Risk Management and Healthcare Policy

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ORIGINAL RESEARCH

The Application and Efficacy of Medication Safety Officer-Based Multidisciplinary Management in Reducing Adverse Drug Reaction and Improving Intravenous Management

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Background: Intravenous (IV) therapy is a common treatment but is associated with high rates of medication errors and adverse events, especially in children. In China, most public hospitals have halted adult outpatient IV services, but pediatric IV management remains a challenge. This study evaluates the effectiveness of medication safety officer (MSO)-based multidisciplinary management on managing IV fluids in children's outpatient and emergency departments, aiming to reduce adverse drug reaction (ADR) and standardize IV infusion management.

Methods: Implementing MSO-based multidisciplinary management integrates multidisciplinary supervision, information system optimization, and fostering medication safety culture. We assessed its effectiveness by examining indicators such as the utilization of IV infusion, the unreasonable rate of IV infusion prescriptions, the incidence of IV infusion ADR and medication expenses among outpatient and emergency department patients.

Results: Although peak pediatric influenza and mycoplasma infections led to increased rates of IV fluids after liberalizing control of COVID-19 epidemic, there was a notable decrease in the percentage of antimicrobials in IV infusion ($P < 0.001$). More importantly, the unreasonable rate of IV infusion prescriptions and the incidence of ADR to IV infusion have significantly decreased, dropping from 7.72% and 0.04% to 4.45% and 0.01%, respectively ($P < 0.001$). Furthermore, both average cost of drugs and per capita cost of using IV drugs significantly decreased ($P < 0.001$).

Conclusion: The implementation of MSO-based multidisciplinary management can effectively improve the irrational use of IV fluids, reduce ADR and medical expenses in pediatric outpatient and emergency departments, to ensure children's medication safety.

Keywords: MSO-based multidisciplinary management, outpatient and emergency, children, intravenous infusion, medication safety

Introduction

Intravenous (IV) fluids are fluids or injectable medications given intravenously to patients to improve microcirculation, prevent and correct electrolyte disorders, and to treat the patient's disease. Because of its fast onset and good therapeutic effect, patients and their families often believe that they can recover faster with IV fluids. And some patients even consider their doctors irresponsible for not prescribing them or ask doctors for IV fluid therapy in the outpatient department.[1] However, the World Health Organization emphasizes that oral administration should be preferred whenever possible, with intramuscular injection as a second option and IV infusion reserved as a last resort. IV medications have been connected with 56% of medication errors and 54% of potential adverse drug event (ADE).[2,3] Besides, children are more susceptible to adverse drug reaction (ADR) during IV infusion due to immature development of liver and renal

Received: 3 December 2024
Accepted: 4 February 2025
Published: 12 March 2025

function and enzyme system, which makes their pharmacokinetics and pharmacodynamics different from those of adults, and poorer tolerance to drugs.[4,5] According to the 2023 National Annual Monitoring Report on ADR, the ADR/ADE reports of pediatric patients involved medicines by dosage form, with injections accounting for 70.4%.[6] At present, most secondary and above public hospitals in China have stopped adult outpatient IV infusion services.[7] But due to the particularity of children's physiological characteristics and the difficulty of implementation, no specific requirements for pediatric outpatient were made. Therefore, in order to ensure the safety of children's infusion, it is particularly crucial to rigorously manage IV infusion in children.

Studies have shown that a team-based collaborative approach is necessary to solve the irrational use of IV fluids in China.[8] Aljadhey et al showed that one of the interventions to prevent medication errors is to provide a medication safety officer (MSO) in the hospital who leads the hospital for promoting the safe use of medicine.[9] The MSO provides their expertise in medication safety to the hospital and participates in policy setting and practice change to enhance the safe use of medications.[10] Currently, the MSO project for Chinese children is still in the pilot phase. The purpose of this study was to introduce MSO-based multidisciplinary management and to verify its effectiveness by comparing variables such as the rate of IV infusion, the unreasonable rate of IV infusion prescriptions, the incidence of IV infusion ADR, and medical expenses in pediatric outpatient emergency department before and after the adoption of MSO-based multidisciplinary management. This explores new options for reducing ADR, improving IV infusion management in pediatric outpatient emergency department, and ensuring medication safety in children.

Methods

Date Source and Collection

MSO-based multidisciplinary management was implemented in April 2022 in our hospital. To evaluate the role of this management model in improving IV infusion management and ensuring medication safety in pediatric outpatient emergency department, data related to IV infusion and medical expenses in outpatient emergency department of our hospital before (April 2021 to March 2022) and after (April 2023 to March 2024) the implementation of MSO-based multidisciplinary management were retrieved from the hospital's prescription automatic screening system (PASS) and hospital information system (HIS).

Among them, the statistics related to outpatient and emergency patients, total number of cases, total IV infusion cases, total antimicrobial IV infusion cases, total IV infusion prescriptions, average cost of drugs and per capita cost of using IV drugs were obtained from the PASS, while total IV infusion ADR cases, the organ system involved and the classification of drugs were obtained from the HIS.

Defined Indicators

All statistics are limited to outpatient emergency departments. The defined indicators were as follows:

1. The utilization rate of IV infusion (%) = Total IV infusion cases/Total number of cases × 100%;
2. The utilization rate of antimicrobial IV infusion (%) = Total antimicrobial IV infusion cases/Total number of cases × 100%;
3. The percentage of antibiotics in IV infusion (%) = Total antimicrobial IV infusion cases/Total IV infusion cases × 100%;
4. The unreasonable rate of IV infusion prescriptions (%) = Total unreasonable IV infusion prescriptions/Total IV infusion prescriptions × 100%;
5. The incidence of ADR to IV infusion (%) = Total IV infusion ADR cases/Total IV infusion cases × 100%;
6. Average cost of drugs = Total cost of drugs/Total number of cases;
7. Per capita cost of using IV drugs = Total cost of IV drugs/Total IV infusion cases.

Implementation of MSO-Based Multidisciplinary Management

In order to improve IV fluid management in pediatric outpatient emergency department and ensuring medication safety in children, our hospital has been working in multiple dimensions, such as multidisciplinary supervision, optimization of information system, and cultivating medication safety culture. An important achievement of the management model is the creation of a closed safety loop of "Physician-pharmacist-nurse-patient". Figure 1 depicts the specific work of MSO-based multidisciplinary management.

In terms of multidisciplinary supervision of rational use of medicines: (1) Appoint a senior and experienced clinical pharmacist, well-versed in management, as the Hospital's MSO. (2) Established an MSO-led multidisciplinary management team involving seven crucial departments: namely pharmacy department, medical, nursing, outpatient clinic, emergency department, information division, and disciplinary inspection and supervision. (3) The pharmacy department grants prescribing authority for antibacterial drugs only to doctors who pass a qualification exam and receive medical department approval. Initially, nearly 8% of doctors failed to pass the assessment, and after training, they were assessed again, and the proportion declined. (4) The MSO team conducts thorough reviews and analysis of IV safety risk reports identify key drug varieties for improvement and subsequently formulate effective measures.

In terms of the regime: (1) Every week, the rate of IV infusion in the outpatient and emergency department is publicized, and the unreasonable IV infusion prescriptions are notified with the doctor's real names in the whole hospital. (2) Unreasonable infusion prescriptions are included in personal performance appraisal. (3) Formulate the guiding principles for the clinical application of key monitored drugs in our hospital and expert recommendations on infusion for common diseases in children's outpatient and emergency department.

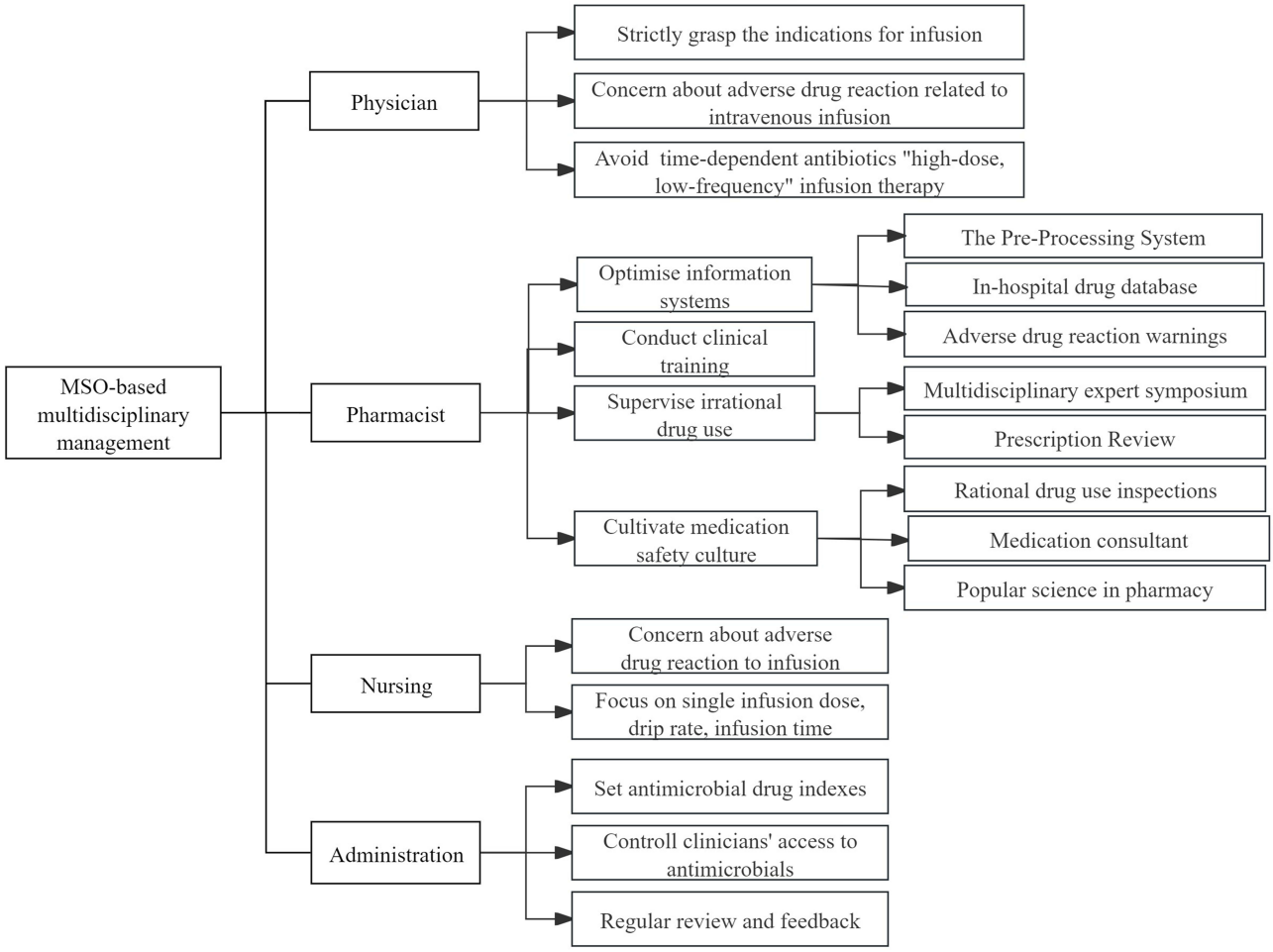

Figure 1 The specific work of medication safety officer (MSO)-based multidisciplinary management.

https://doi.org/10.2147/RMHP.S504874

In terms of optimizing information system: (1) Implement the PASS system, which is now embedded in both the outpatient and inpatient HIS systems. This integration, combined with the actual situation of our hospital and multi-source rule base, has allowed us to establish a front-end audit system for prescription and medical prescriptions. After the physician prescribes a medication, the rational drug use system, in conjunction with a rule-based database, performs an initial review. Prescriptions that pass the initial review proceed to payment and dispensing, while those that do not pass allow the physician to either modify the prescription or submit it for manual review and final confirmation by a pharmacist. This enables us to realize the closed-loop management of pre-audit, mid-intervention and post-evaluation from the information system level. Figure 2 summarizes the specific process for pre-prescription review. (2) Maintain meticulously the knowledge base of pharmacy rules, which is based on a wide range of sources, including drug instruction, national and international therapeutic guidelines, as well as expert consensus, and pharmaceutical monographs. This comprehensive approach ensures that all aspects of drug indications, dosages, routes of administration and dispensing concentrations are systematically covered to maximize the effectiveness and safety of hospital medication.

In the cultivation of medication safety culture, we have started from doctors, pharmacists, patients and other aspects together. (1) For doctors, we encourage them to take the initiative to detect ADR and report them in time through training and seminars, which are linked to physician performance and bonuses. (2) Clinical pharmacists regularly participate in training sessions within clinical departments, focusing on the proper and rational application of antimicrobial drugs. (3) We organize monthly multidisciplinary expert review meetings to enhance the scrutiny of the improper use of drugs such as antimicrobial drugs and provide timely feedback to physicians. (4) For the public, we actively publicize the knowledge of IV infusion, rational use of antibiotics and other medication to correct the wrong cognition of patients. Publicity methods included making leaflets, attractive popular science videos, face-to-face teaching in the infusion room and so on.

In summary, MSO-based multidisciplinary management ensures that every aspect of patient care is carefully examined and optimized to prioritize safety at every step of the medication administration process.

Data Analysis

Data entry was processed using Excel 2019 software and statistical analysis was conducted using SPSS statistical software (version 25.0). Count data were expressed as cases or rates, and group comparisons were analyzed using the chi-

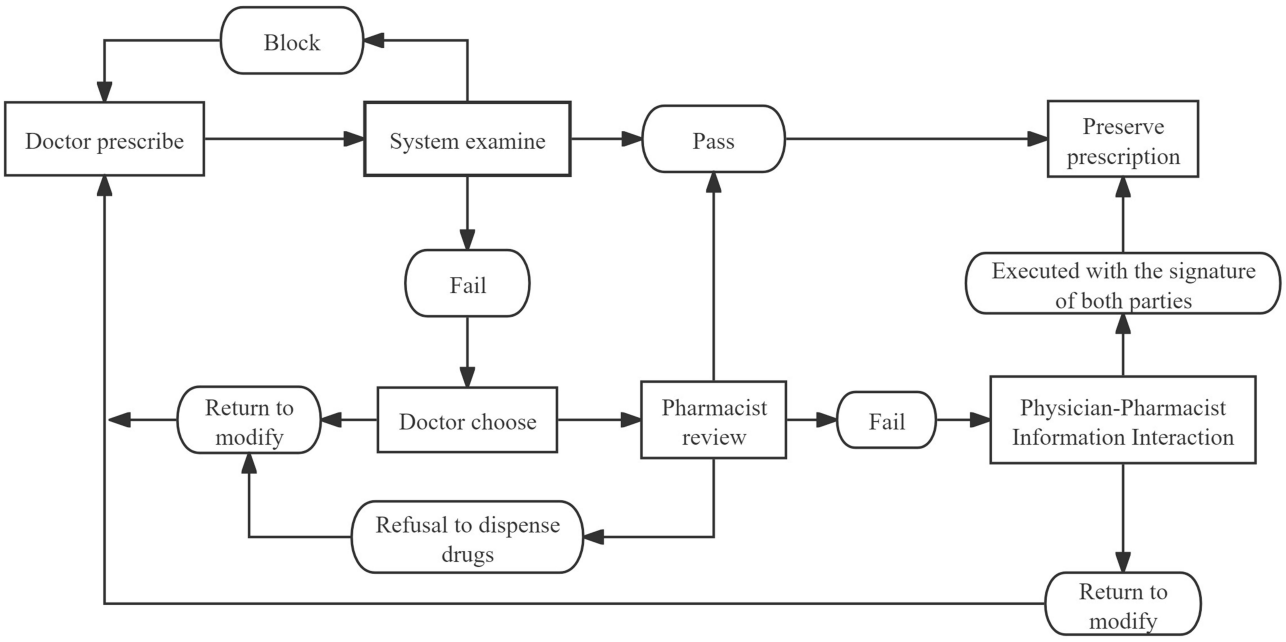

Figure 2 Flowchart for pre-prescription review.

square test. Measurement data were subjected to normality testing using the Shapiro-Wilk test; data that conformed to normal distribution were presented as mean ± standard deviation (SD) and group comparisons were analyzed using the Independent *T*-test; data that did not conform to normal distribution were presented as M (P_{25},P_{75}), and group comparisons were analyzed using Wilcoxon Mann–Whitney test. A significance level was set at α= 0.05.

Results

Changes of IV Infusion Rates Before and After the Implementation of MSO-Based Multidisciplinary Management

Before the implementation of MSO-based multidisciplinary management (April 2021 to March 2022), there were 156,993 IV infusion cases, representing 6.98% of total cases. Among these, 137,563 were antimicrobial IV infusion cases, making up 6.12% of total cases and 87.62% of total IV infusion cases. After the implementation of MSO-based multidisciplinary management (April 2023 to March 2024), the number of IV infusion cases was 251,764, accounting for 7.56% of total cases. Of these, 217,159 were antimicrobial IV infusion cases, accounting for 6.52% of total cases and 86.25% of total IV infusion cases. Although the utilization rate of IV infusion and antimicrobial IV infusion increased after implementing MSO-based multidisciplinary management, the percentage of antibiotics in IV infusion dropped from 87.62% to 86.25% (P<0.001). These results are provided in Table 1.

Given the peak epidemics of COVID-2019, influenza and mycoplasma infections among Chinese children in 2023,[11] resulting in increased infusion rates, we conducted a comparative analysis of IV infusion data during the MSO-based multidisciplinary management implementation (April 2022 to March 2023) against the pre-implementation period (April 2021 to March 2022). The analysis revealed significant decreases in the utilization rate of IV infusion and antimicrobial IV infusion, as well as in the percentage of antibiotics in IV infusion (all $P < 0.001$). These results are provided in Table 2.

Table 1 Comparison of the Utilization Rate of IV Infusion Between Pre-Implementation and Post-Implementation

Indicator	Pre-Implementation	Post-Implementation	Chi-Square Value	*P*-value
The utilization rate of IV infusion (%)	6.98 (156,993/2,249,240)	7.56 (251,764/3,330,683)	663.22	< 0.001
The utilization rate of antimicrobial IV infusion (%)	6.12 (137,563/2,249,240)	6.52 (217,159/3,330,683)	368.06	< 0.001
The percentage of antibiotics in IV infusion (%)	87.62 (137,563/156,993)	86.25 (217,159/251,764)	157.90	< 0.001

Abbreviation: IV, Intravenous.

Table 2 Comparison of the Utilization Rate of IV Infusion Between Pre-Implementation and During Implementation

Indicator	Pre-Implementation	During Implementation	Chi-Square Value	*P*-value
The utilization rate of IV infusion (%)	6.98 (156,993/2,249,240)	4.12 (104,036/2,523,133)	18,767.03	< 0.001
The utilization rate of antimicrobial IV infusion (%)	6.12 (137,563/2,249,240)	3.13 (78,906/2,523,133)	24,529.99	< 0.001
The percentage of antibiotics in IV infusion (%)	87.62 (137,563/156,993)	75.84 (78,906/104,036)	6132.12	< 0.001

Abbreviation: IV, Intravenous.

Table 3 Comparison of the Unreasonable Rate of IV Infusion Prescriptions Between Pre-Implementation and Post-Implementation

Indicator	Pre-Implementation	Post-Implementation	Chi-Square Value	*P*-value
The unreasonable rate of IV infusion prescriptions (%)	7.72 (15,449/200,123)	4.45 (15,431/346,774)	2546.66	< 0.001

Abbreviation: IV, Intravenous.

Table 4 Comparison of the Incidence of ADR to IV Infusion Between Pre-Implementation and Post-Implementation

Indicator	Pre-Implementation	Post-Implementation	Chi-Square Value	*P*-value
The incidence of ADR to IV infusion (%)	0.04 (64/156,993)	0.01 (25/251,764)	42.24	< 0.001

Abbreviations: ADR, Adverse drug reaction; IV, Intravenous.

Changes of the Unreasonable Rate of IV Infusion Prescriptions Before and After the Implementation of the Prescription Pre-Audit System

From April 2021 to March 2022, before the implementation of the prescription pre-audit system, there were 200,123 IV infusion prescriptions in our outpatient and emergency department, with an unreasonable prescription rate of 7.72%. After the prescription pre-audit system was launched (April 2023 to March 2024), the total number of IV infusion prescriptions in outpatient and emergency department rose to 346,774, but the unreasonable prescription rate dropped to 4.45%. It is evident that the implementation of the prescription pre-audit system significantly reduced the unreasonable rate of IV infusion prescriptions in our hospital's outpatient and emergency department ($P< 0.001$). Details are provided in Table 3.

Changes of IV Infusion ADRs Before and After the Implementation of MSO-Based Multidisciplinary Management

In Table 4, we observe that before implementing MSO-based multidisciplinary management, the incidence of ADR to IV infusion was 0.04% (64/156,993), while post-implementation, it decreased to 0.01% (25/251,764). These results demonstrate a significant reduction in IV infusion-related ADR by 0.03% following the adoption of MSO-based multidisciplinary management ($P < 0.001$).

Diving deeper into the data, the ADR associated with IV infusion affected various organ systems, including skin and its accessories, systemic, neurological, respiratory, and cardiovascular systems. Furthermore, the types of drugs involved in IV infusion ADR range from antibacterial drug, glucocorticoids, electrolytes, acid-base balance and nutritional drugs, traditional Chinese medicine and antiviral drug. The specific distribution is shown in Figure 3.

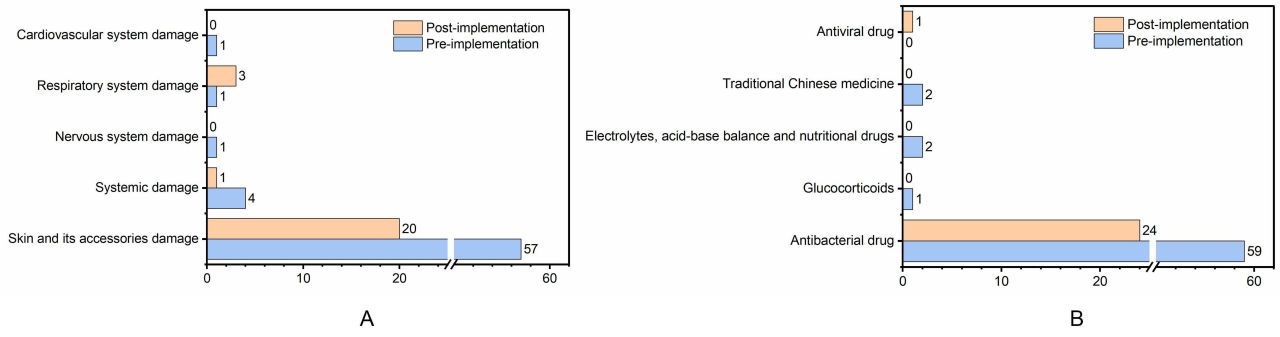

Figure 3 Comparison of organ system (**A**) and the medication types (**B**) associated with in intravenous (IV) infusion adverse drug reaction (ADR) between pre-implementation and post-implementation.

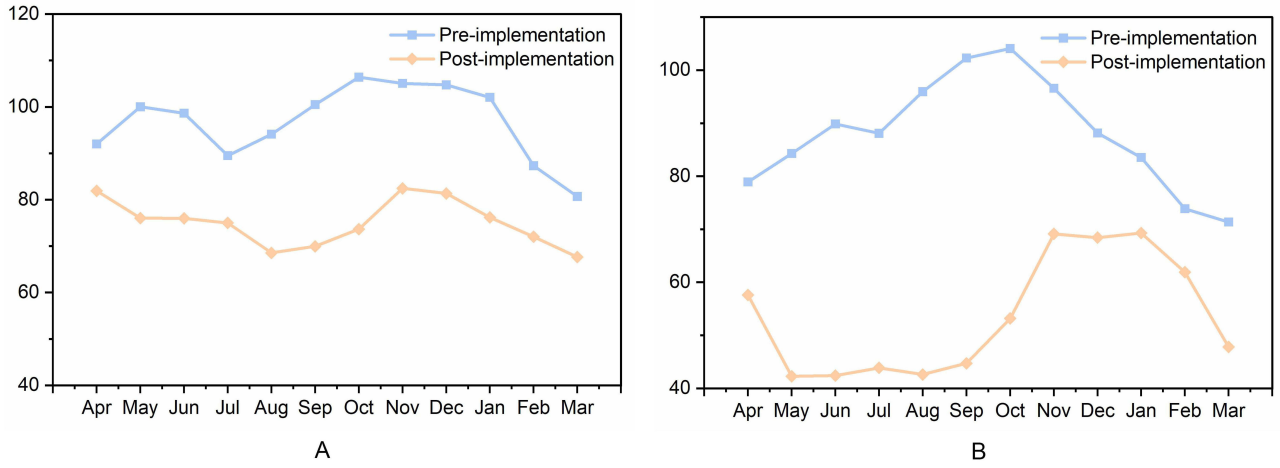

Figure 4 The average cost of drugs (**A**) and per capita cost of using intravenous (IV) drugs (**B**) between pre-implementation and post-implementation.

Changes in the Utilization of Drugs Before and After the Implementation of MSO-Based Multidisciplinary Management

Figure 4 presents our hospital's outpatient emergency department medication use before and after the implementation of MSO-based multidisciplinary management. As can be seen from the figure, following the implementation of MSO-based multidisciplinary management, the average cost of drugs and per capita cost of using IV drugs all showed a downward trend. The average cost of drugs decreased from (96.75 ± 8.04) yuan to (75.06 ± 5.03) yuan, the per capita cost of using IV drugs decreased significantly from 88.11 (80.08, 96.42) yuan to 50.49 (42.93, 66.80) yuan, all differences were statistically significant (P<0.001). The results are summarized in Table 5.

Discussion

IV infusions are an important route of administration in modern drug therapy,[12] and it is also a common and effective treatment for pediatric diseases. However, IV infusions pose a higher risk of error and potential harm than oral medications.[13] Research by Hoste et al has revealed that approximately one-fifth of patients undergoing fluid therapy experience inappropriate fluid usage.[14] Consequently, reducing the use of IV fluids will also greatly reduce the occurrence of ADR in children, thus better ensuring children's medication safety.

Analysis of the Effectiveness of Implementing MSO-Based Multidisciplinary Management

Analyzing the IV infusion rates before and after, as well as before and during the implementation of MSO-based multidisciplinary management, reveals a clear positive impact on reducing the use of IV fluids. As antimicrobial drugs

Table 5 Comparison of the Utilization of Drugs Between Pre-Implementation and Post-Implementation

Time	Average Cost of Drugs (mean±SD) / ¥	Per Capita Cost of Using IV Drugs [M (P_{25},P_{75})] / ¥
Pre-implementation	96.75±8.04	88.11(80.08,96.42)
Post-implementation	75.06±5.03	50.49(42.93,66.80)
t-value / Z-value	7.93	−4.16
P-value	< 0.001	< 0.001

Abbreviations: IV, Intravenous; SD, Standard deviation; M, Median.

https://doi.org/10.2147/RMHP.S504874

are the most commonly used IV medications, strengthening the restrictions on their usage has effectively lowered the utilization of IV infusion while preventing antibiotic resistance. Irrational prescriptions lead to unnecessary drug use, and by reducing such prescriptions, medical risks and costs have been effectively minimized. Additionally, the occurrence of ADR is closely related to the administration route, with IV infusion being particularly significant. With the standardization of IV infusion management for pediatric outpatient and emergency services, the incidence of ADR to IV infusion has significantly decreased, as have average cost of drugs and per capita cost of using IV drugs. These results reflect the success of our hospital's MSO-based multidisciplinary management. This model helps standardize IV infusion management, reduces ADR, alleviates the economic burden on both patients and the healthcare system, and enhances pediatric medication safety.

Our Hospital's Experience in Implementing MSO-Based Multidisciplinary Management

The establishment of the MSO Safe Medication Supervision Team combines the responsibilities of physician, pharmacists, nurses and patients to form a closed loop of "Physician-pharmacist-nurse-patient" safety. Taking advantage of the pharmacist's supervisory initiative, we have continuously optimized the outpatient and emergency prescription review process, expanded the key points of prescription review, updated the drug database information system, so as to provide full-scale pharmacy services for the rational use of IV drugs. For instance, to address the irrational use of time-dependent antimicrobial drugs in our hospital, which is characterized by "high dosage and low frequency", our hospital has set up rules from the following three aspects. Firstly, we have ceased the use of IV drugs that required administration three or four times daily in the outpatient and emergency departments, as they are unsuitable for these departments. Secondly, for IV infusion drugs that can be used in the outpatient and emergency department, we have set system rules to limit single doses. At the same time, we also formulated the expert consensus on the outpatient and emergency department of respiratory diseases in children and expert recommendations on infusion for common diseases in children's outpatient and emergency departments. These measures have enabled our hospital to transition from passively addressing IV drug safety to actively discovering, solving, and preventing safety issues, ultimately ensuring the safety of children's infusions.

The Administration Department formulates and evaluates the antimicrobial drug indexes of each department to strictly control the use of antimicrobial drugs by clinicians. Meanwhile, we have implemented strategies such as public announcements, criticize by name, and incorporate into performance appraisal to ensure the smooth implementation of all the work. Moreover, we improved the awareness of IV infusion among the public and medical staff through a variety of ways, such as rational drug use inspection and pharmacy education. This can help reduce the use of IV fluids blindly, thus safeguarding the safety of medication for children.

Limitation

Our study has several limitations. Firstly, the rigorous epidemic prevention measures enforced from 2021 to 2022, alongside subsequent outbreaks like influenza and mycoplasma infections among Chinese children in 2023, could have influenced the number of children visiting our hospital. Secondly, this study is a single-center study, and the management status and experience described in this article may not be applicable to all children's hospitals.

Continuous Improvement

The management of IV fluids in hospitals requires continuous coordination among all departments to design, implement and regularly update various management policies. Therefore, our hospital will continue to improve in the following aspects: (1) Improve the infusion management system in line with the actual situation of our hospital, and strengthen the management of key monitoring drugs and the improvement of monitoring indicators. (2) Define the clinical indications for IV infusion, improve the list of diseases that do not require IV infusion, and expand the varieties of IV infusion control, so as to provide reference for the rational use of drugs in the clinic. (3) The database is further improved based on evidence-based information such as drug inserts, literature, guidelines, etc., and is regularly updated and maintained so that the system is able to alert and intercept irrational infusion situations in a more comprehensive manner. (4) Improve the hospital drug supply list, especially for oral drugs with clinical efficacy that can be replaced. (5) Strengthening the skills training of prescription reviewing pharmacists and improve their knowledge reserve. (6) Improving the team of MSO-based multidisciplinary management. (7)

Through regular assessments and feedback, promptly identify and address issues, continuously improve and refine the MSO-based multidisciplinary management, and ensure the long-term sustainability of the management model.

Implication and Generalization of MSO-Based Multidisciplinary Management to Other Healthcare Institutions

Based on the analysis of implementation results, it is evident that MSO-based multidisciplinary management has significant advantages in improving medication safety, optimizing medication processes, and reducing medical risks and costs. It has an important example for other healthcare institutions, which can help them improve medication management systems and enhance patient safety.

The next steps for promoting this management model include: (1) Organizing or participating in hospital management seminars to introduce the implementation methods and outcomes of MSO-based multidisciplinary management, assisting other hospitals in effectively adapting and applying the model. (2) Publishing the results of MSO-based multidisciplinary management through industry conferences and journal articles to attract more hospitals' attention and participation. (3) Establishing partnerships with other hospitals and setting up feedback mechanisms to regularly exchange implementation feedback, including management acceptance, clinical outcomes, and team collaboration, thereby continuously refining the MSO-based multidisciplinary management model.

Healthcare institutions implementing MSO-based multidisciplinary management meet the following requirements: (1) Appoint a senior and experienced clinical pharmacist, well-versed in management, as the MSO, enabling the promotion of cross-departmental collaboration and process optimization. (2) Possess a well-established organizational structure and a diverse team of professionals capable of supporting multidisciplinary cooperation. (3) Have sufficient financial and technological resources to invest in information systems and data-sharing platforms, ensuring the smooth progress of multidisciplinary collaboration.

Conclusion

The implementation of MSO-based multidisciplinary management in our hospital has brought about significant improvements in IV infusion management, notably reducing the unreasonable rate of IV infusion prescriptions and the incidence of ADR to IV infusion in pediatric outpatient and emergency department. Moreover, this approach has led to reductions in both patient medication expenses and overall hospital medical costs, ultimately conserving valuable medical resources. These outcomes offer valuable references for other hospitals to reduce ADR, standardize IV infusion management in pediatric outpatient emergency department, and ensure medication safety in children.

Abbreviations

MSO, Medication safety officer; IV, Intravenous; ADR, Adverse drug reaction; ADE, Adverse drug event; PASS, Prescription automatic screening system; HIS, Hospital information system; SD, Standard deviation; M, Median.

Data Sharing Statement

The datasets generated and/or analyzed during the current study are not publicly available because they are subject to Qingdao Women and Children's Hospital. However, the data and materials are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The study adhered to ethical guidelines and was reviewed by the Research Ethics Committee of Qingdao Women's and Children's Hospital prior to commencement. Based on the nature of the research, which is a non-interventional retrospective data analysis involving only macro-level management indicators and no personal patient information, the Research Ethics Committee confirmed the ethics approval is not required. Since the data relates only macro-level management indicators and does not include any personal or identifiable patient data, informed consent is not necessary for this study. Besides, the data was

accessed with the approval of the hospital's Discipline Inspection and Supervision Department, in compliance with institutional policies.

Acknowledgment

We would like to express our gratitude to all the participants in the study.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Disclosure

The authors declare that they have no competing interests.

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