage drugs in MDDs, healthcare professionals must consider potential changes in drug potency, chemical integrity, and physical characteristics [2].

Potential risks of MDD repackaging include API degradation over time, which can result in loss of potency, and the accumulation of toxic degradation products in the drug, posing a danger of adverse reactions. Changes in the appearance of the drug may undermine patient confidence and adherence. Other chemical processes such as hydrolysis, oxidation, isomerization, polymerization, or photodegradation can also occur. In addition, physical instability may lead to alterations in tablet hardness, friability, disintegration, dissolution rate, and ultimately bioavailability. [1-2]. Given these concerns, systematic research on implementation, benefits, risks, and optimization strategies for MDD systems is needed.

Literature was searched in the Joanna Briggs Institute (JBI) Database of Systematic Reviews and Implementation Reports, Cochrane Database of Systematic Reviews, CINAHL (via EBSCO) and MEDLINE (via PubMed). No comprehensive or systematic reviews focusing on the overall implementation and use of MDD systems were identified, particularly in terms of user experience, safety assessment, quality interventions, technological advances and financial considerations.

Consolidated research is lacking, so a scoping review is needed to map current evidence on MDD system implementation, identify best practices and limitations in their use, explore emerging technologies and their role in improving adherence and patient safety, and assess financial and organizational barriers affecting the adoption of MDD services. A scoping review is particularly appropriate for this topic, as it allows for the exploration of extensive evidence and the identification of knowledge gaps that can inform future research and policy recommendations.

Objectives and Research Question

This scoping review aims to answer the following research question: What is the current evidence on the implementation and utilization of MDD systems, and what potential solutions exist for improving these systems, specifically related to user experience, safety assessment methods, quality improvement interventions, technological support, and payment for the service?

The review focuses on five specific topics: user experience with MDD systems; safety and risk assessment; quality improvement interventions (QII); technological advancements in MDD systems; and economic and financial considerations. These objectives establish a structured framework for mapping the key dimensions of MDD systems, encompassing usability, safety, quality enhancement, technological integration, and financial sustainability.

Methods

This scoping review was conducted following the Joanna Briggs Institute (JBI) methodology and adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines [17]. This plan systematically mapped the existing literature on MDD systems, focusing on user experiences, safety, quality interventions, technological advances, and cost factors.

Research Strategy and Identification of Studies

The eligibility criteria followed the PICO (Population, Intervention, Comparison, Outcome) framework, adapted for scoping reviews (Table I).

Table I
Eligibility criteria

Criteria	Description
Population (P)	Patients from primary healthcare or nursing homes using MDD
Intervention (I)	The use of use of MDD/MCA/DAAs
Comparison (C)	Usual care/not using MDD/MCCAs/DAA; not required for inclusion
Outcomes (O)	Studies evaluating user experiences, medication safety, quality improvement interventions, technological innovations, and cost considerations.

The inclusion criteria comprised of studies assessing user experience with MDD systems, whether involving patients or healthcare professionals; research examining safety aspects such as error rates, adverse events, and packaging concerns; studies on quality improvement interventions (QII) aimed at optimizing MDD systems; research evaluating technological innovations in medication dispensing; and economic evaluations or studies on cost-effectiveness and financial models of MDD services. Eligible publications had to be peer-reviewed articles published in English or Portuguese and conducted in community pharmacies, primary care, or nursing home settings.

The exclusion criteria rule out studies unrelated to MDD, MCA, or DAA systems, articles focusing on hospital settings, publications in languages other than English or Portuguese, studies lacking relevant data on outcomes of interest, and systematic reviews or meta-analyses.

Search Strategy

A comprehensive literature search was conducted in PubMed (MEDLINE) and in multiple databases available through EBSCOhost, including Academic Search Complete, the eBook Academic Collection, the eBook Collection, the eBook University Press Collection, the eBook Open Access (OA) Collection, and Library, Information Science & Technology Abstracts. No limits were applied to the publishing year to ensure the inclusion of all relevant studies. The initial search was conducted in November 2022 and was updated periodically with studies and cross-references.

The search strategy was developed using a mix of MeSH terms, keywords and Boolean operators. The query for PUBmed was defined as: (i) Pubmed: (multidose dispensing system [Title/Abstract]) OR (multi drug dispensing system [Title/Abstract]) OR (dose administration aids [Title/Abstract]) OR (medication therapy management [Title/Abstract]). The query for EBSCO was defined as EBSCO search complete: AB multi-dose dispensing systems OR AB multidrug dispensing systems OR AB dose administration aids OR AB medication therapy management

Screening and Selection Process

The screening process began with the removal of duplicate records identified across databases prior to the initial assessment. Titles and abstracts were then screened to determine relevance to the research topic, with studies considered for inclusion if they addressed MDD system implementation in relation to user experience (patients or healthcare professionals), medication safety and adherence, quality improvement interventions, technological innovations, or economic evaluations, including cost-effectiveness analyses. Articles meeting at least one of these criteria proceeded to full-text review. The Rayyan software [25] was used to facilitate semi-automated abstract and title screening, improving efficiency while maintaining a high level of usability and accuracy.

Articles were reviewed independently by two reviewers, and any discrepancies in inclusion were resolved through discussion and consensus meetings. If needed, a third reviewer was consulted for final decision-making.

This rigorous process ensured a transparent, reproducible, and comprehensive approach to identifying studies for inclusion in the scoping review.

Data Extraction

The authors have developed a structured data extraction document aligned with the objective and research question of this scoping review (Table II). This document may be refined throughout the extraction process, based on the emerging needs identified by the researchers.

Data was extracted by two independent reviewers, ensuring consistency and accuracy. In case of discrepancies, a third reviewer was consulted to reach a consensus.

A pilot test of the data extraction form was conducted on a subset of studies to ensure clarity and appropriateness before full data extraction begins.

Data Synthesis

The information extracted from the included studies is presented in a descriptive format, using tables and thematic categorization, while maintaining alignment with the scoping review objectives.

To systematically address the research question, a table was prepared that may include the data presented in Table III, organizing studies by key focus areas.

Table II

Instrument developed by the researchers for data extraction

Data extraction instrument	
Title	Multidose drug dispensing systems: a focus on user experiences, safety, quality, and cost factors
Review question	What is the current evidence on the implementation and utilization of MDD systems, and what potential solutions exist for improving these systems, specifically related to user experience, safety assessment methods, quality improvement interventions, technological support, and payment for the service?
Methodology (Inclusion criteria – PICO)	Population (P) - Patients from primary healthcare or nursing homes using MDD Intervention (I) - The use of use of MDD/MCA/DAAs Comparison (C) - Usual care/not using MDD/MCCAs/DAA; not required for inclusion Outcomes (O) - Studies evaluating user experiences, medication safety, quality improvement interventions, technological innovations, and cost considerations.
Extraction of study details and characteristics	**Study characteristics**: Authors, year of publication, country, and study design. **Population**: Number of participants, demographic details, and clinical setting. **Intervention**: Type of multidose drug dispensing (MDD) system used, implementation process, and duration. **Outcomes measured**: User experience, safety assessment, quality interventions, technological advancements, and cost-related aspects. **Key findings**: Relevant results and conclusions drawn from each study.

Table III

Data synthesis grid for the review question

Authors	**Year published**	**Study type and design**	**Study context**	**Country**	**Aspects of the MDD system evaluated**	**Relevant concepts**
Carruthers *et al*.	2008	Audit	RACFs	Australia	Safety Assessment in the Preparation of DAA/MDD	High rate of incidents in DAA packaging in RACFs; Error types included incorrect packaging, correct packaging but the DAA was no longer required, and operational problems.
Johnell & Fastbom	2008	Cross-sectional Study	SPDR	Sweden	Safety Assessment in the Preparation of DAA/MDD	Higher prevalence of polypharmacy in elderly with low education, however not related after controlling for comorbidity, marital status, and living situation.
Wekre *et al*.	2011	Qualitative Study	Primary Health Care	Norway	Experiences of users and health professionals concerning the use of MDDs	Some unknown challenges were faced by health personnel during the implementation of the MDD system.
Wallerstedt *et al*.	2013	Longitudinal Analysis	Primary Health Care	Sweden	Safety Assessment in the Preparation of DAA/MDD	There's a causal relationship between MDD system and safety concerns as regards prescribing practices.
Gilmartin, Hussainy, *et al*.	2013	Cross-sectional Observational Study	NH	Australia	Safety Assessment in the Preparation of DAA/MDD	High rate of incidents in DAAs packaging supplied to NHs.

Authors	Year published	Study type and design	Study context	Country	Aspects of the MDD system evaluated	Relevant concepts
Gilmartin, Marriott, *et al*.	2013	QIIs	14 Pharmacies and 45 NHs	Australia	Introduction of a quality improvement intervention (QII) in the preparation of MDDs	QII have the potential to improve DAA medicine supply from community pharmacies to NHs and reduce dispensing errors found within them.
Tora *et al*.	2014	A Register Study	NH	Sweden	Use of technology in the preparation/use of MDDs	EES detected potential DRPs in the majority of patients with MDDD. The number of potential DRPs was associated with the number of drugs, age, gender, and type of medication.
Miranda & Costa	2014	Cross-sectional Study	3 Pharmacies	Portugal	Payment for the preparation of the MDD service	AAD system may be viable in community pharmacies, most of users considered the service useful for themselves or for others. A significant number of these clients were willing to pay for the service, although not enough to cover all its costs.
Elliott *et al*.	2016	Audit	RACF's	Australia	Use of technology in the preparation/use of MDDs	Medication discrepancies (medicine omission and extra medicine) and delays were common and contributed, in some cases, to missed doses.
Rantanen *et al*.	2017	Observational Study	Phase 1: NH Phase 2: Home care Patients	Finland	Use of technology in the preparation/use of MDDs	Individualized patient dosing schedules; patient-provider communications; on-time, in-home medication delivery.
Mertens *et al*.	2019a	Cross-sectional Study	8 Pharmacies	The Netherlands	Safety Assessment in the Preparation of DAA/MDD	MDD patients systems, most of the drug regimen changes are adjusted immediately.
Mertens *et al*.	2019b	Cross-sectional Study	3 Pharmacies	The Netherlands	Experiences of users and health professionals concerning the use of MDDs	Patients were involved in the decision to initiate an MDD system and are very satisfied with it, reporting multiple advantages.
Faisal *et al*.	2021	Mixed-Method Study	Primary Health Care	Canada	Use of technology in the preparation/use of MDDs	Pharmacy workload, manpower and financial resources are imperative for successful implementation of real-time adherence-monitoring, MDDs.
Tukukino *et al*.	2022	Descriptive Study	Primary Health Care	Sweden	Use of technology in the preparation/use of MDDs	Interaction alerts are questionable as indicators of problematic prescribing.

Presentation and interpretation of results

The literature search process yielded a substantial initial pool of 1857 relevant references. After employing software to remove duplicates and unrelated articles, the number was reduced to 1753. The abstract screening phase included 1706 of these references, from which 71 were selected for a comprehensive full-text review. Following this thorough evaluation, 15 articles were ultimately chosen for data extraction. This final selection was based on the articles' alignment with the established research objectives and their relevance to the subject matter. The chosen studies span a period from 2008 to 2022 and exhibit considerable variation in their participant numbers, as illustrated in Table IV. This methodical narrowing process ensured that the most pertinent and valuable studies were identified for in-depth analysis.

Table IV

Number of participants in each study

Reference	Number of Participants n =
Faisal *et al.*	5
Gilmartin, Hussainy *et al.*	1757
Wekre *et al.*	24
Carruthers *et al.*	2480
Rantanen *et al.*	17+27
Mertens *et al.*	62
Wallerstedt *et al.*	30,922
Johnell *et al.*	731105
Mertens *et al.*	250
Gilmartin, Marriott *et al.*	435
Elliott *et al.*	88
Tukukino *et al.*	151
Tora *et al.*	180059
Miranda *et al.*	267

The geographical distribution of the selected studies was predominantly concentrated in Europe and Australia, as detailed in Table V. The Nordic countries accounted for six of the studies, while Australia contributed five. Two studies originated from the Netherlands, with Portugal and Canada each providing one study. There was considerable diversity in both the study designs and the intervention settings across the selected research.

Despite the significant heterogeneity among the chosen studies, which encompassed variations in sample sizes, study designs, and subject matter, they were all included in the review. This inclusion was justified by the value and relevance of the information presented in each study. For example, some studies offered insights into important technological innovations, which were deemed crucial for the comprehensive scope of the review. This approach ensured that a wide range of pertinent information was captured, even if it meant incorporating studies with diverse methodologies and focuses.

Table V

Summary of included studies

Reference	Design	Setting	Country
Faisal *et al.*	Mixed-Method Study	Primary Health Care	Canada
Gilmartin, Hussainy *et al.*	Cross-sectional Observational Study	NH	Australia
Wekre *et al.*	Qualitative Study	Primary Health Care	Norway
Carruthers *et al.*	Audit	RACFs	Australia
Rantanen *et al.*	Observational Study	Phase 1: NH Phase 2: Home care Patients	Finland
Mertens *et al.*	Cross-sectional Study	3 Pharmacies	The Netherlands
Wallerstedt *et al.*	Longitudinal Analysis	Primary Health Care	Sweden
Johnell *et al.*	Cross-sectional Study	SPDR	Sweden
Mertens *et al.*	Cross-sectional Study	8 Pharmacies	The Netherlands
Gilmartin, Marriott *et al.*	QIIs	14 Pharmacies and 45 NHs	Australia
Elliott *et al.*	Audit	RACF's	Australia
Tukukino *et al.*	Descriptive Study	Primary Health Care	Sweden
Tora *et al.*	A Register Study	NH	Sweden
Miranda *et al.*	Cross-sectional Study	3 Pharmacies	Portugal

DAA (Dose Administration Aid); MDD (Multidose Drug Dispensing); NH (Nursing Home); QII (Quality Improve Intervention); RACF (Regional Age Care Facility); SPDR (Swedish Prescribed Drug Register)

Some of the selected articles were more focused regarding experiences of users and health professionals, others more about the safety in preparation of these systems and possible interventions to improve it´s execution, some examples of the technology developed in the last years and the possibility of payment for these type of services.

Thus, in order to facilitate the articles screening, considering the objectives previously established for this scoping review, it was decided to analyse the results according the specifics of each article as presented in Table VI, which will be further developed in discussion.

Table VI

Summary of topics of interest

Topics of Interest	Articles that focused the topic
Experiences of users and health professionals concerning the use of MDDs	Wekre *et al*., Mertens *et al*.
Safety Assessment in the Preparation of DAA/MDD	Gilmartin, Hussainy *et al*., Carruthers *et al*., Wallerstedt *et al*., Johnell *et al*., Mertens *et al*.
Introduction of a quality improvement intervention (QII) in the preparation of MDDs	Gilmartin, Marriott *et al*., Elliott *et al*., Tukukino *et al*., Tora *et al*.
Use of technology in the preparation/use of MDDs	Faisal *et al*.
Payment for the preparation of the MDD service	Miranda *et al*.

This scoping review examined current evidence on multidose drug dispensing (MDD) systems, focusing on user experience, safety, technology, and costs. The review explored perspectives from patients and healthcare professionals to identify gaps in knowledge and strategies to improve MDD implementation and medication adherence. Analysis of technology integration provided insights into its impact on dispensing efficiency. These findings provide insights for pharmaceutical care and highlight priorities for future research.

Results and Discussion

In alignment with the established research objectives and drawing from the outcomes measured across the retrieved articles, the review will now delve into a comprehensive examination of each identified topic.

User's experiences (patients and health professionals)

There have been some studies regarding patient's and health personnel experiences, and also opinions about the use of MDD systems. When it comes to health professionals, Wekre et al (2011), detailed in their study that health professionals agreed that this system requires a more frequent communication between all professionals, which may lead to better handling of drugs and fewer dispensing errors, which ultimately can be considered an argument in favor of the use of these systems [10]. However, if a communication problem exists, for example any update of the medication regimen should be transmitted as soon as possible, otherwise patients may experience drug related problems (DRP) [10].

On the other hand, Mertens et al (2019) sought to explore patient's experiences with MDD systems. Their results show the importance of shared decision making between physicians and patients. It was reported that those patients were the ones that rated their experience with MDD system with a higher grade, in contrast with cases in which patients started MDD system without their consent [21]. The authors also point out that prior to this system, other measures should be taken in consideration (simplification of the drug regimen; use of drug reminder charts and/or use of reminder alarms; use of pill boxes), when faced with a situation where patients do not take their medication correctly or are starting to lose their management capacity [21]. If none of the above proved to be useful than an MDD system can be considered.

Safety Assessment

There's a growing concern about the safety of medication preparation of MDD's systems. These systems have individual doses of a day or week supply of drugs arranged according to the dosage schedule for the day and before they are given to the patient several health personnel are involved in its preparation mainly the general practitioner (GP) that prescribe them, the pharmacy staff that prepare them and the nurses that give them to patients, so the probability of error exists.

Having that in mind, Carruthers et al (2008) study had the premise to audit DAAs in RACFs, which is a place where older people can live when they need ongoing help or health care and can no longer live at home [11]. The rate of incidents in DAA packaging was high (4.3%), considering the 297 incidents detected from 6972 packs of medication of the 2480 residents that participated in this study [11]. These incidents can be explained by several reasons such as medication missing from the package (99); medication wrongly dispensed (12); incorrect labelling (32); medication dispensed by the pharmacies that was already ceased by the GP (7); incorrect instructions of dosage (37); medications not delivered to the RACF (13) [11]. These results show the need to improve the safety and awareness for all health professionals about the use and preparation of these systems.

Another study had the same goal, however, this time they were trying to evaluate the safety of DAAs in NH. Currently a large proportion of the NH population have their medicines repacked into DAAs, which enlightens the need to audit the safety of these preparations [13]. The authors ended up with a similarly high rate of incidents, in this case 684 incidents occurred in 457 DAAs from a total of 3959 that were audited of the 1757 residents [9]. Some of the reasons to justify these incidents were unsuitable repacking according to pharmaceutical guidelines (50.1%); added medicine (9.8%); incorrect quantity repacked (5.4%); omitted medicine (5.3%); damaged medicine (5.1%) [9]. The current findings indicate there is the potential for NH residents to receive inaccurate or unsuitably re-packed medicines, with the potential to lead to adverse health consequences if not first identified and rectified.

In Susanna M. Wallerstedt study, the objective was a bit different than the articles previously referred. In this case, patients were already users of MDD systems, the authors were trying to find out a possible association between the use of MDD systems and an increased use of drugs [22]. The results showed that these patients were in fact taking more drugs than previously, having fewer drug changes in their treatment, happening the same during the follow-up [22]. Nevertheless, we cannot assume instantly that the increased use of drugs by these patients it's a direct consequence of the use of MDD systems. The authors have in consideration for example that some of the new drugs were indeed necessary for the patient, regarding his new health state [22]. Also, these patients have a stricter control of their medicines in comparison with normal users, which ultimately may influence part of the results, something that should also be considered.

In Sweden a different approach was tried, to investigate if a possible association could exist between the use of MDD systems and potentially inappropriate drug use (IDU) [23]. The results indicate that multi-dose users may be more exposed to potential IDU [23]. This may partly be explained by the higher drug use in the multi-dose than the ordinary prescription users [23]. Also, these users are more susceptible to fewer renewal of prescriptions and less inclination to make changes to medication lists, which can influence potential IDU [23]. These conclusions highlight the need of improved used of these systems, with a proper and constant communication between health professionals, otherwise it could lead to complications.

In the Netherlands the use of these systems is also growing, however little is known about drug regimen changes when MDD are used. With that premise in mind, Mertens et al (2019) aimed to investigate the frequency type, procedure followed, immediate necessity and time taken to make MDD adjustments [24]. The results of the study show that a considerable part of MDD adjustments were effectuated immediately 135 (52%), 81 (31%) by adjusting the MDD system manually, 49 (19%) by temporarily dispensing the drug separately from the MDD system and 5 (2%) by ordering a new MDD system [24]. Taking these results into account, pharmacists were of the opinion that almost half of adjustments could be deferred adjusted [24]. This type of adjustment takes time and brings additional costs to the preparation of these systems, so they must weigh the pros and cons of immediate or deferred adjustment for every individual patient [24]. Explicit agreements and timely communication between prescribers, patients and pharmacists about the reason and acuteness of immediate MDD adjustments might decrease the number of immediate MDD adjustments, resulting in improved dispensing efficacy as immediate adjustments took around twice the time compared to deferred adjustments.

Quality improvement interventions

Taking into account previous studies on the safety of DAA/MDD preparation and use, something needed to be done to improve these outcomes. Julie Gilmartin and her colleagues created a quality improvement intervention (QII) in order to improve DAA medicine supply 29). The intervention included several strategies like education sessions; guidelines or protocols to direct the DAA supply service; additional DAA medicine checking by the community pharmacist and pharmacy technicians at the NH; stamps or bookmarks to be used in medicine records and to increase awareness of medication regimen changes; logbooks and stickers to record inter-professional communication regarding medication regimens; medicine identification sheets to facilitate DAA checking [25]. This study provides health professionals with practical suggestions to improve their DAA medicine supply service. Respondents believed the intervention had the potential to improve pharmacy medicine supply, or medicine administration involving DAAs in NH [25]. The QII evaluated in this study can also provide a basis for community pharmacies who are striving to improve their DAA medicine supply service.

The same authors decided to explore whether this intervention was also feasible in the context of RACFs. They target DAA medicine supply service provided to their residents with a similar intervention (education session, stickers, bookmarks, template documents articles, posters and guidelines) [9]. The DAAs, containing regularly packed medicines, were compared with the current, prescriber-prepared and updated medicine chart held at the RACF. The overall DAA incident rate increased significantly from 11.5% pre-intervention to 21.0% of all DAAs audited post-intervention [9]. The higher incident rate may reflect the generic nature of the intervention

and its overall lack of specificity for particular types of incidents. These findings emphasize the need that QII to be designed for specific local contexts, taking into account the possibility of certain types of incidents. This study has highlighted the importance of ongoing and wide-scale evaluation of established medicine supply services provided to residents of RACF.

Technological support

While the multidose dispensing services landscape is witnessing innovative solutions, integrating these technological and procedural interventions into the existing workflow of community pharmacies presents significant operational challenges. The successful adoption of these new solutions requires a strategic and adaptive approach that can seamlessly blend cutting-edge developments with the practical realities of community pharmacy environments.

Having that in mind Faisal et al (2021) pretended to explore which factors affected the implementation of a real-time adherence-monitoring, multidose-dispensing system in community pharmacies. They had to disposal the smart adherence technology system, which is essentially a smart multidose blister package and a web-based portal to monitor the patient's medication intake remotely [6]. When a cavity is broken to access the medications, the tele-communications device records the medication intake event and uploads the data to a cloud-based software portal. This allows to observe patient medication schedules, set up notifications and obtain a report on patient medication adherence. The system can also generate reminders which can be sent as text to a mobile phone or an email address. The study participants valued the availability of real-time medication in take data and perceived that it could be a useful tool to aid in clinical decision making related to therapy [6]. Although it was perceived as an easy-to-use system, some of the requirements necessary (initial setup and staff training) can be considered barriers. The need of larger space and specific storage locations for the smart blister package was also something that pharmacy staff referred to as a potential barrier.

Another example of a possible technology that could be used to improve the medication adherence for elderly patients is the one presented in Pekka Rantanen study. It examined the safety and usability of Evondos E300® Medicine Dispensing Robot with Multidose Sachets, an integrated advanced robotic device and telecare system [12]. This was a two-phase study, phase I took place in a NH mainly to test for possible robotic malfunctions that could jeopardize patients safety, phase II involved a less controlled setting, this case home care patients [12]. When the patient presses the device's dispenser button, the device delivers a sachet containing the medicine(s). If a patient misses a sachet or happens a systems malfunction, the telecare system passes that information to the home care unit for action [12]. Thus, no medication doses were missed, the patients still received their medicines. In this trial the home care patients were satisfied with the device and willing to use a robotic system, and the nurses' opinions were positive.

Over recent years, some RACFs implemented electronic medication management systems (eMMS), in which electronic medication administration charts are used instead of a paper chart for the purpose of medicine administration [26]. These hybrid paper–electronic medication management systems, in which GP prescribers' orders are transcribed into an electronic system by pharmacy technicians and pharmacists to create medication administration charts, are increasingly replacing paper-based medication management systems in RACFs. With that in mind Elliot *et al*. investigated possible discrepancies between GPs paper medication orders and pharmacy-prepared electronic medication administration charts, back-up paper charts and DAA, as well as delays between prescribing, charting and administration [26]. Almost half of the identified discrepancies were caused by pharmacy data entry discrepancies, or failure to update the eMMS when there was a change (resulting from either RACF staff failing to notify the pharmacy of medicine changes or failure of the pharmacy to correctly enter the data into the eMMS). Although this study only involved one pharmacy and one RACF, it highlights some of the risks associated with hybrid paper electronic medication management systems, which is why improvements are needed to properly manage patients' medication.

Given the fact that patients are using more and more medicines, the risks of drug interactions are consequently increasing, including in MDD systems. Even though the pharmacy staff whenever is preparing these systems should check for possible interactions, they can happen. With that in mind, Tukukino and colleagues decided to study *Janusmed*®, a decision support integrated into medical records that provides recommendations for managing interactions, to check for possible medication alerts in patients using MDD systems [25]. From the 26 (79%) out of 33 patients using multi-dose drug dispensing, most of the alerts that appeared can be managed by dose adjustments or separated intake [27]. As a decision support tool, it had the intended effect, that is, to affect GPs behavior. However, as these alerts and recommendations continue to appear although the drug treatment is adequately managed, physicians may disregard them, thereby increasing the risk that important alerts are overlooked in a time-strained practice. To avoid information overload, one may hypothesize that the interaction alert system could benefit from increased integration with clinical data.

Drug Related Problems (DRP) due to inappropriate drug use or inappropriate doses are common in the population using MDD systems. They may cause suffering for patients and substantial costs for society. With these assumptions Hammar Tora and his colleagues decided to use the clinical decision support system (CDSS) Electronic Expert Support (EES) to detect possible DRPs in patients with MDD systems [26]. The results show that potential DRPs were detected in most patients with MDD, on average two alerts per patient [30]. Despite having a higher number of drugs, patients with the highest age received a lower number of alerts compared with younger patients [28]. These results can be partly explained considering that elderly have an increased risk of cardiovascular disease comparing with patients ≤ 64 years. However, is of great importance to monitor patients with MDD of all ages for potential DRPs related to age, dose or drug combinations. A CDSS such as EES might be a useful tool in health care and pharmacies, but more research is needed on clinical relevance of alerts and actual patient outcomes.

Payment for the preparation of the DAA/MDD service

MDD systems are increasing in use, however there is a cost associated with preparing this type of system. Given the current funding model for pharmacies, both in the public and private sectors, although these type of systems are funded by the government in some countries, others which isn't. It is necessary to study the public perspective and assess the patient's willingness to pay for this service so that it can be successfully implemented in the community pharmacy context.

Miranda & Costa, 2014 gathered information from community pharmacies using a questionnaire. Their findings revealed that most respondents viewed the service as beneficial, not only for themselves but also for their relatives or acquaintances [29]. Notably, individuals exhibiting non-adherent behaviors were more likely to perceive the service as useful, suggesting that this group should be prioritized when implementing the service. Respondents who believed it was reasonable to pay for the service primarily cited the additional workload it created for pharmacy staff as justification. This study provides valuable insights into public perceptions of pharmacy services and willingness to pay, which are crucial factors in successfully implementing new pharmacy services in community settings. A more recent study with a similar approach also investigated the possibility to pay for the DAA and its preparation. In this case, a structured online questionnaire was used and the results showed that most respondents also stated that they were willing to pay for this service, even more so if it was for a relative [28].

Both studies suggested that the implementation of a MDD system may be feasible in community pharmacy, given the large proportion of respondents who consider it a useful service for themselves and, above all, for others, since they recognize it as a possible tool for promoting adherence. In addition, a significant portion of potential users is willing to pay for the service, though perhaps not enough to cover all its costs or the time spent preparing these systems.

MDD systems generally enhance medication adherence, but they come with certain drawbacks. Several studies have highlighted that patients' knowledge about their medications may decrease when using these systems. Additionally, not all medications are suitable for MDD, and the cost of dispensing via MDD is typically higher than manual dispensing. Patients with reduced manual dexterity or impaired vision may require alternative solutions. Effective use of MDD systems necessitates ongoing communication between general practitioners, pharmacy staff, and patients.

These factors should be carefully considered before implementing MDD systems. It's crucial to recognize that simply adopting these systems without maintaining proper patient follow-up could compromise safety and potentially lead to complications. The decision to use MDD should be made thoughtfully, with a commitment to ongoing patient monitoring and support.

Recent years have seen the emergence of innovative technological options in this field. However, the feasibility of implementing these technologies on a large scale, coupled with their associated costs, may present significant challenges for widespread adoption in community pharmacy settings. While these technological advancements offer promising solutions, their practical implementation requires careful evaluation of both economic and logistical factors within the community pharmacy context

Limitations

The existing literature on multidose drug delivery systems is relatively limited. These devices show potential for improving medication safety by reducing discrepancies and offering convenience and ease of use. However, the search methodology employed in this review could be refined, potentially by using different search equations or better utilization of MeSH terms, to uncover more robust evidence aligned with the research objectives.

Recent publications on the topic demonstrate varied approaches by different authors, which can influence their results and make it challenging to draw firm conclusions about certain aspects of these systems. Implementing the solutions presented and assessing

their benefits poses a challenge, particularly given the differences in pharmacy size, scale, volume, and regulations across countries. Technical challenges, such as the technology required by users and pharmacies, additional workload, and lack of financial remuneration, may render these systems unsuitable in some contexts.

Future research should focus on estimating costs and benefits from various stakeholder perspectives, including healthcare decision-makers and providers, patients and their families, community pharmacies, and public insurance. More rigorous studies employing relevant designs, methods, and outcome measures are needed to provide solid evidence on medication safety, appropriateness of use, and costs associated with MDD systems.

Future perspectives

A limited number of controlled studies have explored MDD systems in primary healthcare settings. Further evidence is needed to draw robust conclusions about MDD outcomes and safety under various conditions. Future research should focus on medication stability within these dispensing systems [11], particularly under varying environmental conditions such as temperature and humidity differences across countries—factors increasingly affected by climate change.

Few studies have addressed medication stability in MDD systems. Recent research has examined not only stability but also which medication brands and excipients are most suitable for repackaging [11].

Conclusions

MDD systems play a crucial role in promoting medication adherence, safety, and dispensing efficiency, making their proper implementation essential in healthcare settings. The use of validated methods to assess MDD systems enabled a comprehensive evaluation of their impact on user experience, safety protocols, technological advancements, and financial sustainability.

By mapping the existing evidence, this scoping review supported the development of targeted strategies to optimize MDD implementation, enhance medication management, and improve patient outcomes. Furthermore, it contributed to healthcare system improvements by informing policies that ensure safer and more efficient dispensing practices. Regarding research implications, this review identified gaps that may lead to future systematic reviews, fostering further investigation into the effectiveness, challenges, and best practices associated with MDD systems.

Conflict of interest

The authors declare no conflict of interest.

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