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Original scientific paper

ASSESSMENT OF PROFESSIONAL COMPETENCES OF COMMUNITY PHARMACISTS IN THE USE OF ADVANCED DRUG DELIVERY SYSTEMS

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Abstract

The professional competences of community pharmacists are constantly developing, which is a result of the development of pharmaceutical technology, leading to the creation of complex drug formulations, which in their turn require new knowledge about their appropriate use to attain the desired therapeutic effects. The purpose of this study was to assess the knowledge of community pharmacists about modified-release formulations of drugs and advanced drug delivery systems, such as transdermal systems, inhalation systems, and modern pediatric formulations.

The research was conducted on 214 community pharmacists using a structured questionnaire. The total level of knowledge was 73.3%, which can be described as moderate to good. The highest level of knowledge was for modified-release formulations (MR) (78.6%), whereas for drug delivery systems (DDS) (69.1%), transdermal systems (66.8%), and inhalation systems (64.5%), the level of knowledge was moderate. The lowest level of knowledge was for modern pediatric formulations (58.3%).

The results of this study have shown that pharmacists have a relatively good level of knowledge of conventional products, but there is a need to increase their knowledge of more advanced products and overcome the difficulties of practical application. It may be concluded from this study that there is a need for more specific education in the field of advanced technological systems, focusing on the quality of service provision and pharmaceutical counseling of patients.

Keywords: modified release products, drug delivery systems, transdermal systems, inhalation systems, pediatric products, community pharmacists, professional education.

Introduction

The recent developments in pharmaceutical technology have introduced a significant transformation in the formulation of drugs as well as their administration. These developments have introduced advanced drug delivery systems (Drug Delivery Systems, DDS), which is one of the most important developments in this area. Advanced drug delivery systems are formulations of utmost importance in modern pharmaceutical technology, which allow the release of the drug to take place in an accurate and specific manner at specific time intervals. The main purpose of using drug delivery systems is to attain optimization of the drug's effects, maximum reduction of adverse effects, as well as optimization of patient compliance (Paudel et al., 2021). By fulfilling these purposes, drug delivery systems allow for the personalization of drug use from a clinical perspective, which is one of the main purposes of pharmaceutical practice and the pharmaceutical industry.

Advanced drug delivery systems comprise a variety of modern dosage forms, including the modified release dosage form, transdermal systems, inhalation systems, oro-dispersible formulation, and nanotechnology-based drug delivery systems, which possess unique characteristics in the context of their application and the release of the active substance. Some of the challenges related to the proper application of the different types of DDS are discussed below.

The modified release dosage form (MR) is considered one of the most commonly used dosage forms, which includes the extended release, controlled release, and delayed release dosage forms through which the active substance is maintained at adequate levels over a longer period of time, allowing the required dosage intervals (Zhang et al., 2020). However, the proper application of the above dosage forms is considered crucial in the context of the unique technological process through which the drug is developed. Specifically, the improper manipulation of the dosage form, including the splitting of the tablet, which is considered common in the context of the tablet dosage form, may affect the release of the active substance.
The transdermal system (TTS) facilitates the administration of medicines through the skin, bypassing the first-pass effect of the liver and providing sustained release of the active substance (Paudel et al., 2021). However, the transdermal route of administration is largely affected by skin characteristics and environmental factors such as temperature and the use of cosmetics, which may affect the therapeutic response. Therefore, the effectiveness of transdermal therapy is not only related to the medication but also to proper patient counseling regarding the strict use of the medication.
Inhalation systems are the class of pharmaceutical preparations through which the direct administration of medicines to the respiratory system is possible, which is considered very important in the treatment of respiratory tract-related diseases such as asthma and chronic obstructive pulmonary disease. However, the effectiveness of the medicines is largely related to the route of administration, requiring a strict and accurate technique of administration. This is the most common error encountered with the use of inhalation systems (Chrystyn et al., 2021).
Oro-dispersible formulations are those formulations that disintegrate in the oral cavity and are commonly used in pediatric and geriatric patients, which improves drug compliance (Preis, 2022). Although these formulations improve drug compliance, when it comes to their administration, there are challenges associated with their administration, which may affect the drug's release and absorption into the body.
It is through *nanoparticle technology* that advanced drug delivery systems such as liposomes and nanoparticles have been developed, which improves the accuracy of drug delivery and bioavailability of the drug, thus improving the management of diseases that require more therapeutic specificity.
Based on these technological developments, it is necessary to develop the quality of professional skills for pharmacists in communities, as these new skills will also increase their professional competencies in healthcare. At both global and European levels, pharmacists are moving from their traditional role in medication dispensing to a more active role in healthcare, including clinical counseling, management of chronic therapies, and patient education (International Pharmaceutical Federation [FIP], 2021; FIP, 2025). Moreover, at the European level, policies are in place to support this transformation and to integrate community pharmacists into primary healthcare systems (Pharmaceutical Group of the European Union [PGEU], 2024).
In North Macedonia, there have also been changes in the legal framework in this direction. Through recent legislative changes and implemented policies, it is aimed that pharmacists' professional competencies will increase in pharmaceutical counseling, pharmacovigilance, and promotion of rational drug use (Ministry of Health of North Macedonia, 2023). This is in line with the international standards set by the World Health Organization and the International Pharmaceutical Federation's guidelines on Good Pharmacy Practice, which highlight the significance of professional competence and continuous education (WHO & FIP, 2011).
However, the complexity of modern pharmaceutical formulations and the use of advanced drug delivery systems pose many challenges in daily practice for community pharmacists. Misuse of these formulations, e.g., improper use of modified release dosage forms and inhalers, could directly impact the effectiveness of the treatment (Chrystyn et al., 2021). This is particularly

true in the case of pediatric patients, where the dosage form must be considered (Ivanovska et al., 2020).

Objective

The aim of this study was to evaluate the degree of knowledge, attitudes, and practices of community pharmacists regarding advanced DDS, including MR formulations, transdermal systems, inhalation systems, orodispersible formulation, or nanotechnology-based DDS, as well as the appropriate method of application of these formulations in pharmaceutical practice. Moreover, the study aimed at examining whether there is any relation between the knowledge of pharmacists and their practice in pharmaceutical practice, regarding these categories of formulations. Specifically, the aims of the study were:

- Knowledge of the level of knowledge of the appropriate use of MR formulations, transdermal systems, inhalation systems, oro-dispersible forms, and nanotechnology-based technologies
- Analysis of pharmacists' attitude toward their role in promoting improvements in the results of treatments and patient compliance, especially for chronic patients
- Knowledge of pharmacists regarding patient counseling and education on the appropriate use of these drug formulations and the appropriate devices
- Identification of demographic and professional factors that affect the level of professional competence

Materials and methods

Study design and participants

The study was designed as a cross-sectional study and was implemented using a validated self-administered questionnaire to assess the knowledge, attitudes, and practices of community pharmacists regarding advanced drug delivery systems (DDS), the administration of which includes the use of modified release (MR) dosage forms, transdermal systems, inhalation systems, orodispersible forms, and nanotechnology-based technologies.
This type of study design has been developed according to the evidence-based literature, where this type of study is widely used to investigate the evaluation of knowledge, attitudes, and practices in health-related research (Setia, 2016).
The selection of the participants was implemented through the use of purposive sampling, which is considered appropriate to recruit professionals with relevant experience (Etikan et al., 2016). This study was implemented between October 20, 2025, and January 20, 2026, in community pharmacies in the territory of North Macedonia. This type of sampling enabled the selection of community pharmacists who are actively involved in community pharmacy practice, with direct involvement in medication dispensing and patient counseling. The questionnaire was filled out anonymously using the Google Forms platform. The inclusion criteria were clearly defined as follows: the pharmacists were those who had graduated from recognized institutions, were employed in community pharmacies, and were actively involved in the practice.
Before the commencement of the study, the participants were informed about the intended study, and the voluntary participation, anonymity, and confidentiality were ensured. It took approximately 8-10 minutes to fill out the questionnaire.

Instrument of study

The development of the questionnaire was informed by previous literature on pharmacists' knowledge and practices regarding the use of modern pharmaceutical technologies (Chrystyn et al., 2021; Paudel et al., 2021). The content validation of the study instrument was conducted by an expert panel, while a pilot study was conducted on the study instrument's clarity and comprehensibility, following recommendations on methodological guidelines for conducting questionnaire studies in health research (Boateng et al., 2018). A pilot study was conducted among 10 community pharmacists. Data collected in the pilot study were not used in the study. The reliability of the study instrument was determined using Cronbach's alpha coefficient, which is widely used in assessing the reliability of study instruments (Tavakol & Dennick, 2011).

The questionnaire consisted of four main parts. In the first part, demographic and professional data were collected, such as age, sex, professional experience, continuous professional education, and sources of information concerning medicines. In the second part of the questionnaire, 18 questions evaluated the knowledge of advanced DDS and their appropriate use. A "yes," "no," and "do not know" scale was used, with 1 point for each "yes" answer and 0 points for "no" and "do not know" answers. The maximum number of points in this section of the questionnaire is 18. In the third part of the questionnaire, pharmacists' attitudes were evaluated with a 5-point scale from "strongly disagree" to "strongly agree," with a maximum of 40 points. In the fourth part of the questionnaire, professional practices were evaluated with a 5-point scale from "never" to "always," with a maximum of 45 points.

In this study, "advanced drug delivery systems" (DDS) means modified-release (MR) products, transdermal patches, inhalers, orodispersible systems, and products using nanotechnology.

Sample size calculation

The sample size was computed using the formula for cross-sectional study designs. It was assumed that the confidence level would be 95% and the margin of error would be 5%. If the prevalence is unknown (i.e., $p = 0.5$), the minimum required sample size would be about 196. This is in line with the recommendations of Naing et al. (2006) and Charan & Biswas (2013) regarding the determination of the sample size in epidemiological research. However, to enhance the precision of the findings, the total sample size was increased to 214 community pharmacists.

Measurement of variables

The knowledge of the community pharmacists was evaluated using objective questions with response categories 'yes,' 'no,' and 'do not know,' which is commonly used in KAP (knowledge, attitude, practice) surveys (Kaliyaperumal, 2004). Attitudes and practices were also evaluated using the Likert scale, which is widely used to measure attitudes and practices in health-related research (Joshi et al., 2015).

Statistical analysis

Descriptive and inferential statistical analyses were used to analyze the data. Tests such as the Chi-square test, t-test, and logistic regression are widely used for data analysis in cross-sectional studies. According to Kim (2017), these tests are the most appropriate for cross-sectional studies. The significance level was set at p-value < 0.05.

Results

Demographic and professional characteristics of the participants

The total number of community pharmacists who took part in the study was 214, which is a sound basis for assessing their knowledge, attitudes, and professional practice concerning advanced drug delivery systems. The analysis of the demographic and professional characteristics of the pharmacists showed that most of the pharmacists were females, whereas their professional experience was distributed in various categories, with a higher number of pharmacists with higher work experience being from the category of pharmacists.

The significant number of pharmacists who took part in continuing professional education programs is noteworthy.

Table 1. Demographic and professional characteristics of participants (n = 214)

Variable	n (%)
Gender	
Female	162(75.7%)
Male	52(24.3%)
Work experience	
< 5 years	48(22.4%)
5-10 years	72(33.6%)
>10 years	94(43.9%)
Continuing professional experience (CPE)	
Yes	146(68.2%)
No	68(31.8%)

As indicated in Table 1, it is evident that the majority of the participants were females, accounting for 75.7%, compared to males, who accounted for 24.3% of the total number of participants. In terms of work experience, it is evident that those with more than 10 years of experience were the largest group, accounting for 43.9%, followed by those with 5-10 years of experience, accounting for 33.6%, compared to those with less than 5 years of experience, accounting for 22.4%.
In addition, it is evident that 68.2% of the pharmacists in the study had participated in continuing professional education, compared to 31.8%, who had not participated in such activities. Therefore, it is evident that the study population has a strong professional background and is active in community pharmacy practice.

Level of knowledge

The evaluation of the level of knowledge showed that the community pharmacists had an overall level of knowledge of 73.3% about the modified release dosage forms and the advanced drug delivery systems. This could be considered moderate to good. However, if the level of knowledge is considered in more detail in relation to the different categories, there are some variations.

Table 2. Level of knowledge by category of formulation

Knowledge category	Mean (%)
Modified-release formulations (MR)	78.6%
Advanced drug delivery systems (DDS)	69.1%
Transdermal therapeutic systems (TTS)	66.8%
Inhalation systems (IS)	64.5%
Modern pediatric formulations	58.3%
Total	**73.3%**

As indicated in Table 2, the highest knowledge level was recorded for modified release formulations (78.6%), which could be attributed to their widespread use in daily practice, thereby increasing exposure for pharmacists during counseling. Conversely, knowledge levels were lower in relation to advanced drug delivery systems (69.1%) and transdermal therapeutic systems (66.8%), which could be attributed to the complexity of these systems, necessitating deeper knowledge on release mechanisms and absorption influences.

Pharmacists also recorded a moderate knowledge level in relation to inhalation systems (64.5%), which not only requires knowledge but also skills in order to demonstrate appropriate techniques in using these systems. This is often cited as a challenge in pharmaceutical practice. The lowest knowledge levels were recorded in relation to modern pediatric formulations (58.3%), indicating that this is still a demanding field. This is particularly important since pediatric formulations necessitate consideration of dosage, pharmaceutical form, safety, and acceptability in children. .

From a practical point of view, the above findings can be interpreted as pharmacists feel more confident with commonly used formulations, whereas there is a need to improve their knowledge in other, more specialized, complex areas such as transdermal and inhalation systems, in which the education of patients and the correct use of the formulations are essential to achieve the best therapeutic results.

Pharmacists' attitudes toward MR formulations and DDS

The study also aimed to investigate pharmacists' attitudes toward the importance of the formulations, considering their role in the correct use of the formulations through appropriate patient education. The findings of the study indicated that pharmacists' attitudes toward the importance of the formulations were generally positive, with a mean score of 3.94 ± 0.56 on the Likert scale, which means that pharmacists have a positive approach to the importance of the formulations, showing a significant level of interest in the topic.

Table 3. Attitudes toward DDS and MR (Likert Scale 1–5)

Statement	Mean ±SD
DDS improve treatment effectiveness	4.21±0.48
MR increase patient adherence	4.05±0.52
Additional training on DDS needed	4.32±0.44

The pharmacists has a key role in patient education	4.18±0.50
I feel confident in counseling on DDS	3.44±0.71

As can be seen in Table 3 above, the most common answer was the need for additional training in the area of DDS (4.32 ± 0.44). The significance of this answer should be emphasized in that it demonstrates the pharmacists' awareness of the gaps in the level of knowledge they currently possess. However, it also indicates that they are ready to learn and improve. In addition, the score was rather high in the area of the efficacy of the application of DDS in the treatment process (4.21 ± 0.48), and the role of pharmacists in the process of patient education in the proper application of DDS (4.18 ± 0.50).
On the other hand, the lowest score was recorded in the area of the confidence of pharmacists in patient counseling in the proper application of DDS (3.44 ± 0.71). In this context, it can be suggested that there is a gap in the level of knowledge of the significance of the application of DDS in clinical practice and the confidence of pharmacists in patient counseling in the proper application of DDS.
The above findings clearly indicate the necessity of developing educational interventions and training programs that are specifically aimed at improving the skills of pharmacists in patient counseling with regard to the proper use of these formulations.

Professional services of community pharmacists for the correct administration of DDS

In the third section of the questionnaire, an assessment was made in order to evaluate the services that are currently provided with regard to patient counseling on the proper use of these formulations in community pharmacies. The findings clearly indicate that there is a considerable variation in the extent of these services with regard to different categories of formulations. The results of this section are presented in the table below.

Table 4. Professional services offered by pharmacists for correct administration of DDS

Practice	Always (%)	Sometimes (%)	Rarely (%)
Counseling on MR	68.7%	24.3%	7.0%
Checking inhaler use	41.2%	38.8%	20.0%
Counseling on transdermal therapeutic systems TTS	36.9%	42.8%	21.0%
Education on correct use of DDS	39.7%	40.2%	20.0%

From Table 4, it can be concluded that counseling on the use of modified-release formulations was the most common service, with 68.7% of pharmacists stating that they always perform this service, whereas only 7.0% of pharmacists stated that they rarely perform this service. This could be attributed to the higher level of knowledge in this category, as well as to the frequent use of such formulations in routine practice, which could increase pharmacists' familiarity with their use in the treatment of various diseases.
On the other hand, the services of the correct use of inhalation devices, transdermal systems, and other advanced drug delivery systems were less common. This could be attributed to the fact that, in the current practice in North Macedonia, such services are expected to be provided

by medical specialists, such as pulmonologists, dermatologists, or pediatricians in the case of pediatric formulations. Under this context, only 41.2% of pharmacists stated that they always check patients' inhaler technique, whereas 36.9% of pharmacists stated that they always provide counseling on transdermal systems. Finally, 39.7% of the total number of pharmacists who participated in the study stated that they regularly provide education to patients on the proper use of DDS.

It is interesting to note that the highest percentage was recorded for the option "sometimes," indicating that these services are delivered on an occasional basis, despite their importance and role in pharmaceutical care.

The findings of this study have particular relevance from a clinical point of view, since inappropriate inhaler use, inappropriate use of transdermal patches, or inadequate counseling on formulations with specific release characteristics may have direct consequences on the effectiveness of treatment.

Factors influencing the level of knowledge

To determine which factors influence pharmacists' professional competence, the relationship between knowledge levels and certain demographic and professional characteristics was examined. The findings indicated that continuing professional education and work experience of more than 10 years were significant factors in relation to knowledge levels.

Table 5. Factors influencing knowledge level

Variable	OR (95% CI)	p-value
Continuing professional education	2.45 (1.60-3.75)	<0.001
Experience >10 years	1.98(1.25-3.12)	<0.001
Gender	NS	0.21

As presented in Table 5, pharmacists who had undergone continuing professional education were 2.45 times more likely to display higher levels of knowledge compared to those who had not undergone any training. This factor was the most significant, as it directly influenced professional competence. This indicates that there is need for continuous training in order to enhance knowledge in terms of advanced pharmaceutical formulation technology.

Furthermore, pharmacists who had over 10 years of work experience were 1.98 times more likely to display higher levels of knowledge. This indicates that professional experience is crucial in developing skills and exposure to different pharmaceutical formulations. On the other hand, gender was not identified as a significant factor in this study ($p = 0.21$), as it did not influence levels of knowledge.

Discussion

This study presents a comprehensive and significant evaluation of the knowledge, attitude, and practice of community pharmacists in relation to advanced drug delivery systems and modified release drug formulations. The results of this study show that, in general, pharmacists have a moderate to good level of knowledge (73.3%), implying a sound knowledge base. However, there is a need to further improve knowledge, especially in relation to more specialized drug therapies.

One of the important findings of this study was that pharmacists had a higher level of knowledge in relation to MR drug formulations (78.6%) than that of DDS (69.1%) and, in particular,

modern pediatric drug formulations (58.3%). This may be attributed to the fact that pharmacists are more familiar with MR drug formulations, as they are more commonly used in practice. In contrast, pharmacists are less familiar with DDS and pediatric drug formulations, as they require more specialized knowledge and are less commonly used in practice. Similar findings have also been reported in previous studies, where the complexity of modern drug therapies and drug technologies has been associated with differences in knowledge not only among pharmacists but also among other healthcare professionals (Paudel et al., 2021; Preis, 2022). However, despite the level of knowledge, the attitudes of pharmacists regarding the clinical significance of these formulations were generally positive, with an average of 3.94 ± 0.56. It is interesting to note that pharmacists demonstrated a high level of agreement in regards to the necessity of further training, indicating their awareness of the knowledge level and their willingness to improve their competencies in order to deliver higher quality services. One of the interesting results of the present survey is the level of discrepancy between theoretical knowledge and practical application in counseling patients in regards to the correct use of DDS (3.44 ± 0.71). Such results have also been reported in previous studies (Chrystyn et al., 2021).

More information in regards to the problem of knowledge and attitudes of pharmacists can be derived from the results of the survey in regards to the level of services that is currently provided in community pharmacies. The results indicated that counseling in regards to MR formulations is relatively well established (68.7% reported always providing this service), while in regards to more complex systems, such as inhalers and transdermal systems, the results are less consistent. It is worth noting that the highest percentages of responses were recorded in the "sometimes" category. This implies that these practices are not incorporated in professional activities. This is clinically significant because improper use of these systems may impair the effectiveness of treatments.

Another significant aspect is the impact of continuing professional education and experience as independent factors related to high levels of knowledge ($p < 0.001$). It has been noticed that the participation of pharmacists in continuing educational programs is significantly related to high levels of competence. This is another important aspect, which indicates the significance of continuous professional development in relation to the maintenance of high levels of knowledge about modern pharmaceutical technologies.

In general, the above findings show that although the theoretical background and positive attitudes are well established, the standardization of professional practices and the strengthening of competencies are the main challenges related to the effective integration of DDS and MR formulations in community pharmacy practice.

Conclusion

This study reveals that community pharmacists in the territory of North Macedonia have a moderate to good level of knowledge in theory about advanced drug delivery systems and modified release drug products, and a high level of appreciation for the importance of these drug products.

However, there are certain aspects that need to be improved in relation to the counseling of patients on the proper use of these drug products. This may be due to traditional practice, as these services are traditionally considered the role of medical specialists and not community pharmacists. The recent changes in the legal framework, giving community pharmacists additional competencies, put them in front of new responsibilities for which they may not be well prepared.

The findings of this study emphasize the importance of specialized training, especially with regard to pharmacists' skills in the effective delivery of patient counseling on the appropriate use of such formulations. The incorporation of such services in routine community pharmacy

practice is expected to contribute to the effectiveness of treatment, which is in line with the main goal of optimization of treatment and adherence.

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