

# Antibiotic Stewardship in Pediatric Bone and Joint Infections: A Retrospective Study in Casablanca

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## Abstract

**Introduction:** Pediatric bone and joint infections are frequent and require rapid empirical antibiotic therapy, which must be adapted to the local microbiological ecology in order to limit unjustified use of broad-spectrum agents. Our study focuses on pediatric bone and joint infections (BJIs) managed in Casablanca, describing their epidemiological and microbiological characteristics and examining how well empirical antibiotic regimens align with subsequent targeted therapy. **Methods:** We conducted a retrospective, single-center observational study including all children aged 0 - 15 years hospitalized for a bone or joint infection between January 2020 and December 2023. Information was extracted from medical files using a standardized data collection sheet and covered clinical presentation, microbiological findings and details of empirical and targeted antibiotic treatment. Descriptive statistics were produced, and univariate analyses were performed to explore the relationships between the empirical regimen, pathogen isolation and the later need for broadened targeted therapy. **Results:** 161 children were included (mean age  $6.38 \pm 4.56$  years; median 6 years), with most patients belonging to the 1 - 9-year age range and very few presenting significant comorbidities. Septic arthritis was the leading diagnosis (46.0%), followed by soft-tissue collections (16.8%) and subperiosteal abscesses (15.5%). Microbiological samples were obtained in 99.4% of cases; cultures were negative in 46.6%, demonstrated susceptible pathogens in 40.4% and resistant strains in 8.7%. The empirical antibiotic therapy was predominantly amoxicillin-clavulanic acid combined with gentamicin (AC + G) (87.6%), while broader-spectrum combinations were only exceptionally prescribed. Targeted therapy also mainly relied on AC + G (88.8%), with vancomycin, imipenem-amikacin or ceftriaxone-gentamicin reserved for specific situations. Among patients started

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on standard AC + G, 96.5% continued on simple AC + G after adaptation, and only 3.5% required escalation to a broader regimen. In contrast, 60.0% of children who initially received a broad-spectrum empirical treatment ultimately required broadened targeted therapy (OR 40.8; 95% CI 11.5–144.4;  $p < 0.0001$ ). Isolation of a pathogen was significantly associated with the use of escalated targeted treatment, whereas the link between pathogen isolation and the initial choice of a broad-spectrum empirical regimen did not reach statistical significance. **Conclusion:** Our study shows that a standardized narrow-spectrum empirical regimen, adapted to the local microbiological ecology, is sufficient in most cases and supports the implementation of strict antimicrobial stewardship.

## Keywords

Pediatric Bone and Joint Infections, Osteomyelitis, Septic Arthritis, Empirical Antibiotic Therapy, Targeted Therapy, Antimicrobial Stewardship

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## 1. Introduction

Pediatric bone and joint infections (BJIs) encompass acute hematogenous osteomyelitis, septic arthritis and mixed forms, defined by bacterial invasion of the bone and/or joint and typically presenting with fever, pain and functional impairment of the affected limb [1] [2]. They are distinguished from chronic or inflammatory conditions, such as tuberculosis, Lyme disease or inflammatory arthropathies by their acute onset, infectious context and the risk of rapid destruction of the growth cartilage in the absence of timely management [1] [3]. Pathophysiologically, most pediatric BJIs arise from transient bacteremia in otherwise healthy children, facilitated by the particular vascular anatomy of the metaphysis and synovium, which favors septic embolization [1] [3]. The principal pathogens are *Staphylococcus aureus* (methicillin-susceptible or methicillin-resistant) and *Kingella kingae* in infants and preschool children, alongside  $\beta$ -hemolytic streptococci, *Streptococcus pneumoniae* and, more rarely, Gram-negative bacilli according to age and underlying conditions [1]-[4].

Epidemiological data from North American, Latin American and European cohorts indicate that BJIs constitute a significant cause of pediatric hospitalization, with an incidence estimated between 10 and 80 cases per 100,000 children, depending on age, vaccination status and geographical setting, with a peak between 6 months and 4 years and a male predominance [1] [2] [4]. The widespread use of MRI, now regarded as the reference modality for diagnosis and assessment of disease extent, has enabled earlier detection of bone and joint involvement, particularly in deep-seated or pauci-symptomatic forms [2] [5] [6]. In parallel, the deployment of molecular biology techniques, especially *K. kingae*-targeted PCR on osteoarticular samples and oropharyngeal swabs, has substantially improved microbiological yield in preschool children and highlighted often subtle clinical presentations linked to this pathogen [3] [4] [6].

These diagnostic advances have driven major changes in therapeutic strategies.

Current recommendations underline the necessity of prompt treatment while avoiding unnecessary invasiveness [2] [4]-[6]. Protocols now favour limited drainage procedures rather than extensive surgery, shortened courses of intravenous antibiotics followed by early oral switch, and, in carefully selected low-risk cases, exclusive oral therapy from the outset, provided adherence and follow-up are optimal [2] [4] [5]. Empirical regimens are designed to cover the dominant pathogens (MSSA, locally prevalent MRSA and *K. kingae*), then refined according to culture and susceptibility results, with an effort to minimise exposure to very broad-spectrum agents in immunocompetent children [1]-[4] [6]. In this context, our study aims to evaluate the adequacy of empirical antibiotic choices with local microbiology and to analyse concordance between empirical and targeted therapy, in order to optimise antibiotic stewardship in paediatric BJIs.

## 2. Methodes

### 2.1. Study Design

We conducted a retrospective, observational, single-center study with primarily descriptive objectives and an analytical component. The study covered a 4-year period, from 1 January 2020 to 31 December 2023, and was based on a review of medical records of children hospitalized for osteoarticular infection.

### 2.2. Setting

The study was carried out in the pediatric department of a university hospital in Casablanca, which provides medical and surgical management of osteoarticular infections in children. This tertiary-care center includes conventional pediatric wards and an intensive care unit, as well as access to an operating theatre and a full technical platform (microbiology laboratory, standard and advanced imaging, and pre-operative anesthetic assessment).

### 2.3. Participants

We included all patients aged 0 - 15 years who were hospitalized during the study period with a clinical and/or paraclinical diagnosis of osteoarticular infection and who received intravenous antibiotic therapy and/or surgical management. Eligible diagnoses comprised septic arthritis, acute or chronic osteomyelitis, subperiosteal abscess, phlegmon, infection related to orthopedic material and soft-tissue collections in continuity with bone.

We excluded incomplete or non-exploitable records, non-osteoarticular infections, and non-infectious inflammatory conditions (rheumatologic, tumoral or hematologic diseases mimicking infection). The final sample thus represented an exhaustive series of osteoarticular infections in children managed in the department between 2020 and 2023 (N = 161).

### 2.4. Variables

The following variables were collected:

1) **General characteristics:** year of admission, age (continuous and grouped), sex, past medical history (osteoarticular/traumatic, tumoral, other) and prior antibiotic use; 2) **Diagnostic and paraclinical data:** type and site of infection, imaging performed, and microbiological samples (joint fluid, bone, soft tissue, blood cultures); 3) **Microbiology:** global culture result (sterile, susceptible, resistant, not reported) and distribution of pathogens; 4) **Therapeutic management:** empirical and targeted antibiotic regimens and surgical procedures (drainage, type of surgery, hardware removal); 5) **Outcomes:** clinical/biological evolution, complications, functional sequelae, length of stay and vital status at discharge.

## 2.5. Data Sources/Measurement

Data were collected retrospectively using a standardized case report form. Information was extracted from admission registers, medical records, operative reports, nursing charts, microbiology reports, and radiology reports.

Key variables (diagnosis, empirical and targeted antibiotic regimens, microbiological results, and outcome) were double-checked and cross-validated between medical charts, surgical reports, and microbiology logs. Internal consistency checks were performed to identify missing or implausible values.

During the study period, molecular diagnostic tools such as *Kingella kingae*-specific PCR were not routinely available at our center and therefore were not used in the management of these cases. Microbiological diagnosis relied exclusively on conventional cultures from blood, joint fluid, bone or soft tissue samples.

## 2.6. Definitions and Operational Variables

Osteoarticular infection was defined as an inflammatory bone and/or joint syndrome of infectious origin, confirmed either by isolation of a pathogen on deep samples or blood culture, or by a consistent combination of clinical, biological and radiological findings justifying specific antibiotic therapy. Empirical therapy referred to the empirical regimen given before culture results, with the standard regimen being amoxicillin-clavulanic acid plus gentamicin (AC + G). Simple targeted therapy corresponded to continuation of AC + G, whereas broadened targeted therapy involved second-line regimens (e.g. ceftriaxone-gentamicin, imipenem-amikacin, vancomycin) in case of resistance or poor evolution. Culture results were classified as sterile, susceptible, resistant or not reported, and outcome as favorable, complicated or death.

Clinical outcome was classified as *favorable* when the patient showed clinical and biological improvement under treatment, with resolution of fever and local signs, normalization or clear decrease of inflammatory markers, no need for additional surgical intervention or antibiotic escalation, and discharge without immediate complications.

Outcome was considered *complicated* in the presence of any of the following:

persistence or recurrence of infection requiring antibiotic escalation or prolonged treatment, need for repeat surgical drainage, occurrence of systemic complications (septicemia, ICU admission), or development of functional sequelae at discharge.

No deaths occurred during the study period.

### **2.7. Bias**

We limited information and selection bias by using a single standardized form, cross-checking key data between sources, and double-checking critical variables. Some under-reporting of history or complications may still exist if not documented.

### **2.8. Study Size**

The study included all eligible children hospitalized for osteoarticular infection between 2020 and 2023. No prior sample size calculation was done, as the design was exhaustive and mainly descriptive.

### **2.9. Quantitative Variables**

Quantitative data (e.g. age, length of stay) were described as mean  $\pm$  SD or median (min–max, IQR), and qualitative data as counts and percentages, grouped into clinically relevant categories.

### **2.10. Statistical Methods**

We performed descriptive analysis for all variables, then univariate analyses to explore links between empirical regimen and targeted therapy, and between pathogen isolation and the use of broadened regimens. Proportions were compared with chi-square or Fisher tests; results were expressed as OR with 95% CI, with  $p < 0.05$  considered significant. Analyses were run with SPSS 23 and Excel.

### **2.11. Ethical Considerations**

The study used anonymized retrospective data, with no identifying information collected. Institutional and/or ethics committee approval was obtained, and confidentiality was maintained in line with local regulations and the Declaration of Helsinki.

## **3. Results**

### **3.1. Participants**

Over the study period (2020-2023), 161 patients were included. Admissions were more frequent in 2022 (37.9%) and 2023 (42.9%), whereas 2020 and 2021 accounted for only 11.2% and 8.1% of cases, respectively (**Table 1**). The mean age was  $6.38 \pm 4.56$  years (range 0.05 - 15 years, *i.e.* approximately 18 days to 15 years), with a median of 6 years (Q1 = 2; Q3 = 10). The most represented age groups were 5 - 9 years (30.4%) and 1 - 4 years (28.6%), followed by 10 - 14 years

(27.3%), while infants under 1 year (12.4%) and adolescents  $\geq 15$  years (1.2%) were less frequent.

The vast majority of patients had no notable past medical history (89.4%). Osteoarticular or traumatic antecedents (6.8%), bone or malignant tumors (1.9%) and various other medical histories (1.9%) were uncommon. Prior antibiotic therapy was documented in only 13.0% of cases (**Table 1**).

### 3.2. Descriptive Data

From a diagnostic standpoint, arthritis was the most frequent condition managed (46.0%), followed by soft-tissue collections (16.8%) and subperiosteal abscesses (15.5%). Phlegmons (6.8%), infections related to orthopedic material (6.2%), chronic osteomyelitis (3.7%) and septicopyaemia (2.5%) were less common, whereas acute otitis media and pandothysitis each accounted for only 1.2% of diagnoses (**Table 2**). A microbiological sample was taken in almost all cases (99.4%), reflecting a systematically diagnostic approach.

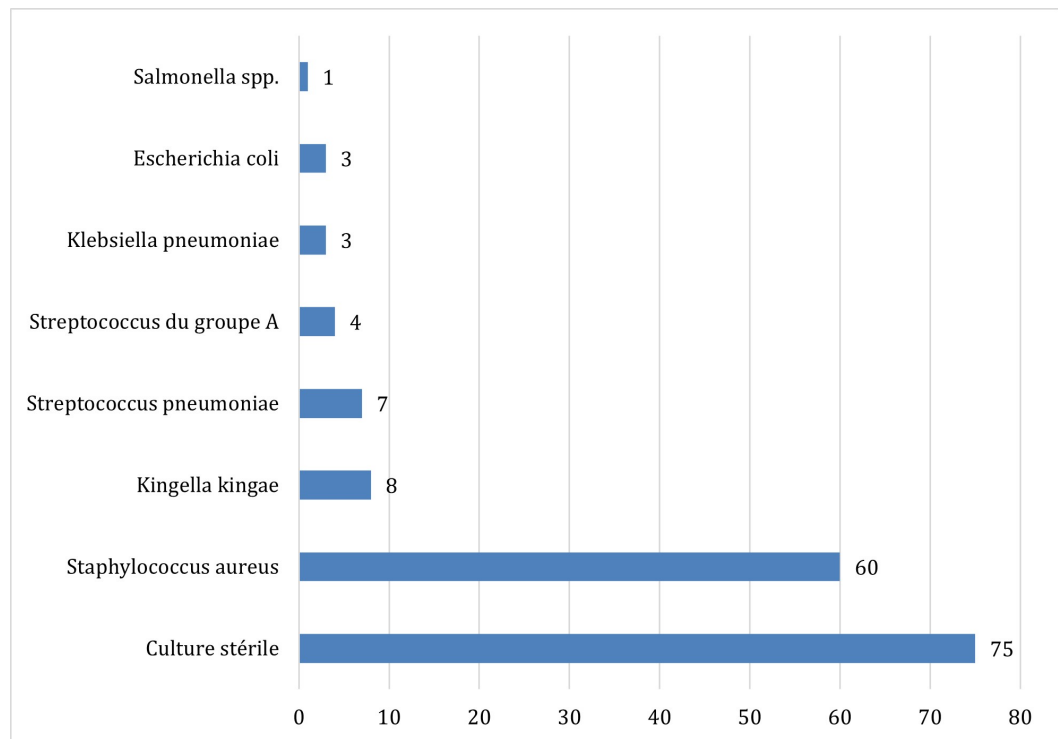
Microbiological analysis showed that nearly half of the samples were sterile (46.6%), while 40.4% of cultures demonstrated susceptibility to the antibiotics tested and 8.7% showed documented resistance; results were not available in 4.3% of cases. The detailed distribution of isolated pathogens is presented in **Figure 1**.

**Table 1.** General characteristics of children managed for bone and joint infection in the pediatrics department of a university center in Casablanca, from 1 January 2020 to 31 December 2023 (N = 161).

Variable	Category	Count (n)	Percentage (%)
Year of admission	2020	18	11.2
	2021	13	8.1
	2022	61	37.9
	2023	69	42.9
Age group	<1 year	20	12.4
	1 - 4 years	46	28.6
	5 - 9 years	49	30.4
	10 - 14 years	44	27.3
	$\geq 15$ years	2	1.2
N = 161; min = 0.05 years ( $\approx 18$ days); max = 15 years; mean = $6.38 \pm 4.56$ ; median = 6; Q1 = 2; Q3 = 10			
Past medical history	No particular past medical history (RAS)	144	89.4
	Musculoskeletal/traumatic history	11	6.8
	History of bone or malignant tumors	3	1.9
	Miscellaneous medical history	3	1.9
Prior antibiotic therapy	No	140	87.0
	Yes	21	13.0

**Table 2.** Diagnostic and paraclinical data of children hospitalized for bone and joint infection in the same center (2020-2023).

Variable	Category	Count (n)	Percentage (%)
Diagnosis	Arthritis	74	46.0
	Soft tissue collection	27	16.8
	Subperiosteal abscess	25	15.5
	Phlegmon	11	6.8
	Infection on hardware	10	6.2
	Chronic osteomyelitis (COM)	6	3.7
	Septicopyemia	4	2.5
	Acute otitis media (AOM)	2	1.2
	Pandiaphysitis	2	1.2
	Sample collected	Yes	160
No		1	0.6

**Figure 1.** Distribution of pediatric bone and joint infections according to the isolated pathogen over the study period (2020-2023).

### 3.3. Outcome Data

Regarding antibiotic management, the most frequently used empirical regimen was the combination amoxicillin-clavulanic acid plus gentamicin (AC + G), prescribed in 87.6% of patients. So-called “broad-spectrum” empirical regimens were used in a smaller proportion of cases: ceftriaxone + gentamicin + metronidazole (8.7%), ceftriaxone + gentamicin + vancomycin (3.1%) and AC + G + vancomycin

(0.6%) (Table 3).

For targeted therapy, AC + G also remained predominant (88.8%), while vancomycin alone was used in 4.3% of patients, imipenem + amikacin in 3.7% and ceftriaxone + gentamicin in 2.5%. The adapted regimen was not specified in 0.6% of cases (Table 3). Overall, these findings indicate a treatment strategy largely centered on a standard AC + G regimen, with less frequent use of broadened antibiotic combinations.

### 3.4. Main Results

The combined analysis of empirical and adapted regimens (Table 4) showed a strong concordance between empirical use of AC+G and maintenance of the same combination after adaptation: among patients who started on standard empirical AC + G, 136 remained on this regimen as targeted therapy, whereas only 5 required escalation to vancomycin. In contrast, patients who initially received a broad-spectrum empirical regimen (AC + G + V, CTX + G + M or CTX + G + V) more often required a broadened adapted regimen (vancomycin, imipenem + amikacin, ceftriaxone + gentamicin).

When data were grouped (Table 5), 96.5% of patients who started with standard empirical AC + G subsequently received a simple adapted regimen (AC + G), and only 3.5% required a broadened adapted antibiotic therapy. Conversely, among patients initially treated with a broad-spectrum empirical regimen, 60.0% required a broadened adapted regimen, while 40.0% remained on AC + G. This difference corresponds to an odds ratio (OR) of 40.8 (95% CI 11.5 - 144.4;  $p < 0.0001$ ), indicating a strong association between use of a broad-spectrum empirical regimen and the subsequent need to maintain or escalate to a broadened adapted regimen (Table 5).

**Table 3.** Empirical and targeted antibiotic regimens, and overall antibiogram results in children with BJIs (2020-2023).

Variable	Category	Count (n)	Percentage (%)
Empirical antibiotic regimens (probabilistic ATB)	Amoxicillin-clavulanic acid + Gentamicin	141	87.6
	Ceftriaxone + Gentamicin + Metronidazole	14	8.7
	Ceftriaxone + Gentamicin + Vancomycin	5	3.1
	Amoxicillin-clavulanic acid + Gentamicin + Vancomycin	1	0.6
Targeted antibiotic therapy (adapted ATB)	Amoxicillin-clavulanic acid + Gentamicin	144	89.4
	Vancomycin	7	4.3
	Imipenem (Tienam®) + Amikacin	6	3.7
	Ceftriaxone + Gentamicin	4	2.5
Overall antibiogram	Sterile culture	75	46.6
	Susceptible (S)	65	40.4
	Resistant (R)	14	8.7
	Not reported	7	4.3

**Table 4.** Correlation between empirical antibiotic therapy and targeted therapy in children hospitalized for BJIs (2020-2023).

Variable	Category (empirical ATB)	Targeted ATB AC + G n	Targeted ATB CTX + G n	Targeted ATB IPM + AMK n	Targeted ATB VANCO n	p-value
Empirical ATB/targeted ATB	AC + G	136	0	0	5	p < 0.001
	AC + G + V	1	0	0	0	
	CTX + G + M	4	3	5	2	
	CTX + G + V	3	1	1	0	

**Table 5.** Correlation between the type of empirical regimen (standard versus broad) and the use of broadened targeted antibiotic therapy.

Variable	Category	Simple targeted ATB (AC + G) n (%)	Broadened targeted ATB* n (%)	OR (95% CI) for "broadened regimen ≠ AC + G"	p-value
Empirical regimen vs type of targeted ATB	AC + G	136 (96.5%)	5 (3.5%)	1 (reference)	-
	Broadened empirical regimen (≠ AC + G)	8 (40.0%)	12 (60.0%)	40.8 (11.5 - 144.4)	< 0.0001

### 3.5. Other Analyses

The impact of microbiological results on antibiotic strategy was explored using binary analyses (Table 6). The presence of an isolated pathogen was significantly associated with more frequent use of a broadened adapted regimen: among patients with sterile cultures, only 3 received broadened therapy compared with 72 treated with simple AC + G, whereas in patients with a documented pathogen, 14 received broadened therapy versus 72 on simple AC + G. By contrast, children who were started on a broad-spectrum empirical combination (amoxicillin-clavulanic acid with gentamicin and vancomycin, or ceftriaxone with gentamicin and metronidazole, or ceftriaxone with gentamicin and vancomycin) more frequently required an adapted regimen that remained broad (vancomycin, imipenem plus amikacin, or ceftriaxone plus gentamicin).

**Table 6.** Binary analyses involving pathogen isolation, type of targeted antibiotic therapy and initial empirical regimen.

Analysis	Category	Group 1 n	Group 2 n	OR (95% CI)	p-value
Presence of a pathogenic organism vs sterile culture and use of a broadened targeted ATB	Sterile culture	72 (simple ATB)	3 (broadened ATB)	-	0.018
	Pathogenic organism isolated	72 (simple ATB)	14 (broadened ATB)	4.67 (1.29 - 16.94)	
Presence of a pathogenic organism vs sterile culture and broadened empirical regimen	Sterile culture	69 (empirical AC + G)	6 (broadened empirical)	-	0.15
	Pathogenic organism isolated	72 (empirical AC + G)	14 (broadened empirical)	2.24 (0.81 - 6.15)	

When the data were pooled (Table 5), 96.5% of patients initially treated with the standard empirical combination of amoxicillin-clavulanic acid plus gentamicin were subsequently managed with the same simple adapted regimen, and only

3.5% required escalation to a broadened adapted antibiotic treatment. In contrast, among those who started with a broad-spectrum empirical regimen, 60.0% ultimately received a broadened adapted regimen and 40.0% remained on amoxicillin-clavulanic acid plus gentamicin. This contrast corresponds to an odds ratio of 40.8 (95% confidence interval 11.5 - 144.4;  $p < 0.0001$ ), reflecting a strong association between the use of a broad-spectrum empirical regimen and the subsequent need to continue or intensify towards a broadened adapted regimen (Table 5).

We also examined whether the isolation of a pathogen influenced the initial choice of empirical antibiotic regimen. When comparing children with a documented pathogen to those with sterile cultures, the use of a broad-spectrum empirical regimen was more frequent in the former group, although this difference did not reach statistical significance, the OR was 2.24 (95% CI 0.81 - 6.15;  $p = 0.15$ ), indicating a trend towards more frequent use of broad-spectrum empirical regimens in the presence of a pathogen, but without a significant difference in this cohort (Table 6).

Overall, these analyses highlight:

- very frequent use of the standard AC + G regimen, both empirically and as targeted therapy;
- a strong association between the initial use of a broad-spectrum empirical regimen and the subsequent need to maintain or reinforce this approach in adapted therapy;
- and a significant influence of pathogen isolation on the decision to broaden antibiotic therapy, whereas the relationship between microbiology and the empirical regimen is less clear statistically.

#### 4. Discussion

This study, conducted in a tertiary center in Casablanca between 2020 and 2023, provides original data on antibiotic adaptation in pediatric bone and joint infections. The population included 161 children with a mean age of 6.38 years, with a predominance of the 1 - 9-year age groups. These results are in line with major pediatric series in which BJIs occur mainly in preschool and school-aged children, although other cohorts dominated by *Kingella kingae* report an earlier peak around 2 - 4 years [7]-[9], and higher ages in series focusing on acute hematogenous osteomyelitis [10]-[13]. The low rate of comorbidities and the rarity of bone or tumor history in our series are similar to cohorts including otherwise healthy children [7] [9] [13].

From a diagnostic standpoint, the distribution between arthritis, soft-tissue collections, subperiosteal abscesses and osteomyelitis mirrors the diversity of presentations described in large mixed series [7]-[9] [12]-[14]. The microbiological approach was highly systematic, with sampling performed in 99.4% of patients, a rate higher than in several studies where 25% - 30% of children have no microbiological investigation [10] [12]. Despite this strategy, almost half of samples remained sterile, a result comparable to that reported in acute hematogenous oste-

omyelitis when molecular techniques are not routinely used [11]-[13]. By contrast, teams that have widely implemented *K. kingae*-specific PCR or other molecular tools report higher documentation rates above 60%, with *K. kingae* predominating in younger children [7]-[9]. This heterogeneity highlights the degree to which the available technical platform influences the ability to refine antibiotic adaptation.

This focused empirical strategy, centered on a limited number of standard combinations, differs from the more varied approaches described in other pediatric series. In several European cohorts, first-line treatment is most often based on an antistaphylococcal beta-lactam (such as co-amoxiclav, cloxacillin or cefazolin), sometimes combined with an aminoglycoside and adapted to the child's age [7] [9] [12] [13]. In contrast, many North American teams routinely include empirical coverage of methicillin-resistant *Staphylococcus aureus* (MRSA) with clindamycin or vancomycin, reflecting a non-negligible prevalence of MRSA infections in children [10] [11] [15]. In those studies, *S. aureus* frequently represents more than half of all isolates, with a substantial proportion of MRSA that justifies broader empirical regimens [10]-[13]. Conversely, in series where *Kingella kingae* and methicillin-susceptible *S. aureus* (MSSA) predominate, a more targeted empirical regimen is generally sufficient, with very good agreement between empirical treatment and susceptibility profiles [7] [9] [15]. Our results, characterized by the apparent absence of MRSA and the central place of standard regimens, fall within this second pattern and are in line with a restrained use of reserve antibiotics.

A key message from our work is the excellent match between the standard empirical regimen and the definitive targeted therapy. Among children who initially received amoxicillin-clavulanic acid combined with gentamicin (AC + G), more than 96% remained on this same combination after adaptation, and only 3.5% required escalation to a broadened regimen. This remarkable stability contrasts with reports in which the first-line treatment is frequently revised, either because microbiological documentation reveals resistant organisms or because the clinical response is deemed insufficient [12] [14].

Musso *et al.* reported a change in intravenous regimen in half of their cases [12], while Cohen *et al.* described modification of empirical treatment in almost one quarter of children with septic arthritis, mainly within the first three days of hospitalization [14]. Conversely, the studies by Lemoine *et al.* and Filleron *et al.* show, as in our work, excellent adequacy between relatively simple empirical regimens (co-amoxiclav, cloxacillin, cefamandole) and susceptibility profiles, with very few necessary adaptations and clinical cure rates close to 100% [7] [9]. Taken together, these converging data suggest that, in settings with low MRSA prevalence, a standardized empirical strategy based on a beta-lactam, with or without an aminoglycoside, provides a solid foundation for subsequent targeted adjustment.

Our analysis also shows a strong association between the initial use of a "broad" empirical regimen (third-generation cephalosporin-based schemes, metronidazole and/or vancomycin) and the continuation of broadened targeted antibiotic therapy (OR 40.8; 95% CI 11.5 - 144.4;  $p < 0.0001$ ). In our setting, the use of an

initially broad-spectrum antibiotic regimen appears less as simple “over-treatment” and more as a clinical marker of infections that are more severe or complex, in which the subsequent need for prolonged and expanded coverage is ultimately confirmed once microbiological data become available. This pattern is similar to that reported in cohorts where broad regimens are deliberately reserved for complicated presentations, suspected methicillin-resistant *Staphylococcus aureus* infection, or the most critically ill children [10]-[12].

Our two-by-two analyses further show that the documentation of a pathogen is significantly associated with the prescription of a broadened targeted regimen, whereas the mere presence of an identified organism is not significantly linked to the initial decision to start with a broad-spectrum empirical treatment. In other words, it is mainly the microbiological result, obtained a posteriori, that leads to broadening antibiotic therapy rather than clinical suspicion alone. These findings echo those of Mobayed *et al.*, who emphasize the value of a disease-specific antibiogram to safely support relatively focused empirical regimens [15], and those of Hu *et al.* and Roversi *et al.*, who underline the importance of local ecology for calibrating empiricism and guiding subsequent adaptation [8] [11].

Finally, our study has several practical implications for antibiotic adaptation in pediatric BJIs. The strong concordance between empirical AC + G and targeted therapy, combined with the rarity of MRSA, supports maintaining a relatively narrow first-line regimen, in line with series demonstrating the efficacy of shorter treatments with early oral switch [9] [12]. The high proportion of sterile cultures and the absence of targeted PCR techniques nonetheless suggest a potential underestimation of hard-to-culture pathogens, particularly *K. kingae* in younger children [7]-[9]. The gradual integration of molecular tools, regular updating of the local antibiogram, and clear clinical criteria for the use of broad-spectrum regimens should further optimize the balance between infection control, prevention of resistance, and rational antibiotic use in pediatrics.

Although nearly half of microbiological samples were sterile, this did not appear to negatively affect clinical outcomes. The vast majority of children, including those with sterile cultures, evolved favorably under the standard empirical regimen based on amoxicillin-clavulanic acid and gentamicin. This suggests that, in our setting, the most likely uncultured pathogens are effectively covered by this regimen. Similar findings have been reported in other series, where favorable outcomes were achieved despite limited microbiological documentation, particularly in the absence of routine molecular diagnostics. These results support the safety of a narrow-spectrum empirical approach when adapted to local epidemiology, even in the context of a high rate of culture-negative infections.

Despite the limitations related to the monocentric and retrospective design, the internal consistency of our results and their concordance with several major international series [7]-[15] suggest that the Casablanca approach—centered on a standardized AC + G regimen with targeted adaptation based on microbiological results and clinical course—is a relevant strategy for managing pediatric bone and

joint infections in a setting with low prevalence of highly resistant organisms.

## 5. Conclusion

In our center, pediatric osteoarticular infections are managed mainly with a standardized empirical antibiotic regimen based on amoxicillin-clavulanic acid and gentamicin, which proves appropriate in the vast majority of cases, with limited use of broader-spectrum protocols. Isolation of a pathogen and the empirical use of broad-spectrum agents are strongly associated with continuation of extended antibiotic therapy, highlighting the risk of unjustified prolongation of such treatments. These findings support an antibiotic stewardship strategy based on narrow-spectrum empirical regimens tailored to local ecology, combined with systematic microbiological sampling and targeted adjustment rather than empirical broadening of therapy.

## What Is Known about This Topic

Pediatric bone and joint infections (BJIs) are common emergencies that expose children to a risk of cartilage destruction, functional sequelae and systemic complications in the absence of timely management. Bone and joint infections in children are most often due, depending on age, to *Staphylococcus aureus* (both methicillin-susceptible and methicillin-resistant strains) and *Kingella kingae*. Published series show wide variation between countries in the choice of empirical antibiotic therapy: some teams favor relatively focused antistaphylococcal beta-lactams, while others use combinations that include glycopeptides or third-generation cephalosporins, especially in regions where methicillin-resistant *S. aureus* is common. This heterogeneity highlights the importance of tailoring therapeutic protocols to local microbiological patterns and of avoiding unnecessary exposure to broad-spectrum antibiotics, in line with rational antibiotic use and stewardship principles.

## What Our Study Adds

Our work provides the first detailed data, from a tertiary center in Casablanca, on antibiotic adaptation in pediatric BJIs, based on an exhaustive cohort of 161 children followed over four years. It shows that a standardized empirical strategy centered on amoxicillin-clavulanic acid plus gentamicin remains appropriate in the vast majority of cases, with a very low rate of escalation after microbiological documentation. The analysis shows that starting treatment with a so-called broad empirical regimen is strongly linked to the subsequent maintenance of an expanded-spectrum therapy, while it is chiefly the identification of a causative pathogen that significantly prompts later extension of the antibiotic spectrum. Taken together, these findings provide solid local arguments in favor of initiating therapy with narrow-spectrum regimens tailored to the Moroccan microbiological context, coupled with systematic microbiological sampling and careful, evidence-based adjustment of treatment, rather than routine empirical broadening of antibiotic cov-

erage.

## Author Contributions

**Salma Bouchti, Khadija Essafi:** ensured study design, data collection, statistical analysis and manuscript drafting.

**Hasna Darouich, Kaoutar El Fakhr, Samira Kalouch:** provided scientific supervision, methodological oversight, critical revision and final approval of the manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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