BMIJ
ISSN: 2148-2586

bmij (2025) 13 (2):858-878
doi: https://doi.org/10.15295/bmij.v13i2.2599

Research Article

Prioritisation of criteria in hospital medication management with the analytical hierarchy process

Analitik hiyerarşi süreci ile hastane ilaç yönetiminde kriterlerin önceliklendirilmesi

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Abstract

This study aims to identify and prioritise the key criteria that affect decision-making processes in hospital medication management. For this purpose, the Analytic Hierarchy Process (AHP), a multi-criteria decision-making method, was employed. Data were collected through a survey conducted with 21 expert pharmacists working in public and private hospitals. The criteria were determined through a systematic literature review and expert consultations. Five main criteria—safety, medication preparation and distribution, storage and inventory management, personnel training and competence, and technology and information systems—were evaluated using pairwise comparisons. As a result of the analysis, safety (0.34686) was identified as the highest priority criterion, followed by technology and information systems (0.27019), while storage and inventory management (0.07290) had the lowest priority. At the sub-criteria level, patient safety (0.17004) and data security (0.11909) emerged as the most significant factors. The study's limitation is that it reflects only the perspectives of pharmacists, which may restrict the inclusion of viewpoints from other healthcare professionals. Nevertheless, the study offers original and quantitative findings for pharmaceutical risk management. The results may contribute to hospital administrators in prioritising investments in digital technologies, safety protocols, and personnel development. This study is among the pioneering research that systematically prioritises hospital medication management criteria using the AHP method.

Keywords: Medication Management, Patient Safety, Analytic Hierarchy Process (AHP), Decision-Making, Risk Management

Jel Codes: C44, I18, L65

Submitted: 15/05/2025

Revised: 12/06/2025

Accepted: 23/06/2025

Online Published: 25/06/2025

Öz

Bu çalışma, hastane ilaç yönetiminde karar verme sürecini etkileyen temel kriterleri belirleyip önceliklendirmek amacıyla gerçekleştirilmiştir. Bu amaçla, çok kriterli karar verme yöntemlerinden Analitik Hiyerarşi Süreci (AHS) kullanılmıştır. Veriler, kamu ve özel hastanelerde görev yapan 21 uzman eczacıdan anket yöntemiyle elde edilmiştir. Kriterler sistematik literatür taraması ve uzman görüşleri doğrultusunda belirlenmiştir. Güvenlik, ilaç hazırlama ve dağıtımı, depolama ve envanter yönetimi, personel eğitimi ve yetkinliği ile teknoloji ve bilgi sistemleri olmak üzere beş ana kriter ikili karşılaştırmalar yöntemiyle değerlendirilmiştir. Analiz sonucunda güvenlik (0.34686) en yüksek önceliğe sahip kriter olarak belirlenmiş, onu teknoloji ve bilgi sistemleri (0.27019) izlemiş; depolama ve envanter yönetimi (0.07290) ise en düşük önceliği almıştır. Alt kriterler arasında hasta güvenliği (0.17004) ve veri güvenliği (0.11909) öne çıkmıştır. Çalışmanın yalnızca eczacıların görüşlerine dayalı olması, farklı sağlık profesyonellerinin bakış açılarını yansıtma açısından sınırlılık oluşturmaktadır. Bununla birlikte, çalışma farmasötik risk yönetimine ilişkin özgün ve nicel bulgular sunmaktadır. Elde edilen sonuçlar, hastanelerin dijital teknolojiler, güvenlik protokolleri ve personel gelişimine yönelik yatırımlarını önceliklendirmelerine katkı sağlayabilir. Bu çalışma, AHS yöntemi kullanılarak hastane ilaç yönetiminde kriterlerin sistematik önceliklendirilmesine yönelik yapılan öncü araştırmalardan biridir.

Anahtar Kelimeler: İlaç Yönetimi, Hasta Güvenliği, Analitik Hiyerarşi Süreci (AHS), Karar Verme, Risk Yönetimi

JEL Kodları: C44, I18, L65

Citation: Kalender, S., Prioritisation of criteria in hospital medication management with the analytical hierarchy process, bmij (2025) 13 (2): 858-878, doi: https://doi.org/10.15295/bmij.v13i2.2599

Introduction

The medication management process involves ensuring the safe use of medicines at various stages, including procurement, storage, ordering, transfer, administration, and monitoring of drugs (Tanık, Sarıbay and Baba, 2018). This process, which encompasses all steps from obtaining the drug to administering it to the patient, directly impacts the quality of health services (Yiğit and Oral Kara, 2019). The medication management process in hospitals is crucial for patient safety and treatment efficacy, as medication errors during this process can pose serious risks to patient health (Epstein, Gratch and Grunwald, 2007; Tanık et al., 2018). In hospitals, multiple steps are involved in preparing medicines before they are administered to patients, which increases the likelihood of errors. While most medication errors are minor, some can lead to adverse drug events (ADEs) resulting in significant costs and even death (Johnson, 2016; Perras et al., 2010; Uzun and Arslan, 2008). Specifically, errors during drug procurement, administration, and monitoring of effects on the patient jeopardise patient safety and raise mortality and morbidity rates (Epstein et al., 2007).

A medication error is defined as a preventable event that harms the patient or results in the incorrect administration of medication, despite being under the control of healthcare professionals, patients, or manufacturers (Tanık et al., 2018). Reports from health authorities indicate that medication safety-related errors account for 18-20% of all medical errors, with the most harm caused during the administration of drugs (Sağlık Bakanlığı, 2015). To minimise errors in drug administration, eight basic principles must be followed: correct patient, correct drug, correct dose, correct time, correct route, correct drug form, correct record, and correct response (Aygin and Cengiz, 2011). However, even with these principles in place, a small error at any stage of the medication flow process can jeopardise patient and employee safety. For instance, if a physician misspells the pharmaceutical form of a medication when requesting a purchase, the wrong medication may be administered. Similarly, mishandling drugs in terms of temperature and storage conditions can harm the patient and disrupt the treatment process (Sağlık Bakanlığı, 2015; Erciyes Üniversitesi Sağlık Uygulama ve Araştırma Merkezi, 2022).

To prevent such errors, a systematic approach is necessary in medication management processes. Different methods and interventions must be combined to achieve successful outcomes (Kalender and Özkan, 2024). Healthcare personnel involved must understand the importance of medication safety and remain vigilant throughout the process. The medication management process in hospitals is crucial for ensuring patient and medication safety. Identifying and prioritising critical aspects of the process is essential for effective management. The Analytic Hierarchy Process (AHP), a multi-criteria decision-making technique developed by Saaty (2008), is commonly used to structure decision-making processes in the healthcare sector (Vaidya and Kumar, 2006; Doğan and Akbal, 2019). AHP is preferred for managing hospital processes as it allows for modelling different stakeholders' perspectives, integrating quantitative and qualitative criteria, and facilitating easy combination with other methods (Erbay and Akyürek, 2020). This study aims to identify and prioritise critical criteria in the medication management process of hospitals using the AHP method. These criteria, once determined, will guide decision-makers in enhancing the effectiveness of medication management processes. The methodology section provides detailed information about the technique used in this study.

Literature review

There is an extensive body of literature that examines the management processes of hospitals from various aspects and evaluates them using different methods. However, there is no direct study that prioritises the effective factors in the pharmaceutical management processes of hospitals with the AHP method. Nevertheless, various studies are using the AHP method in different fields such as hospital management, pharmaceutical supply chain, risk management and health information systems (Hussain and Subramoniam, 2014; Alharthi, Sultana, Al-Amoudi and Basudan, 2015; Elahi et al., 2017; Doğan and Akbal, 2019; Silva and Mattos, 2019; Böker and Çetin, 2020; Uslu, Hancıoğlu, Yılmaz and Kedikli, 2022). Hospital management is a critical issue, not only in terms of operational efficiency, but also in terms of patient safety and cost control. Therefore, AHP, one of the multi-criteria decision-making techniques, is a widely used method for optimising healthcare services. AHP analyses complex decision-making processes in a hierarchical structure and reveals the relative importance of criteria and sub-criteria. It is a powerful tool in risk management and strategic decision-making processes, especially in hospitals. For example, Uslu et al. (2022) evaluated risk management in hospitals from the perspective of health managers using the AHP method. In the study, managers' perceptions of risk management were examined, and the most critical risk factors were determined through prioritisation using the fuzzy AHP method. This study demonstrates that the AHP method is a highly effective tool for structuring risk management processes in hospitals. The AHP method is not only limited to risk management but is also used in the optimisation of management processes and the determination of success factors in

hospitals. For example, Doğan and Akbal (2019) used the AHP method to select the most suitable medical equipment suppliers in a university hospital. The study revealed that quality, cost, and delivery times play a critical role in supplier selection. Böker and Çetin (2020) combined the ABC-VED, AHP, and TOPSIS methods for inventory classification in the healthcare sector, evaluating factors such as cost, consumption, criticality, and supplier risk. This study has made significant contributions to the identification and management of critical drugs by providing a more holistic approach to pharmaceutical inventory management in hospitals. Similarly, various studies that utilise the AHP method as a decision support mechanism in hospital management processes reveal that this method is an effective tool for identifying critical success factors. For example, Silva and Mattos (2019) identified and prioritised the critical success factors required for the adoption of a traceability system in the pharmaceutical supply chain using the AHP method. In the study, the importance of traceability in pharmaceutical management processes was emphasised by identifying 18 critical success factors, which consisted of technological, organisational, and environmental factors. Additionally, the study reveals that technological infrastructure plays a crucial role in the pharmaceutical supply chain. Elahi et al. (2017) identified and ranked the factors influencing the selection of pharmaceutical products using the AHP method. In the study, "quality" was identified as the most crucial factor. Hussain and Subramoniam (2014) identified the critical success factors of pharmaceutical management information systems using the AHP method and analysed the importance of these factors. The study emphasises that the factors affecting the adoption and use of pharmaceutical information systems should be evaluated in a hierarchical structure. Similarly, Alharthi et al. (2015) ranked the critical success factors for implementing pharmacy barcode systems in hospitals using the AHP method and analysed the importance of these factors. The study emphasises that issues such as patient safety, workflow efficiency, and the reduction of error rates are critical for the success of technological integration in medication management.

The existing literature strongly suggests the importance of using the AHP method in hospital management processes. The AHP method is widely used as a decision support mechanism in hospitals, especially in areas such as risk management, inventory control, supply chain optimisation and technological integration. The AHP method stands out as a powerful decision support tool for identifying and prioritising critical factors in hospital pharmaceutical management processes. AHP enables strategic decisions to be made in various areas such as the adoption of health management information systems, the implementation of pharmacy barcode systems and the integration of drug traceability systems. This method guides decision-making processes in critical areas such as pharmaceutical supply chain management, inventory control and patient safety. However, there is no comprehensive study in the literature directly addressing which criteria are decisive or critical in the hospital medication management process and how to prioritise them. In this context, the main contribution of this study is to identify the essential factors of hospital medication management processes and systematically prioritise these factors using the AHP method. In this way, evidence-based decision-making processes for improving medication management processes in hospitals will be supported.

Materials and methods

The medication management process in hospitals is a complex and error-prone system that includes stages such as prescribing, ordering, dispensing, tracking, and administration. Effective management of this process is crucial for ensuring patient safety and operational efficiency. In this context, the purpose of this study is to identify the critical criteria in the medication management process of hospitals and prioritise these criteria according to their importance using the AHP method. AHP is a widely used method in multi-criteria decision-making processes, allowing decision-makers to evaluate and prioritise various criteria systematically. Below, the definition, theoretical background, and method steps of the AHP method are detailed.

Fundamentals and application features of the Analytic Hierarchy Process

AHP is one of the multi-criteria decision-making methods (Vaidya and Kumar, 2006). This method is a measurement theory used to evaluate measurable and intangible criteria, taking into account quantitative data as well as people's experiences and knowledge in the decision-making process. In this respect, it employs an approach that incorporates both objective and subjective decisions, integrating quantitative and qualitative factors (Vargas, 1990; Badri, 1999; Ömürbek and Tüter, 2020). Since its development, AHP has become one of the most widely used multi-criteria decision-making tools by decision-makers and researchers. One of the most essential features of this method is its flexibility in being integrated with various techniques, such as linear programming, fuzzy logic, and quality function deployment. In this way, users can manage their decision processes more systematically and effectively

by utilising the advantages of different methods (Vaidya and Kumar, 2006). AHP allows complex problems to be analysed systematically by placing them in a hierarchical structure. This process enables the evaluation of criteria and sub-criteria in an ideal ranking, facilitating the decision-maker's consideration of a large number of quantitative and qualitative factors within a structured system (Badri, 1999). One of the most essential advantages of AHP is its ability to control and reduce inconsistencies in expert judgments. This method minimises bias in the decision-making process and allows consensus to be achieved through the geometric mean of individual judgments (Aminbakhsh et al., 2013).

The theoretical background of AHP

AHP is carried out in three stages: hierarchical design, pairwise comparison, and consistency check (Wind and Saaty, 1980). This process enables decision-makers to address complex problems within a structured framework and identify the most suitable option. In the first stage, hierarchical design, a complex decision problem is typically modelled as a simple hierarchical structure by dividing it into sub-problems, each of which can be analysed independently (Vargas, 1990; Badri, 1999; Aminbakhsh, Gunduz and Sonmez, 2013). The hierarchical structure is a system that aims to understand the interactions between the components of the problem and examine how these interactions affect the overall system. This process simplifies the problem and makes it easier for decision-makers to analyse (Saaty, 1977). The design of the hierarchical structure is a process that requires expertise in decision-making and is based on the experience and knowledge of decision-makers. Therefore, decision-makers can work together to reach consensus both in designing the hierarchy and in the evaluation process (Vargas, 1990; Badri, 1999). The design process begins with defining the fundamental problem, and then a hierarchical structure is created by identifying the main criteria and their corresponding sub-criteria (Saaty, 1990; Saaty, 1994). The requirements in the hierarchical structure are determined based on the knowledge and experience of the decision-makers, and various methods, such as detailed literature reviews and expert opinions, are utilised at this stage (Saaty, 1977; Çavmak, Çavmak and Özeltürkay, 2024).

After the hierarchical structure is established, the second stage is the pairwise comparison process. In this stage, the criteria are compared in pairs based on the decision-maker's judgment, and a pairwise comparison matrix is created for each level. Through this method, the relative importance of the criteria is determined (Saaty, 2008). Pairwise comparisons are made using a specific scale (see Table 1), and the relative importance of the criteria is evaluated on a scale ranging from 1 to 9 (Saaty, 1990). This scale covers the entire spectrum of comparisons and includes 1/9 for the least critical criteria, 1 for equally essential criteria, and 9 for the most important criteria (Vaidya and Kumar, 2006; Bolayır and Ölmezoğlu-İri, 2023).

Table 1: AHP Scale for Comparisons

Intensity of importance	Definition	Verbal explanation
1	Equal importance	Two elements contribute equally to the purpose
3	Moderate importance	Experience and personal assessments favour one element slightly over another.
5	Strong importance	Experience and personal assessments often favour one element over another.
7	Very strong importance	One element is strongly favoured, and its dominance is demonstrated in practice.
9	Extreme importance	The evidence favouring one element over another appears indisputable
2, 4, 6, and 8	Values for intermediate comparison	The evaluation falls between two levels
Reciprocals (1/x)		A value attributed when element "i" is compared to element "j" becomes the reciprocal when "j" is compared to "i"

Source: Saaty, 1990; Saaty, 2008

In the pairwise comparison stage, the relative importance of the criteria is determined based on the scale presented in Table 1 (Saaty, 1990; Saaty, 2008). During this stage, a separate pairwise comparison matrix is created for each decision maker's evaluation. When comparing alternative Ai and alternative Aj, the individual preference of expert k is represented by the term aijk. The experts' overall judgment is then calculated using the geometric mean method and integrated into matrix A (Aminbakhsh et al., 2013).

This process enhances consistency in the decision-making process by combining individual evaluations and contributes to the development of a collective evaluation structure.

(1) $\left(a_{ij}\right)_{nxn} = \sqrt[n]{a_{ij1}Xa_{ij2}Xa_{ij3}X\ldots Xa_{ijn}}$

In formula (2) below, "n×n" represents the total number of criteria used in the comparison. The columns of the matrix are denoted by "i" and the rows are denoted by "j". Here, the term "aij" refers to the pairwise comparison value between criterion i. and criterion j. (Eraslan and Algün, 2005; Aminbakhsh et al., 2013).

(2) $A = \begin{pmatrix} a_{11} & a_{21} & \cdots & a_{1n} \\ a_{21} & a_{22} & \ddots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$

After the judgment matrix A is created, the normalisation stage is started. At this stage, a normalised matrix is made to compare the weights between the criteria more consistently. The normalised matrix is obtained by dividing the elements in each column by the sum of the elements in that column (Çavmak et al., 2024).

(3) $a'_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij}$

Following normalisation, the eigenvector (w) is calculated by averaging each row. The eigenvector is also referred to as the relative importance vector. The resulting eigenvector matrix determines the relative importance level of each factor and represents the weights used in the decision process (Eraslan and Algün, 2005; Çavmak et al., 2024).

(4) $w_i = \left(\frac{1}{n}\right) \sum_{i=1}^{n} a'_{ij}$

In the final stage, consistency analysis evaluates the consistency of the comparisons. At this stage, the Consistency Ratio (CR) and Consistency Index (CI) proposed by Saaty (1990) are calculated using the maximum eigenvalues derived from the eigenvectors of the comparison matrix (Aminbakhsh et al., 2013; Lan, 2021). The CR value is a measure that determines the level of acceptability of the pairwise comparisons made by the participants and is generally expected to be 10% or less (Saaty, 1990). To calculate the CR, the CI must be calculated first. CI is calculated by subtracting the number of criteria (n) from the maximum eigenvalue (λmax) of the comparison matrix and dividing the resulting value by the number of criteria minus one (Lan, 2021; Çavmak et al., 2024).

(5) $CI = \lambda max - n/\mathrm{n} - 1$

CR is calculated by dividing the CI by the Random Index (RI) values. The RI values used in this study were derived by Saaty (2008) and represent the average consistency indices obtained from randomly generated pairwise comparison matrices depending on the number of criteria (Esen and Yiğit, 2021; Lan, 2021) (see Table 2). If inconsistencies are detected as a result of these calculations, decisions should be reviewed and comparisons should be repeated (Saaty, 1990).

(6) $CR = \frac{CI}{RI}$

Table 2: Random Index (RI) Values

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0.58	0.89	1.11	1.25	1.35	1.40	1.45	1.49	1.52	1.54	1.56	1.58	1.59

Source: Saaty, 2008

Ethical considerations

Ethical approval for this study was obtained from the Social and Human Sciences Ethics Committee of OSTIM Technical University, with the decision dated 13/12/2024 and numbered 25571. Potential participants were informed through the survey form that their participation was voluntary, and the collected data would be used solely for scientific purposes.

Application

In this study, the AHP method, one of the multi-criteria decision-making methods, was utilised to prioritise the critical factors in hospitals' medication management process. To begin, a comprehensive literature review was conducted to identify the essential factors that impact the medication management process. Additionally, input was sought from three expert pharmacists working in hospitals to validate the findings from the literature. Based on the literature review and expert evaluations, the main and sub-criteria to be considered in the study were determined. The main criteria

were categorised into five main areas: (1) safety, (2) medication preparation and distribution, (3) storage and inventory management, (4) training and competence, and (5) technology and information systems. Four sub-criteria were identified under each main criterion, resulting in a total of 25 criteria being evaluated. The research model, which showcases the main and sub-criteria identified in the study, is presented in Figure 1. Additionally, Table 3 provides the definitions and explanations of the sub-criteria.

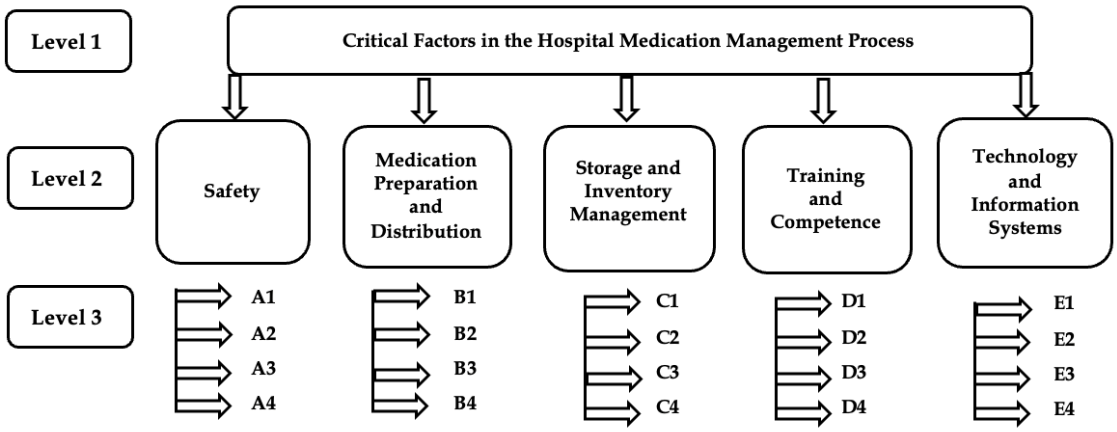

Figure 1: Research Model for Prioritising Criteria in the Hospital Medication Management Process

Source: Created by the author.

Table 3: Main and Sub-Criteria Descriptions in Hospital Medication Management

Main Criteria	Sub-Criteria	Explanation
(A) Safety	Patient Safety (A1)	Ensuring that patients receive the correct medication in the correct dose, at the proper time, and via the correct route.
	Drug Interactions (A2)	Monitoring potential drug interactions to prevent adverse effects.
	Side Effect Management (A3)	Informing patients about potential side effects and systematically monitoring their occurrence.
	Patient Identification (A4)	Securing patient identification processes to ensure accurate drug administration.
(B) Medication Preparation and Distribution	Dosing (B1)	Preventing incorrect dosage preparation and ensuring accurate medication administration.
	Labelling (B2)	Ensuring that medications are properly labelled and packaged with clear and comprehensible instructions.
	Transportation (B3)	Maintaining safe transportation of medications, especially those requiring a cold chain, under appropriate temperature and humidity conditions.
	Distribution (B4)	Ensuring medications are delivered to the correct patient, in the correct quantity, and at the proper time.
(C) Storage and Inventory Management	Storage Conditions (C1)	Providing appropriate storage based on factors such as temperature and humidity.
	Expiration Date Management (C2)	Regularly monitoring and managing medications approaching expiration.
	Stock Monitoring (C3)	Maintaining optimal stock levels to prevent shortages or overstocking.
	High-Risk Medication Storage (C4)	Storing high-risk and narcotic drugs in locked and secure areas.
(D) Training and Competence	Staff Training (D1)	Providing regular training on medication management processes.
	Competence Assessment (D2)	Assessing staff competencies in medication management.
	Error Reporting (D3)	Recording and reporting errors in medication management.
	Side Effect Management Training (D3)	Ensuring staff are adequately trained on the side effects of medication.
(E) Technology and Information Systems	Data Security (E1)	Ensuring the security of patient information and preventing unauthorised access.
	System Alerts and Error Controls (E2)	Enhancing the effectiveness of system alerts for dosage accuracy, drug interactions, and patient identity verification.
	Electronic Prescription System (E4)	Preventing incorrect prescription entries through electronic systems.
	Medication and Inventory-Tracking Software (E4)	Ensuring accuracy and efficiency in medication and stock management through specialised software.

Source: The classification and prioritisation of factors in hospital medication management were synthesised from the existing literature (Cain and Haque, 2008; Hughes and Blegen, 2008; Powell-Cope, Nelson and Patterson, 2008; Sağlık Bakanlığı, 2015; Silva and Mattos, 2019; Wondmieneh, Alemu, Tadele and Demis, 2020; Justinia et al., 2021; Kalender and Özkan, 2024; Xiao et al., 2025) and structured in Table 3.

* Additionally, preliminary expert opinions from senior hospital pharmacists were incorporated to refine and validate the criteria.

After creating the research model, the pairwise comparison of criteria began based on the judgment of decision-makers. In this process, the main and sub-criteria were ranked according to their importance using comparison forms. These rankings were carried out based on the weights determined on a 1-9 scale developed by Saaty (1990). The comparison forms were prepared as questionnaires on Microsoft Word 365 and transferred to Google Forms for ease of access, implementation, and participation.

The number of participants in AHP applications varies depending on the study's purpose, scope, and context. Melillo and Pecchia (2016) stated that the appropriate sample size for AHP-based surveys can range from 19 to 400, depending on the expected weights of alternatives, the margin of error, and the alpha level. Therefore, the goal was to reach 20 expert pharmacists with at least one year of experience using the snowball sampling method. Although the initial target was 20 participants, an additional eligible pharmacist completed the questionnaire through referral. As Ting, Memon, Thurasamy and Cheah (2025) noted, such slight deviations from the planned sample size are standard in snowball sampling, making it challenging to predict the final number of respondents.

Snowball sampling is a method used to investigate populations that are difficult to reach or have specific characteristics. In this method, existing respondents suggest other potential respondents who are suitable for the study. Snowball sampling is recognised as an effective data collection method, especially in small and dispersed populations that require expertise. It is widely used in the social sciences and is preferred in studies that require examining hard-to-reach or sensitive groups with specific expertise (Biernacki and Waldorf, 1981). In this cross-sectional and descriptive study, data collection took place between January 2, 2025, and January 10, 2025, via Google Forms. The study, conducted voluntarily, involved 21 specialised pharmacists working in public and private hospital pharmacies.

Participants were given a pairwise comparison questionnaire based on the central and sub-criteria presented in Figure 1. The data from the questionnaires were transferred to Microsoft Excel for analysis following the steps of the AHP method, and the importance levels of the criteria were determined. After creating pairwise comparison matrices for each stage of the hierarchy, the remaining steps of the AHP process were followed. First, the normalisation stage was completed, followed by the calculation of eigenvectors (w). The consistency check stage was then initiated to evaluate the consistency of the comparisons. In this stage, the Consistency Index (CI) and Consistency Ratio (CR) were calculated, and the decision matrix was created. Consistency opinions <10% were accepted, and the criteria weights were determined. The results are detailed in the findings section.

Participants were given a pairwise comparison questionnaire based on the central and sub-criteria presented in Figure 1. The data collected were entered into Microsoft Excel and analysed following the steps of the AHP. For each level of the hierarchy, pairwise comparison matrices were created, followed by normalisation and the calculation of priority vectors (eigenvectors, w). Subsequently, consistency checks were performed to assess the logical coherence of expert judgments. Individual consistency ratios (CR) were calculated for all participants. All individual CR values ranged between 0.02 and 0.10, with an average of 0.07. All were below the acceptable threshold of 0.10, confirming the internal consistency of expert judgments. Therefore, all responses were retained for analysis. The findings are presented in the results section.

Results

In the study, critical criteria in hospital medication management processes were identified using the AHP method, and the importance weights of these criteria were calculated. The relative importance levels of the main and sub-criteria obtained as a result of the research are systematically analysed and presented in detail in Table 5. Additionally, the descriptive characteristics of the expert pharmacists participating in the study were analysed, and the demographic data of the participants, including their professional experience, working areas, and specialisation levels, are presented in Table 4.

Table 4: Demographic and Professional Characteristics of Participants

Identifying Information		**n**	**%**
Profession	Expert Pharmacist	21	100
Years of Professional Experience	1 year	4	19.05
	2 to 5 years	8	38.10
	6 to 10 years	7	33.33
	11 to 20 years	1	4.76
	Over 20 years	1	4.76
Years of Experience in the Institution	1 year	6	28.57
	2 to 5 years	12	57.15
	6 to 10 years	1	4.76
	11 to 20 years	1	4,76
	Over 20 years	1	4.76
Is the institution's medication management process fully digitalised?	Yes	7	33.33
	No	14	66.67
Electronic applications and systems used in the institution's medication management process	Electronic Prescribing System (e-Prescribing)	21	100
	Clinical Decision Support System (CDSS)	10	47.62
	Computerised Physician Order Entry (CPOE) Electronic	10	47.62
	Medication Administration Records (eMAR)	8	38.10
	Closed-loop Medication System (CLMS)	7	33.33
	Automated Medication Dispensing Systems (e.g., Argus, Pyxis)	7	33,33
	Barcoding or Radio Frequency Identification (RFID) Systems	7	33.33
	Drug Tracking System	21	100
	Data Security, Analytics, and Reporting System	2	9.52
	Patient Tracking Software	1	4.76

Source: Author's compilation based on survey responses (2025).

When examining Table 4, it is evident that 19.05% of pharmacists have 1 year of experience, 38.10% have 2-5 years, 33.33% have 6-10 years, 4.76% have 11-20 years, and 4.76% have more than 20 years of experience. It was found that 57.15% of specialist pharmacists have been working in the same institution for 2-5 years. Additionally, 33.33% of pharmacists stated that the medication management processes in their workplace are fully electronic, while 66.67% mentioned that the process is not fully digitalised. All pharmacists reported using e-Prescribing and the Drug Tracking System (DTS) in the hospitals where they work. However, 47.62% reported using systems such as clinical decision support systems (CDSS) and computerised physician order entry (CPOE), while 38.10% reported using electronic medication administration records (eMAR). Among pharmacists who reported fully electronic medication management processes in their hospitals, 9.52% mentioned using the Data Security, Analytics, and Reporting System (DSAS), and 4.76% reported using Patient Tracking Software (PMS). This indicates that while some hospitals have achieved full automation in their medication management processes, the use of digital solutions for data security and patient tracking remains limited.

Upon examining Table 5, it is revealed that, according to the opinions of 21 expert pharmacists, the most essential criteria in the medication management processes of hospitals are grouped under five main categories: "safety", "medication preparation and distribution", "storage and inventory management", "training and competence", and "technology and information systems". These criteria were evaluated using the pairwise comparison method and ranked based on their importance. The most significant main criterion was "safety" with a weight score of 0.34686, followed by "technology and information systems" with a weight score of 0.27019. The third criterion was "medication preparation and distribution," with a weight score of 0.19692. "Staff training and competence" was the fourth criterion, with a weight score of 0.11313, and "storage and stock management" was the last, with a weight score of 0.07290.

The sub-criteria under the main criteria in the hospital medication management process were ranked based on expert evaluations. The ranking results are presented in Table 6. The sub-criteria were ranked using two different approaches. First, each main criterion was assessed individually, and the sub-criteria were ranked according to their assigned weights. In this ranking, "patient safety" (0.49022) was the most significant sub-criterion under the main criterion "safety," whereas "side effect management" (0.12025) had the lowest importance. Within the main criterion "medication preparation and distribution," "dosing" (0.35670) was the highest-ranked sub-criterion, while "labelling" (0.14247) held the lowest priority. In the main criterion "storage and inventory management," "high-risk medication storage" (0.47238) was identified as the most critical sub-criterion, whereas "stock monitoring" (0.12231) had the lowest significance. In the main criterion "training and competence," "error reporting" (0.35670) emerged as the most critical factor, while "staff training" (0.14817) was the least prioritised sub-criterion. Finally, under the main criterion "technology and information systems," "data security" (0.44077) was

found to be the most crucial sub-criterion, while "medication and inventory-tracking software" (0.11729) ranked lowest.

In the second ranking, all sub-criteria were evaluated collectively without distinguishing among the main criteria. As a result, the five sub-criteria with the highest priority in the medication management process were identified as "patient safety" (0.17004), "data security" (0.11909), "patient identification" (0.08648), "system alerts and error controls" (0.08343) and "dosing" (0.07787). On the other hand, "stock monitoring" (0.00891) was the least essential sub-criterion among all. These findings emphasise the importance of patient-centred and technology-driven priorities in hospital medication management. The focus on patient safety, accurate identification, and systematic error controls highlights the critical need to prevent medication-related harm. Additionally, the high ranking of data security and dosing underscores the growing significance of digital infrastructure and precise pharmacological practices. On the other hand, the relatively low prioritisation of stock monitoring suggests that while inventory oversight is still essential, it may be viewed as less critical compared to direct patient safety and digital control mechanisms.

Table 5: Weighting of Main and Sub-Criteria in Hospital Medication Management Using AHP (Based on 21 Expert Opinions) *

Main	Sub-Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Mean	Percentage
A - Safety	A1 - Patient Safety	0.25000	0.63079	0.71898	0.56469	0.30625	0.59667	0.48197	0.51121	0.48438	0.38750	0.68158	0.41118	0.47889	0.47129	0.51252	0.47402	0.48438	0.49531	0.44243	0.52313	0.38750	0.49022	49.02%
	A2 - Drug Interactions	0.25000	0.15618	0.11895	0.17960	0.14375	0.22915	0.07946	0.08226	0.22396	0.12917	0.16832	0.10724	0.07405	0.09842	0.06572	0.05254	0.22396	0.08093	0.15515	0.19629	0.12917	0.14020	14.02%
	A3 - Side Effect Management	0.25000	0.09759	0.04312	0.10688	0.24375	0.05535	0.06375	0.08579	0.13021	0.17917	0.07505	0.12039	0.08721	0.09233	0.07888	0.08383	0.16146	0.07130	0.16831	0.15165	0.17917	0.12025	12.02%
	A4 - Patient Identification	0.25000	0.11544	0.11895	0.14883	0.30625	0.11882	0.37482	0.32074	0.16146	0.30417	0.07505	0.36118	0.35984	0.33796	0.34288	0.38961	0.13021	0.35246	0.23410	0.12892	0.30417	0.24933	24.93%
B - Medication Preparation and Distribution	B1 - Dosing	0.25000	0.39529	0.18040	0.06060	0.25000	0.32500	0.25000	0.58523	0.41848	0.52001	0.38004	0.38438	0.41129	0.42553	0.66209	0.54403	0.63943	0.58523	0.30417	0.38750	0.34517	0.39542	39.54%
	B2 - Labeling	0.25000	0.39529	0.11222	0.39916	0.25000	0.24167	0.25000	0.06615	0.08120	0.09663	0.06115	0.09688	0.06115	0.04728	0.05499	0.03666	0.04090	0.06615	0.17917	0.12917	0.07610	0.14247	14.25%
	B3 - Transportation	0.25000	0.11787	0.35369	0.30301	0.25000	0.24167	0.25000	0.16437	0.21727	0.18275	0.14751	0.22813	0.14751	0.19541	0.15708	0.14381	0.14356	0.16437	0.12917	0.17917	0.21124	0.19373	19.37%
	B4 - Distribution	0.25000	0.09156	0.35369	0.23722	0.25000	0.19167	0.25000	0.18425	0.28306	0.20061	0.41129	0.29063	0.38004	0.33178	0.12583	0.27550	0.17611	0.18425	0.38750	0.30417	0.36749	0.26317	26.32%
C - Storage and Inventory Management	C1 - Storage Conditions	0.25000	0.25000	0.16667	0.17917	0.22396	0.13616	0.10000	0.15923	0.22396	0.29771	0.22370	0.25840	0.31244	0.43202	0.21875	0.31246	0.41118	0.14883	0.17917	0.36118	0.24451	0.24236	24.24%
	C2 - Expiration Date Management	0.25000	0.25000	0.16667	0.30417	0.16146	0.21652	0.10000	0.14137	0.13021	0.08990	0.07038	0.07913	0.10934	0.08640	0.09375	0.08464	0.36118	0.17960	0.30417	0.10724	0.13599	0.16296	16.30%
	C3 - Stock Monitoring	0.25000	0.25000	0.16667	0.12917	0.13021	0.12277	0.10000	0.15923	0.16146	0.11511	0.07548	0.07178	0.04618	0.09956	0.09375	0.04377	0.12039	0.10688	0.12917	0.12039	0.07647	0.12231	12.23%
	C4 - High-Risk Medication Storage	0.25000	0.25000	0.50000	0.38750	0.48438	0.52455	0.70000	0.54018	0.48438	0.49729	0.63043	0.59069	0.53204	0.38202	0.59375	0.55913	0.10724	0.56469	0.38750	0.41118	0.54304	0.47238	47.24%
D - Training and Competence	D1 - Staff Training	0.10263	0.25000	0.09740	0.08318	0.11354	0.08670	0.71648	0.06164	0.21727	0.14137	0.08239	0.17456	0.13951	0.04309	0.10089	0.08185	0.06533	0.17917	0.08640	0.10895	0.17917	0.14817	14.82%
	D2 - Competence Assessment	0.10263	0.25000	0.52656	0.16074	0.17604	0.25849	0.09072	0.06164	0.08120	0.08185	0.14192	0.11140	0.26004	0.12212	0.11875	0.14137	0.09418	0.12917	0.09956	0.11630	0.12917	0.15494	15.49%
	D3 - Error Reporting	0.39737	0.25000	0.18802	0.39887	0.37188	0.37548	0.09640	0.32855	0.41848	0.43601	0.39380	0.42368	0.05915	0.40603	0.51339	0.43601	0.38136	0.38750	0.38202	0.45919	0.38750	0.35670	35.67%
	D4 - Side Effect Management Training	0.39737	0.25000	0.18802	0.35721	0.33854	0.27933	0.09640	0.54816	0.28306	0.34077	0.38189	0.29035	0.54129	0.42876	0.26696	0.34077	0.45913	0.30417	0.43202	0.31556	0.30417	0.34019	34.02%
E - Technology and Information Systems	E1 - Data Security	0.25000	0.19167	0.30417	0.16831	0.41118	0.04191	0.67051	0.65852	0.36118	0.24167	0.54877	0.61559	0.58132	0.63256	0.66859	0.38189	0.52936	0.49937	0.54304	0.45919	0.49729	0.44077	44.08%
	E2 - System Alerts and Error Controls	0.25000	0.32500	0.38750	0.44243	0.36118	0.51462	0.19549	0.23148	0.41118	0.32500	0.29999	0.23791	0.25028	0.20701	0.17885	0.39380	0.31480	0.29979	0.24451	0.31556	0.29771	0.30877	30.88%
	E3 - Electronic Prescription System	0.25000	0.24167	0.12917	0.15515	0.12039	0.28644	0.06220	0.05414	0.12039	0.19167	0.07136	0.10589	0.12537	0.11173	0.07628	0.14192	0.10507	0.10567	0.13599	0.11630	0.08990	0.13318	13.32%
	E4 - Medication and Inventory-Tracking Software	0.25000	0.24167	0.17917	0.23410	0.10724	0.15703	0.07179	0.05586	0.10724	0.24167	0.07988	0.04060	0.04303	0.04870	0.07628	0.08239	0.05077	0.09517	0.07647	0.10895	0.11511	0.11729	11.73%
Category	**Main Criteria**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**Mean**	**Percentage**
A	Safety	0.59046	0.59691	0.20918	0.16079	0.24504	0.50356	0.42400	0.07084	0.32475	0.36921	0.40028	0.20527	0.38609	0.37427	0.38135	0.37581	0.16139	0.3455	0.35685	0.42071	0.38179	0.34686	34.69%
B	Medication Preparation and Distribution	0.24153	0.18985	0.13765	0.04803	0.10840	0.04732	0.04379	0.03401	0.0572	0.36921	0.25695	0.36542	0.31062	0.24958	0.20288	0.17496	0.43983	0.2267	0.20604	0.1981	0.22728	0.19692	19.69%
C	Storage and Inventory Management	0.05925	0.08543	0.06181	0.06160	0.07765	0.07083	0.04463	0.39799	0.07826	0.04428	0.06449	0.05023	0.03913	0.04069	0.06332	0.05414	0.05278	0.04948	0.04187	0.05066	0.04233	0.07290	7.29%
D	Training and Competence	0.05371	0.05207	0.16118	0.36666	0.03855	0.19234	0.17040	0.20608	0.04904	0.09868	0.06876	0.1053	0.09674	0.08134	0.1008	0.09381	0.06689	0.10511	0.08369	0.09056	0.09397	0.11313	11.31%
E	Technology and Information Systems	0.05504	0.07574	0.43019	0.36292	0.53036	0.18595	0.31718	0.29108	0.49075	0.11861	0.20951	0.27378	0.16742	0.25411	0.25166	0.30127	0.27911	0.27321	0.31155	0.23997	0.25463	0.27019	27.02%
TOTAL		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%

Source: Author's compilation based on AHP results (2025).

*The detailed prioritisation of main and sub-criteria is presented in Table 5. Due to layout constraints, the table has been inserted as an image in the manuscript. However, the editable Excel version is also provided as a supplementary source file.

Table 6: Ranking of Main and Sub-Criteria Based on AHP Importance Weights

Main Criteria	Sub-Criteria	W	Rank 1*	All Sub-Criteria	W	Rank 2*
Safety	A1 - Patient Safety	0.49022	1	A1 - Patient Safety	0.17004	1
	A2 - Drug Interactions	0.14020	3	E1 - Data Security	0.11909	2
	A3 - Side Effect Management	0.12025	4	A4 - Patient Identification	0.08648	3
	A4 - Patient Identification	0.24933	2	E2 - System Alerts and Error Controls	0.08343	4
Medication Preparation and Distribution	B1 - Dosing	0.39542	1	B1 - Dosing	0.07787	5
	B2 - Labeling	0.14247	4	B4 - Distribution	0.05187	6
	B3 - Transportation	0.19893	3	A2 - Drug Interactions	0.04865	7
	B4 - Distribution	0.26317	2	A3 - Side Effect Management	0.04172	8
Storage and Inventory Management	C1 - Storage Conditions	0.24236	2	D3 - Error Reporting	0.04036	9
	C2 - Expiration Date Management	0.16296	3	B3 - Transportation	0.03918	10
	C3 - Stock Monitoring	0.12231	4	D4 - Side Effect Management Training	0.03847	11
	C4 - High-Risk Medication Storage	0.47238	1	E3 - Electronic Prescription System	0.03597	12
Training and Competence	D1 - Staff Training	0.14817	4	C4 - High-Risk Medication Storage	0.03445	13
	D2 - Competence Assessment	0.15494	3	E4 - Medication and Inventory-Tracking Software	0.03169	14
	D3 - Error Reporting	0.35670	1	B2 - Labeling	0.02806	15
	D4 - Side Effect Management Training	0.34019	2	C1 - Storage Conditions	0.01767	16
Technology and Information Systems	E1 - Data Security	0.44077	1	D2 - Competence Assessment	0.01753	17
	E2 - System Alerts and Error Controls	0.30877	2	D1 - Staff Training	0.01675	18
	E3 - Electronic Prescription System	0.13318	3	C2 - Expiration Date Management	0.01189	19
	E4 - Medication and Inventory-Tracking Software	0.11729	4	C3 - Stock Monitoring	0.00891	20

* Sub-criteria were ranked using two approaches. In the first (Rank by main criterion), sub-criteria were prioritised within their respective main criterion categories. In the second (Overall rank), all sub-criteria were ranked globally based on their total importance weights.

Discussion

This study prioritises critical criteria in the medication management processes of hospitals, providing a comprehensive perspective on the processes. Using the AHP method, the study categorises medication management processes in hospitals into five main areas: "Safety", "Medication Preparation and Distribution", "Storage and Inventory Management", "Training and Competence", and "Technology and Information Systems". The sub-criteria under each main category were compared and prioritised by the expert pharmacists. In the literature, numerous studies have evaluated various hospital processes using the AHP method. Some studies use AHP as a standalone decision-making method, while others combine it with other multi-criteria decision-making techniques. When examining existing studies, topics such as evaluating risk factors in waste management processes of hospitals (Lee, Vaccari and Tudor, 2016; Voudrias, 2016; Thakur and Ramesh, 2017; Esen and Yiğit, 2021), supplier selection, lean management systems, and inventory classifications (Adebanjo et al., 2016; Hussain, Malik and Al Neyadi, 2016; Alakaş, Bucak and Kızıltaş, 2019; Böker and Çetin, 2020) stand out. Additionally, the AHP method is widely used in evaluating service quality and performance criteria in hospitals (Akdağ, Kalaycı, Karagöz, Zülfikar and Giz, 2014; Doğan and Gencan, 2014; Aktaş, Cebi and Temiz, 2015; Alimohammadzadeh, Bahadori and Hassani, 2016; Kıdak, Arslan and Burmaoğlu, 2016; Lupo, 2016; Liao and Qui, 2016; Taş, Bedir, Eren, Alağaş and Çetin, 2018; Derici and Doğan, 2019). Some studies utilise AHP in conjunction with various decision-making techniques for personnel selection in hospitals (Türeli and Davraz, 2019; Esen, Yiğit and Güldan, 2020). Furthermore, studies have evaluated the factors affecting the implementation, adaptation, and adoption of hospital information systems using the AHP (Ahmadi, Nilashi, and Ibrahim, 2014; Ahmadi Rad, Nazari, Nilashi, and Ibrahim, 2015; Nilashi, Ahmadi, Ahani, Ravangard, and bin Ibrahim, 2016). Notably, studies have evaluated the effectiveness of barcode systems in reducing errors in drug distribution processes using the AHP method (Alharthi et al., 2015). Overall, the AHP method focuses on issues such as quality and performance evaluation, as well as the management of medical waste in hospitals. Controlling costs, increasing efficiency, and improving service quality are crucial concepts in today's hospitals, supporting the need for such studies (Erbay and Akyürek, 2020). However, there is no study in the existing literature that prioritises or evaluates in detail the criteria in the medication management processes of hospitals using the AHP method. This gap enhances the original value of the study and makes a significant contribution to the health services

management literature. Additionally, the study's results are expected to inform critical decisions, regulations, and planning for hospital medication management processes.

One of the essential findings of this study is that the top priority main criterion in the medicines management process of hospitals is "safety" with a weight score of 34.7% (normalised). Additionally, among all sub-criteria, the most prioritised criterion was found to be "patient safety" with 17.00%. This result shows that patient safety is of critical importance in medical management processes. Similarly, a study conducted by Uslu et al. (2022) evaluated the risk management of hospitals from the perspective of healthcare managers using the AHP method. In the survey, managers' perceptions of risk management were examined, and risk themes were prioritised using the Fuzzy AHP method. According to the results, the most critical risk factors were identified as "patient safety" with a normalised weight score of 32.8%, "employee safety" with 16.1% and "financial risks" with 11%. These findings suggest that the current study supports the critical role of patient safety in the medicines management process.

There are also various studies evaluating service quality in hospitals with the AHP method. In these studies, factors such as safety, patient orientation and reliability come to the fore (Alimohammadzadeh et al., 2016; Khanjankhani et al., 2016; Shafii et al., 2016; Pekkaya and Imamoğlu, 2017). Patient safety is recognised as a critical element for the quality of hospital services and the effectiveness of health systems. Especially, the prevention of medical errors plays a fundamental role in ensuring patient safety. In this context, the Institute of Medicine's (IOM) report, "To Err is Human: Building a Safer Health System," states that medical errors cause approximately 44,000 to 98,000 deaths in the United States each year. It is emphasised that medication errors cause a significant portion of these deaths. It was also reported that deaths due to medication errors were higher than deaths due to workplace injuries (Institute of Medicine (U.S.) Committee on Quality of Health Care in America, 2000). These findings provide valuable insights into the impact of medication errors on patient safety. The Medication Safety Guideline published by the Ministry of Health in Turkey also supports these findings. According to the report, medication errors account for 18-20% of all medical errors, with the most significant harm resulting from errors that occur during the administration phase of medication (Sağlık Bakanlığı, 2015). National and international reports clearly show that medication errors are one of the most critical factors threatening patient safety.

Darıcı and Yeşilot (2024) emphasised that patient safety in healthcare institutions has become one of the most important issues worldwide, and that medication errors are the most significant risk factor threatening patient safety in healthcare services. Similarly, studies indicate that medication errors are primarily associated with the medication administration process. For example, Silva and Mattos (2019) stated that drug traceability systems directly contribute to patient safety by improving safety in the drug supply chain. In addition, Darıcı and Yeşilot (2024) emphasise that healthcare professionals should be fully aware of medication safety practices in the medication management system to intervene correctly at all stages of the medication flow process. In a study by Yiğit and Oral Kara (2019), it was stated that medication management in hospitals is a critical process not only to ensure patient safety, but also to minimise medication errors and waste, increase efficiency, and reduce costs. The study highlighted that automated medication dispensing systems improve patient safety, reduce medication errors, and minimise medication waste. Furthermore, these systems help keep narcotic drugs under control, optimise the drug supply process by determining the minimum stock level, and reduce error rates. The study by Elleuch, Hachicha, and Chabchoub (2014) presents a multi-stage approach to identifying, assessing, and mitigating risks in the pharmaceutical supply chain of hospitals. Within the scope of the research, an integrated methodology incorporating analytical tools such as Failure Mode and Effects Analysis (FMEA), Design of Experiments (DOE), Discrete Event Simulation (DES), AHP, and Desirability Optimisation is proposed to identify and manage risks in medication management processes. This methodology aims to improve the safety of drug flow and minimise potential disruptions in the supply chain, especially in hospital pharmacies. The study identified three main risk factors in the hospital pharmaceutical supply chain: non-compliance in procurement processes, staff shortages, and medicines reaching shelf life limits. Failure to manage these risks can result in delays and errors that directly compromise patient safety. Therefore, the safety of drug management processes in hospitals is a critical factor not only for patient health but also for the sustainability and operational efficiency of the healthcare system. Identifying risks in advance and developing preventive strategies ensures the efficient use of resources and guarantees the continuity of healthcare services. In line with these findings, the identification of "safety" as the most prioritised main criterion and "patient safety" as the most critical sub-criterion of medication management in hospitals is consistent with previous studies. It supports patient safety-oriented approaches in the literature.

In this study, "stock monitoring" was found to be the least essential main criterion in the pharmaceutical management processes of hospitals. There may be several reasons why this criterion has the lowest priority. Firstly, all of the pharmacists participating in the study reported that the drug tracking system (ITS) is used within the scope of electronic medication management systems (EMMS) in the hospitals where they work. The Pharmaceutical Tracking System (ITS) was developed by the Ministry of Health in Turkey to monitor the entire process of medicines, from production to delivery to patients, and to ensure the safety of these medicines. It has been implemented throughout the country since 2010 to prevent drug counterfeiting, illicit drug trade, and ensure drug safety. ITS is utilised by health institutions, including manufacturers, importers, pharmaceutical warehouses, pharmacies, and hospitals, to ensure traceability, particularly for medication tracking and stock monitoring, across all stages of medicines management.

Through ITS integration, hospitals secure their pharmaceutical procurement processes, enable stock management, and ensure the safe delivery of medicines to patients. It also helps prevent drug waste and misuse by maintaining drug records and verifying the authenticity of drugs (Yorulmaz, Malçok Altunkan, Yasemin and Keleş, 2012; TITCK, 2019). Pharmacists may have evaluated the stock monitoring criterion as less critical due to the long-term use of ITS in hospitals. The established culture of drug tracking and stock management in hospitals, created by over 15 years of ITS system use in Turkey, could also contribute to the low prioritisation of this criterion. Additionally, the continued use of manual methods by pharmacists in many hospitals to track stocks, especially in small-scale hospitals or institutions with staff accustomed to manual processes, may be a common practice. A study conducted by Karaca and Kıran (2016) reported that pharmacists working in hospital pharmacies spend most of their working hours on routine and tiring tasks such as drug distribution and stock control. The study also revealed that three-quarters of pharmacists expressed a desire to provide drug counselling to physicians and perform clinical pharmacy roles, rather than traditional pharmacy roles. This desire may explain why pharmacists consider the stock monitoring process a less prioritised criterion.

It is possible that stock and inventory monitoring have become less of a priority in hospitals due to the adoption of modern inventory management approaches. For example, the Just-In-Time (JIT) production model and lean management systems ensure that materials are available when needed, reducing the need to hold stock and minimising storage costs. Balkhi, Alshahrani and Khan (2022) reported that JIT practices in healthcare improve patient outcomes by reducing waste and non-value added activities. Lanza-León, Sánchez-Ruiz, and Cantarero-Prieto (2021) found that lean management techniques, such as Kanban, reduce inventory holding rates and increase employee satisfaction. These factors may explain pharmacists' tendency to rate the stock monitoring criterion as less critical. Although "storage and inventory management" was identified as the lowest-priority main criterion, the most crucial sub-criterion within this category was "high-risk medication storage." This finding reflects the pharmacists' sensitivity to high drug safety standards, even within domains considered less critical overall, such as stock and inventory management. Mansur's (2016) study reveals that high-risk medicines have the potential to cause serious adverse effects when misused and therefore constitute one of the main focal points of medicines safety strategies. Accordingly, pharmacists must take an active role in managing medication processes to ensure the safe storage, distribution, and administration of high-risk medications. In this context, developing strategic plans to reduce medication errors and fostering a culture of medication safety in hospitals are among the primary responsibilities of pharmacists. Therefore, according to the study's findings, pharmacists prioritising the storage of high-risk medicines as a priority issue aligns with their responsibilities to ensure patient safety. However, when all sub-criteria were ranked collectively based on their global weights, this sub-criterion was found to rank 13th. This suggests that, although it holds relative importance within its category, it is not perceived as a top priority across the entire medication management process.

As a result of the study, it was determined that technology and information systems are the second most critical main criteria in the medication management processes of hospitals. Within this criterion, the sub-criteria "data security", "patient identification", and "system alerts and error control mechanisms" were found to have the highest priority. Technology and information systems play a crucial role in medication management processes, reducing error rates, ensuring patient safety, and enhancing operational efficiency. EMMS help prevent medication errors by automating processes such as prescribing, dispensing, and administering medicines. A study conducted by Kalender and Özkan (2024) stated that EMMSs increase patient safety by reducing medication errors and providing a more reliable environment in healthcare services. However, the increasing digitalisation in medication management in hospitals brings various challenges in terms of data storage, confidentiality, and security. Especially the protection of sensitive patient information and data related to medication management processes is of great importance in terms of increasing trust in the systems (Özkan and

Kalender, 2024). Therefore, data security and error control systems are becoming increasingly important in hospitals. Mansur (2016) emphasises that proper management of high-risk medicines is critical for patient safety and that medication safety strategies should focus on high-risk medicines, systematic error controls, and data security. Computerised Physician Order Entry Systems (CPOE) and Clinical Decision Support Systems (CDSS) are critical technological applications that support healthcare professionals in medication management processes. In a study by Radley et al. (2013), CPOE systems were shown to reduce medication errors by 48%. CDSS systems detect potential risks such as drug interactions, overdose, and patient allergies in advance, alert healthcare professionals in real-time, and prevent ADEs. These systems provide evidence-based guidance to healthcare professionals, increasing patient safety through early warning mechanisms (Sutton et al., 2020). In this context, the integration of technology and information systems in medication management is becoming increasingly important to reduce error rates, ensure patient safety, and support healthcare professionals.

Although "technology and information systems" was identified as the second most crucial main criterion among all, the sub-criteria "drug and stock tracking software" and "e-prescription system" were found to be the least prioritised within this category. This may be attributed to the high level of trust that healthcare professionals have in the e-prescription system, given its mandatory implementation in Turkey for many years. In Turkey, the e-prescription system was officially implemented in 2012, and its use became compulsory in public, private, and university hospitals (Akıcı and Altun, 2013; Özkan and Kalender, 2024). Therefore, pharmacists' familiarity with this system and confidence in its effectiveness may have led them to evaluate the e-prescription system as a relatively low-priority criterion.

In a study by Alharthi et al. (2015), the barriers to successful implementation of a barcode scanning system in hospitals in Saudi Arabia were analysed using the AHP method. The study identified critical success factors for the successful implementation of a dispensing barcode system through a literature review. Twenty-eight pharmacists working in a local hospital in Saudi Arabia were surveyed. Three main barriers to barcode system success were identified: planning deficiencies (including process flow issues and training requirements), resistance factors (such as fear of change, communication issues, and negative perceptions of technology), and technical challenges (including a lack of software, hardware, and vendor support). The study's results revealed that health workers' resistance to new technologies is the most significant factor affecting the system's success. In this respect, the study shows that resistance barriers have a greater impact than planning and technology barriers. In particular, the study found that fear of change was the most significant factor, while training was the least important factor. In this context, it is crucial to develop strategies that promote the adoption of new technologies in pharmaceutical management processes. The study by Alharthi et al. is similar to this study in that it utilises the AHP method and focuses on the distribution process, which is a key aspect of pharmaceutical management in hospitals.

As a result of this study, it was determined that "medication preparation and dispensing" was the third most crucial criterion among the main criteria. It was also found that the most critical sub-criterion in the drug preparation and dispensing process was "dosing", and the least essential criterion was "labelling." The low priority of the labelling criterion may be related to the fact that labelling errors are more easily detected than other types of errors. Thanks to the specialised knowledge of pharmacists and healthcare professionals, mislabeled medicines can be corrected before they are delivered to patients. On the other hand, the reliance of experienced health workers on direct knowledge of the medicine, rather than relying on labels, may have led to labelling errors being underestimated. However, the drug administration guideline published by the Ministry of Health (Sağlık Bakanlığı, 2015) states that special colour codes (e.g., red label) and warning signs should be used in the labelling of high-risk drugs. It also states that automatic warning systems that track expiry dates on drug labels are mandatory in hospitals. These regulations are necessary steps towards preventing mislabeling. In particular, labelling errors in the preparation of individual drug dosages can be quickly detected by healthcare professionals. Therefore, it is an expected result that pharmacists rated the labelling criterion as less important than other criteria. On the other hand, according to the study results, "dosing" was identified as the most critical criterion in the drug preparation and dispensing process. It was also found that dosing was the fifth most crucial criterion among all sub-criteria. As it is known, there are eight basic steps determined to ensure safety in drug administration (Aygin and Cengiz, 2011). The first three steps are listed as "correct patient," "correct drug," and "correct dose", respectively. These basic principles aim to prevent adverse effects by ensuring that the drug is administered to the correct patient at the correct dose and concentration. Tyson et al. (2020) emphasised the importance of correct dosing in administering drugs to patients. Dosing is critical for patient safety and treatment efficacy. Incorrect dosing practices can lead to adverse effects, resulting in treatment failures or even death. Considering that even the most minor dosing errors in drug administration can cause serious adverse effects, it is

understandable that pharmacists give high priority to dosing criteria. Özsoy, Güngör, Aksu, and Araman (2013) emphasised that dose adjustments should be made more carefully in special groups, such as geriatric patients, due to differences in drug metabolism. Since errors made at the dosing stage may lead to treatment failures or adverse effects resulting in death, it is an expected result that pharmacists prioritise this criterion. In this respect, the reasons for the importance pharmacists attribute to the dosing criterion in the study can be explained in two ways. The first is that pharmacists act by the principles of drug administration. The second is that even a small error in dosing can have a significant impact, potentially resulting in death. This finding supports the critical role of pharmacists in ensuring patient safety in medication management processes.

Finally, the study determined that the main criterion of "training and competence" is the fourth priority criterion in hospitals' medication management processes. Within this main criterion, the most crucial sub-criterion is "error reporting," while the least important criterion is "staff training." This finding aligns with a study by Alharthi et al., which also ranked the training criterion as the least important. They found that training processes in hospitals have lower priority compared to other operational processes. In Turkey, pharmacy education was extended from four to five years by a decision made by the Council of Higher Education (YÖK) in 2005. This decision was based on the directives of the European Union Recommendation Committee on Pharmacy Education. The goal was to broaden the education provided in pharmacy faculties and enhance the competencies of professionals in the field. As part of the program, pharmacy faculty students are required to complete at least six months of compulsory internship training in addition to theoretical and practical courses to gain professional competence (Şahin, 2005; EczÇEP, 2019). In this context, it can be said that specialised pharmacists graduate with sufficient knowledge and skills through both theoretical and practical training during their five-year undergraduate education. A study conducted by Karaca and Kıran (2016) determined that pharmacists perceived the courses they took for hospital pharmacy during their undergraduate education as adequate for professional practice. This finding may be one reason why pharmacists consider the "staff training" sub-criterion less important in medication management processes within hospitals. However, the prioritisation of "error reporting" by expert pharmacists may be directly linked to "side effect management training," which they identified as the second most important criterion. Increased awareness of error reporting is closely tied to efforts to enhance patient safety in healthcare services. The drug safety guideline published by the Ministry of Health (Sağlık Bakanlığı, 2015) established various regulations and policy frameworks for the safe administration of medicines. Monitoring, recording, and reporting adverse events in patients has become a mandatory requirement. In 2016, the Ministry of Health introduced the Safety Reporting System (GRS™) to report errors occurring in medical processes in hospitals. Any incident threatening patient safety in hospitals must be reported to this system. Error reports are categorised using the Error Classification Systems (HSS™) and the Medication Errors Classification System (IHSS™). Additionally, the Root Cause Analysis (RCA) method is utilised to analyse potential error causes and develop solution strategies (Sağlık Bakanlığı 2017; 2021a; 2021b). Similarly, pharmacovigilance activities such as monitoring ADEs, reporting adverse effects (to the World Health Organisation Uppsala Drug Monitoring Centre), and risk management planning are conducted by the Turkish Pharmacovigilance Centre (TÜFAM) (Sağlık Bakanlığı, n.d.). These national regulations highlight the importance placed on medication safety and error reporting processes. In line with this regulatory framework, pharmacists in the study prioritised "error reporting" as the most critical training-related sub-criterion. Although error reporting and side effect management training were ranked ninth and eleventh among all sub-criteria, these positions still reflect relatively high prioritisation in a comprehensive evaluation. This supports the conclusion that pharmacists are professionally aware of safety-critical processes and act responsibly in line with national standards.

Conclusion

One of the most widely used tools for decision-making in the presence of multiple criteria is the AHP method. This method is beneficial in healthcare processes where uncertainty and complexity are high. In this study, the AHP method was used to prioritise the critical factors in the medication management processes of hospitals. The study revealed that safety is the most prioritised main criterion, and patient safety is the most prioritised sub-criterion in the medication management processes of hospitals. These results emphasise the importance of rigorously implementing safety criteria in hospital medication management processes. The lack or inadequacy of safety protocols not only jeopardises patient safety but also undermines trust in the healthcare system. Therefore, establishing and maintaining a culture of safety in all healthcare processes of hospitals, including medication management, is crucial to improving service quality. Strict adherence to safety criteria improves patient outcomes and enhances the overall effectiveness of healthcare services.

The study findings also highlight the critical role of technology and information systems in hospital medication management processes. Data security, system alerts, and error controls were identified as among the most crucial sub-criteria in medication management processes. EMMS contribute to preventing medication errors by automating processes such as prescribing, dispensing, and administration. However, increased digitalisation poses new challenges related to data security and privacy. Therefore, implementing advanced security policies and strengthening technological infrastructure in hospitals are essential for efficiency in medication management processes and patient safety. Additionally, the study found that storage and stock management were identified as the least essential criterion among pharmacists' assessments. However, the sub-criterion of storing high-risk medicines was evaluated as a very important factor by pharmacists. This suggests that while stock control and inventory management in medicine management processes are generally automated and systematic, high-risk medicines require more careful management.

In conclusion, this study provides evidence-based information for decision-makers by identifying priority factors for improving medication management processes in hospitals. Regulations regarding medication management systems in hospitals will have a significant impact on patient safety and the prevention of medication errors.

Limitations

In this study, the AHP method was used to identify and prioritise critical criteria in hospital medication management processes. However, several limitations should be noted:

Sample selection

The study involved a specific group of specialist pharmacists and did not include other healthcare professionals such as clinical pharmacists, nurses, physicians, or hospital administrators. Including diverse professional roles may yield different perspectives and priority rankings in medication management.

Sample size

The findings are based on responses from 21 specialist pharmacists. Since the participants were from a limited number of institutions, the generalizability of the results may be limited. Future studies with broader and more diverse samples, including various hospital types (e.g., public, private, and university hospitals), are recommended to improve external validity.

Geographical limitation

The study was conducted in hospitals located within a single country. As medication management systems and healthcare infrastructures vary significantly across countries, the findings may not be directly transferable to other health systems. Comparative international studies may offer more globally relevant insights.

Methodological limitation

The AHP method is based on subjective evaluations, relying on the perceptions and experiences of decision-makers. This introduces potential biases in prioritisation. Employing alternative or complementary decision-making approaches such as Fuzzy AHP, TOPSIS, or DEMATEL may provide a more robust validation of the findings.

Process design constraint

This study did not differentiate between electronic and manual medication management systems. However, priority rankings may vary between institutions with digitalised versus paper-based processes. Further research should consider this distinction to generate more granular findings.

Time and resource constraints

As a cross-sectional study, data collection was limited to a specific time frame. Ongoing changes in health policy, technology, and practice may influence medication management priorities over time. Longitudinal studies are recommended to observe dynamic trends and the evolution of the system.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The author has no conflict of interest to declare.

Grant Support:

The author declared that this study has received no financial support.

Ethics Committee Approval:

Ethics committee approval was received for this study from OSTIM Technical University, Social and Human Sciences Ethics Committee on 13/12/2024 and document number 25751.

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