

Implementation of clinical pharmacy activities in pediatric cardiology

Gabrielle Robineau

Hôpital Cardiologique, Hospices civils de Lyon

Morgane Cabon

Hôpital Cardiologique, Hospices civils de Lyon

Thomas Perouse-De-Montclos

Hospices Civils of Lyon

Marc Lilot

Hospices Civils of Lyon

Thibault Blache

Hospices Civils of Lyon

Cécile Leconte

Hospices Civils of Lyon

Corinne Ducreux

Hospices Civils of Lyon

Roland Henaine

Hospices Civils of Lyon

Valentine Bréant

Hôpital Cardiologique, Hospices civils de Lyon

Delphine Hoegy

`delphine.hoegy@chu-lyon.fr`

Hôpital Cardiologique, Hospices civils de Lyon

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Abstract

Introduction

Pediatric cardiology is a medico-surgical specialty using high-risk medications such as anticoagulants, beta-blockers and antiarrhythmics. Most of the time, the patients are less than 6 years old so need to use multidose drinkable medications. Those make them particularly vulnerable. Clinical pharmacy activities as medication review and pharmaceutical interviews can help to reduce medication-related errors. This study aimed, for the first time, to assess the feasibility of implementing clinical pharmacy services in a pediatric cardiology department.

Materials and Methods

From January 2022 to December 2024, clinical pharmacy activities were implemented in a university hospital, included hospital medication review to identify and resolve medication-related problems, as well as pharmaceutical interviews to inform and educate patients and their caregivers about home medication usage.

Results

During three years, over 592 working days, 5 848 medication reviews were performed for 2 267 patients. A total of 564 medication-related problems (9.6% of prescriptions) were identified, most commonly involving anti-infective agents. Of these, 44.1% were related to dosage, and 67.7% led to changes in prescriptions. Additionally, 409 pharmaceutical interviews were conducted before discharge.

Conclusion

Medication review helped secure hospital prescriptions, with several identified issues considered clinically significant. Educational interviews from pharmacist to patients and/or their parents emerged as a promising strategy to secure the utilization of high-risk medications at home. This high-risk moment of the care pathway needs to be prioritized and especially for vulnerable population as pediatrics.

Impact statements

- The pharmacist identifies drug-related problems and provide pharmaceutical interventions to resolve them with prescribers in pediatric cardiology.
- Before discharge, pharmaceutical interviews are an interesting strategy to secure the utilization of high-risk medications at home.
- The implementation of clinical pharmacy activities in pediatric cardiology care should be clinically and time-consumingly evaluated to be transferred for others pediatric specialties.

1. Introduction

Pediatric patients are at risk of medication-related errors [1–2] due to their developmental specificities. For example, the ability to swallow solid oral formulations typically develops only after the age of six, making the use of liquid multi-dose oral medications common. This contributes to a high risk of medication errors in this setting. Furthermore, the medical-surgical pediatric cardiology specialty uses medications at high risk of adverse effects due to narrow therapeutic windows, such as anticoagulants or beta-blockers.

Previous studies have shown that clinical pharmacy can help prevent and correct medication errors in vulnerable populations, including pediatric patients [3–5], in intensive care unit (ICU) [6]. These activities are carried out within an interprofessional framework involving pharmacists, physicians, and nurses. Key activities include the safety assessment of prescriptions through medication review to detect and resolve therapeutic issues, as well as the safety assessment of home administrations through targeted medication educations to patients and caregivers.

The aim of this study was to assess the feasibility of implementing clinical pharmacy services in a pediatric cardiology medical-surgical department.

2. Materials and methods

2.1 Design, patients and implementation

This was an observational prospective single-center study conducted in cardiological medical-surgical department of a university hospital, between November 2021 and December 2024.

The department included a conventional hospitalization unit (CHU) with 14 patient beds, an intensive-progressive care unit (IPCU) with 8 beds, and a pediatric cardiology ICU with 10 beds. All consecutive patients, admitted in hospitalization were eligible.

Following a training phase from early November to late December 2021, clinical pharmacy activities began in January 2022, led by a senior pediatric pharmacist at 0.3 full-time equivalent. Activities were first implemented in the CHU and IPCU, and then extended to the ICU in September 2022. From November 2023, a pharmacist resident at 0.7 full-time equivalent was trained and so implemented to those activities.

In the CHU and IPCU, the pharmacist or resident participated in medical handovers (30–45 minutes once a week) and nursing handovers (30–45 minutes once a day). In the ICU, only the pharmacist attended medical handovers once a week (30–45 minutes). During working hours (8:30 am to 17:30 pm), both the pharmacist and the resident were accessible by phone.

Figure 1 illustrates the process implementation of clinical pharmacy activities in pediatric cardiology.

2.2 Clinical Pharmacy Activities

2.2.1 Hospital medication review

This activity targeted prescriptions, aiming to optimize it. Pharmaceutical interventions (PIs) were communicated to prescribers either verbally or by telephone. This review was conducted by the clinical pharmacist using Module E of Philips' IntelliSpace Critical Care and Anesthesia (ICCA) software (version J). From January 2022 to December 2024, medication review [7] was performed once daily for hospitalized patients in the CHU and IPCU, on days when the pharmacist was present, for all prescriptions containing at least one medication. This activity was extended to ICU patients from September 2022, on a weekly basis. Starting in April 2023, medication review and PIs could be tagged directly in the software.

2.2.2 Pharmaceutical Interviews at discharge

This activity targeted patients and/or their caregivers, aiming to optimize their knowledge and skills for a proper home day-to-day management and administration of medications [8]. For patients under 6 years of age, the interview was conducted with a parent or legal guardian. For patients over 6 years of age, the interview involved both the patient and a parent or legal guardian. Educational tools were developed to support these interviews, through a physician–pharmacist–patient association collaboration and were evaluated by some parents and nurses. These include information about indications, side effects, interactions, handling and administration techniques for specific pharmaceutical preparations: by instance carvedilol capsule and oral suspension 1 mg/mL, amlodipine oral suspension 1 mg/mL, amiodarone capsule, bumetanide capsule, and spironolactone oral suspension 5 mg/mL. All interviews were documented in the patient's medical record and communicated to the community pharmacist.

From January 2022, pharmaceutical interviews were systematically conducted whenever oral anticoagulants were prescribed or after pediatric heart transplantation were performed. On medical demand, other discharge interviews were realized for patients with at least one medication on their discharge prescription (others than oral anticoagulants and post-transplantation). For each interview, an hospital medication review was realized and traced as described in this study and a discharge medication review was realized but without traceability.

2.4 Data Collection

Data were recorded during activities, manually in an Excel database. Patient age and the number of medications were recorded at the time the patient file was first opened. For hospital medication reviews, the data collected were the following: problem detected or not, means PIs or not. In the case of PIs, the name of the medication involved (using the nonproprietary name), the type of problem and the prescriber's response (whether the prescription was modified accordingly) were recorded. For pharmaceutical interviews at discharge, the data collected were the following: anticoagulant oral interview, post-transplantation interview, other medications interviews and for how many patients.

2.5 Data Analysis

An initial analysis of the study population was conducted based on patient age and the number of medications prescribed at hospital admission.

Descriptive analysis then focused on the number of clinical pharmacy activities performed—specifically prescription analysis and pharmaceutical interviews—across each care unit. To evaluate the impact on medication safety, the number of pharmaceutical interventions conducted by the pharmacist was assessed. Medications were classified according to the Anatomical Therapeutic Chemical (ATC) classification. Additionally, the types of problems identified were classified, along with the outcomes of the pharmaceutical interventions. Pharmaceutical interventions were coded according to the French Society of Clinical Pharmacy's hospital coding grid [9].

The number of PIs between 2022 and 2024 was compared.

2.6 Ethics approval

This study was approved by the Scientific and Ethical Committee of the Hospices Civils de Lyon on July 29, 2021, and from the National Commission for Information Technology and Civil Liberties (CNIL) on the same date. Beginning in January 2022, a non-opposition information notice was distributed by the healthcare team to the caregivers of all newly admitted patients.

3. Results

3.1 Study population

The study took place from January 2, 2022, to December 31, 2024, means 756 weekdays. Over 592 effective working days, clinical pharmacy activities were performed for 2 267 patients: 445 were under 1 month of age, 707 were between 1 and 12 months, 377 between 1 and 5 years, and 738 were older than 5 years. The average number of medications per patient was 6.11 at the beginning of clinical pharmacy activities for each of them.

3.2 Clinical Pharmacy Activities

3.2.1 Medication review

A total of 5 848 medication reviews were performed for 2 267 patients during 592 working days. Of these, 564 resulted in PIs, representing 9.6% of the total reviewed. A total of 370 patients (16.3%) received at least one intervention. The detailed results are presented in Table I.

Among the 564 PIs, the most common was about anti-infectives medication. Figure 2 illustrates the distribution of pharmaceutical interventions by pharmacological class.

The most common intervention type was dosage-related, accounting for 44.1% ($n = 249$) of all interventions. It is worth noting that limitations in the prescribing software—specifically, its inability to

indicate galenic formulations—may have led to underreporting of problems in that category. The number and percentage of interventions by problem type are provided in Table II, with examples.

Pharmaceutical interventions were discussed with prescribers, resulting in:

- 382 accepted as proposed (67.7%)
- 87 rejected (15.6%)
- 49 resolved differently by the prescriber (8.7%)
- 46 not documented (8.1%)

3.2.2 Pharmaceutical Interviews at discharge

A total of 409 pharmaceutical interviews were performed for at least 389 patients (among those describe above): 129 interviews about oral anticoagulants, 37 about post-transplantation and 243 about other medications. For the latter, the most frequently involved medications required early or compassionate access (formerly known as 'temporary use authorization') or compounded preparations. Those results are presented in Table III.

4. Discussion

To our knowledge, this study is the first to describe the implementation of clinical pharmacy activities in pediatric cardiology.

Regarding our results about hospital medication review activity, this study underscores that this activity detects prescribing errors in vulnerable populations as describe previously in literature [3–5]. Although fewer than 10% of prescriptions were properly optimized through PIs, the clinical significance could be considerable: it allowed by instance to correct a rivaroxaban dose from 3.5 mg every 8 hours to 0.9 mg every 8 hours—appropriate for the patient's age and weight.

In pediatrics the dosage-related problems are one of the most frequent, which aligns with our findings. Also, PIs related to galenic formulations are frequent [2], especially when most patients are under 6 years old, as is the case in pediatric cardiology. However, our data likely underrepresent galenic-related PIs due to limitations in the prescribing software, which does not allow to indicate galenic forms. Beyond the documented PIs, the pharmacist in our study routinely provides support to nurses and prescribers regarding formulation choices.

In our study, anti-infectives were the most frequently involved in PIs. In our hospital, a mobile pediatric infectious diseases team assists prescribers to manage these therapies across all specialties. Even if this mobile team helps a lot routinely, our data show importance of pharmacist complementary training and also guidance for prescribers about those specific therapies. Pharmacist has to be trained on these elements. As the problems detected, the medications involved in PIs reflect both prescriber practices and the pharmacist's training and expertise. Regarding the integration moment of the pharmacist

resident, there was no significant difference in the number of medication reviews and PIs or even in qualitative data of PIs, unlike what we could expected. We could think senior pharmacist trains pharmacist resident with regard to his proper expertise.

The acceptance of PIs in our study is comparable to literature. However, increasing even more the pharmacist's physical presence on the units allow improving the relevance and acceptance of interventions [5;10]. This increase of pharmacist physical presence was asked routinely by prescribers. This was made possible thanks to the additional human resource. Also, this allows increasing number of pharmaceutical interviews at discharge. To work on hospital-home discharge, the pharmaceutical physical presence is even more essential: it is necessary to know daily that patient will be discharged and be reactive in consequences. Recent French regulations have made it mandatory to educate families before hospital discharge to the use of a specific liquid formulations of rivaroxaban [11]. It shows that this is recognized as a strategy to secure medication administrations at home: optimizing families' knowledge and practical skills make a proper day-to-day management of medications at home [12–13]. The medication expert which is the pharmacist can perfectly take on this role [14]. Nurses are often involved in the education process at discharge, because they are responsible for the administration during hospital stay. In our study, the pharmaceutical interviews are placed to be complementary to nurses' interventions. Several studies have shown that it is essential to support this discharge for pediatric cardiology patients, because medication use can be quite difficult for families [15–17].

The implementation of new clinical pharmacy activities is not well-documented in the literature, as noted by Sim et al. [10]. One key facilitator in this implementation could certainly be the pharmacist's prior expertise in clinical pharmacy and also in pediatrics. However, the pharmacist initially had no specific training in cardiology. Integration into the care team was gradual. Over time, pharmacist-physician relationships evolved into a true partnership built on trust [18–19], as in our experience. This trust is reinforced daily and is especially critical at the start of each semester with new medical residents. Since May 2022, each rotation begins with a senior physician presentation of the clinical pharmacy activities, followed by a pharmacist-led training session entitled "Awareness of Medication Errors". When the pharmacist resident started activities in November 2023, the mutual trust between pediatric cardiology teams and the senior pharmacist facilitated certainly their integration. The trust was transferred naturally.

One of the main limitations of this study is traceability bias, as data collection was performed manually for each activity. Due to time constraints, some activities may not have been documented. For instance, one of the pharmacist's routine contributions—providing pharmaceutical support and advice upon medical or nursing request for both inpatients and outpatients—was not included in this analysis, as it could not be reliably and quickly tracked.

Another limitation relates to the learning curve of the clinical pharmacist. As their expertise evolves, the relevance and impact of PIs are likely to improve over time. Evaluating the clinical impact of these interventions through a multidisciplinary approach could be valuable in future studies.

The scope of these activities is also limited by staffing constraints. It would have been informative to assess the time required for each type of activity. As Sim CM-H et al. [18] emphasized, one key facilitator in implementing clinical pharmacy activities is the consistent availability of a trained pharmacist on the ward. This study did not integrate a time-consuming evaluation and even less a medico-economic evaluation. Evaluating the transferability of this clinical pharmacy model to other pediatric specialties represents a compelling area for future research.

5. Conclusion

Our findings highlight the fact that it is necessary and also feasible to implement clinical pharmacy activities in pediatric cardiology medico-surgical department in hospitalo-university center. This population is vulnerable, because almost all of them are less than 6 years old and frequently use multidose drinkable medications, and because of high-risk medications, such as anticoagulants, beta-blockers or antiarrhythmics. Although only 9.6% of prescriptions were subject to pharmaceutical interventions, the clinical significance of these optimizations is considerable. To improve efficiency, future studies should evaluate how to target high-risk patients and/or high-risk medications. These evaluations should consider the time-consuming expertise required from pharmacists. This study also highlights a particularly risky moment -the hospital discharge- which needs support to prevent home administration medication error. A future study could propose an interprofessional nurse-pharmacist-physician program to secure the use of medications at home, which evaluate the time spent to achieve the goal and also trace medication review at discharge.

Declarations

Conflict of Interest Statement:

The authors have no conflicts of interest to disclose.

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None

Author Contribution

Dr Hoegy conceptualized and designed the study; recruited participants; led data collection, analysis, and interpretation; drafted the initial manuscript; reviewed and revised the manuscript; and approved the final manuscript as submitted. Dr Robineau, Dr Cabon recruited participants; led data collection, analysis, and interpretation; reviewed and revised the manuscript; and approved the final manuscript as submitted. Dr Perouse de Montclos, Dr Henaine, Dr Lilot supervised the conceptualization and design of the study; supervised data collection, analysis, and interpretation; critically reviewed and revised the

manuscript; and approved the final manuscript as submitted. Dr Bréant, Dr Blache, Dr Leconte, Dr Ducreux contributed to the design of the study, participated in drafting the manuscript and revising it, and approved the final manuscript as submitted.

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Tables

Table 1 to 3 are available in the Supplementary Files section.

Figures

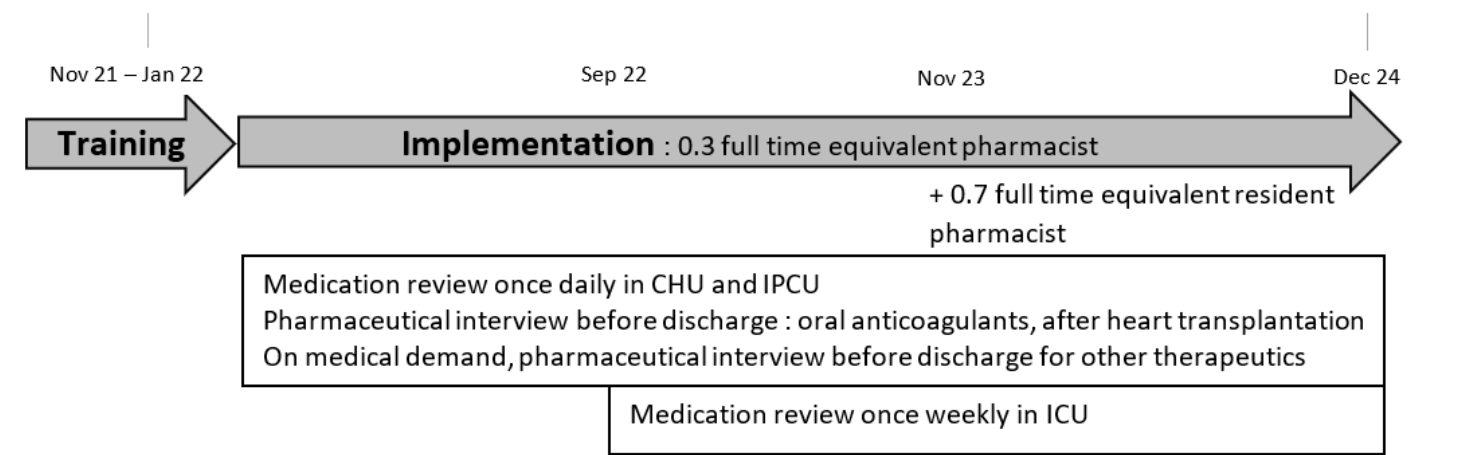


Figure 1

Implementation process of clinical pharmacy activities in pediatric cardiology

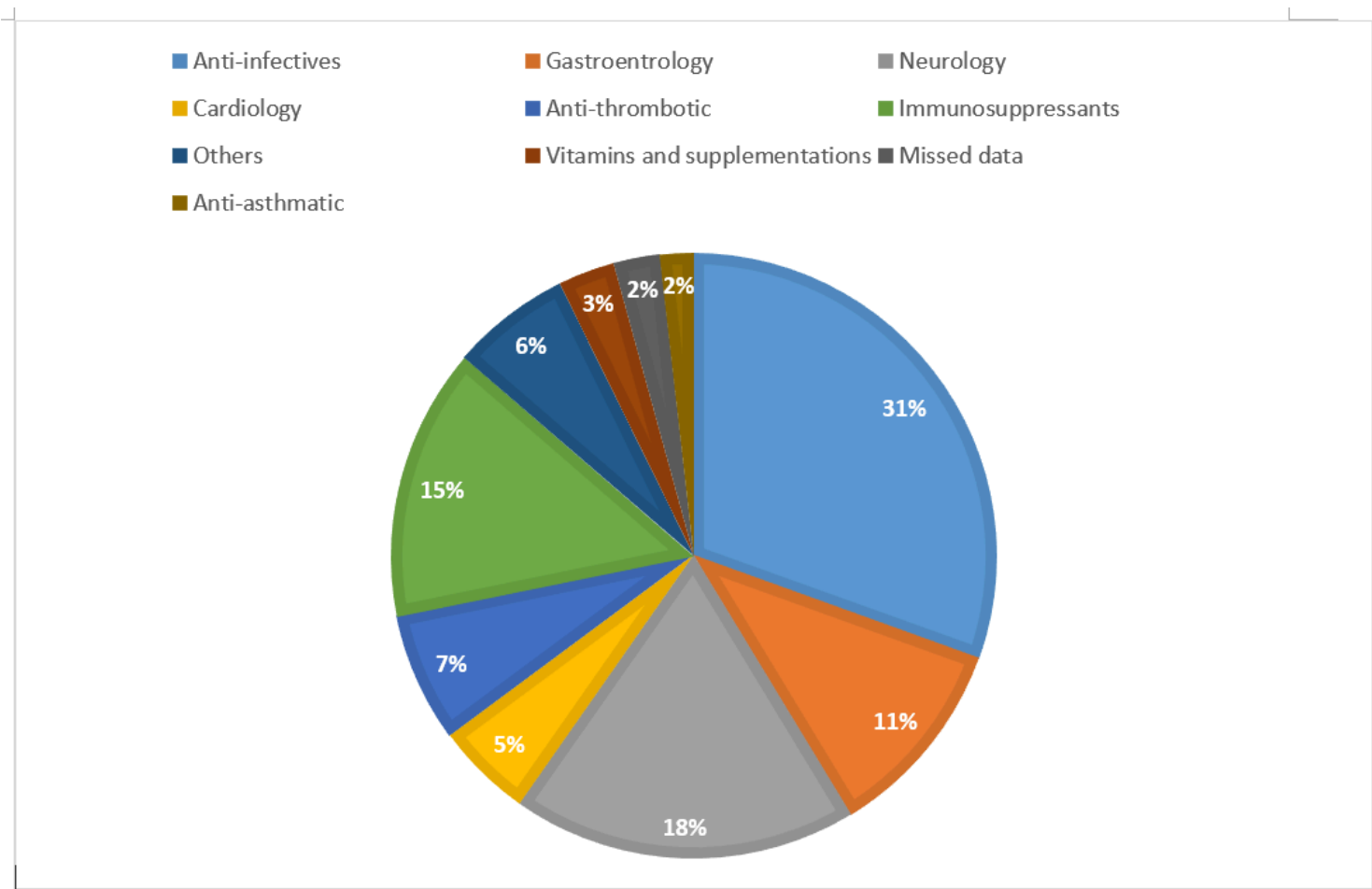


Figure 2

Distribution of PIs according to the type of medication by pharmacological class

Supplementary Files

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- [Table1.docx](#)
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