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Impact of COVID-19 on Antimicrobial Stewardship Activities in Hospitalised Children: A Scoping Review

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ABSTRACT

Aim: COVID-19 has brought unprecedented challenges to the healthcare system. The rapid spread of the virus, laboratory burnout, exhausted staff, diagnostic uncertainty and lack of guidelines cumulatively disrupted hospital antimicrobial stewardship (AMS) programs. This scoping review evaluated how the COVID-19 pandemic has impacted the implementation of AMS, particularly within the context of clinical audits.

Methods: An initial trend analysis was performed using a database search from 2000 to 2022. This review was developed following PRISMA-Scr guidelines. Databases such as Medline, Embase, Cochrane Library and CINAHL were searched using Medical Subject Headings and free text for 'Children', 'antimicrobial stewardship' and 'COVID-19'. Primary studies that reported data on antimicrobial use among hospitalised children during COVID-19 from December 2019 to December 2022 were considered.

Results: Paediatric AMS-related research output changed annually by −4.94% in 2022 compared to 14.44% in 2019. Of 677 articles, 15 were included, with 3 added through snowballing technique. All the studies were observational and from countries of all income levels. A quantitative measure of antibiotic use was the commonly assessed sub-category of AMS, while three studies performed the audit for a reason for antibiotic use, microbiological cultures, and surgical prophylaxis. Most studies reported antimicrobial use as prevalence, while two reported the days of therapy, and two used the AWaRe classification and the antibiotic spectrum index (ASI).

Conclusions: Paediatric AMS activities were disrupted during the COVID-19 pandemic. A basic quantitative measure of antibiotic use was the only measure of assessment, with other AMS components unreported. A robust paediatric-focused AMS resilient to future pandemics and evidence-informed stewardship approach is needed.

1 | Introduction

The first SARS-CoV-2 case in late 2019 quickly escalated into a global pandemic, severely disrupting the healthcare system [1, 2]. Challenges included rapid disease spread, shortages of medical supplies and staff, and strained laboratories [3]. Children with their distinct pathophysiology were less impacted by COVID-19, but antimicrobial use remained high, raising concerns over inappropriate prescriptions [4–6].

Before the pandemic, antimicrobial agents were still commonly prescribed in children [7, 8]. Over 60% of encounters had an

Summary

- What is known
  - The use of antimicrobial agents is common in paediatrics and is increasing with about half of the prescriptions deemed inappropriate.
  - Antimicrobial Stewardship programs have proven to improve antimicrobial utilisation practices.
- What is new
  - The COVID-19 pandemic has greatly affected the paediatric antimicrobial stewardship programs across the world and continues to adversely affect its functioning during the post-pandemic phase.
  - Basic prescription-based antimicrobial utilisation indicators were reported without implementation or study of any of the other AMS components/performance indicators.

antibiotic, of which 20%–67% were deemed inappropriate [9–12]. A global point prevalence survey reported that 37% of hospitalised children had received at least one antimicrobial, and about 22% were targeted therapies [13]. A meta-analysis of the last two decades has reported a pooled antibiotic prescription rate of 45% and concluded a high antibiotic usage in ambulatory care for acutely ill children [14]. The primary concern was the use of broad-spectrum antibacterials and the significantly longer duration of therapies [15]. Such overuse of antibiotics is associated with an increased incidence of adverse events, duration of hospital stays, cost of treatment, and prevalence of Multi-Drug Resistant microorganisms (MDR) [15–17]. The emerging Antimicrobial Resistance (AMR) due to the spread of MDR organisms is a global health concern that is worsening every year [18–20].

To combat the growing issue of AMR, the Antimicrobial Stewardship (AMS) program implements interventions that systematically improve antimicrobial use. This quality improvement program has been widely adopted to specific hospital goals. The World Health Organization (WHO), the Centre for Disease Control and Prevention (CDC) and other global organisations have proposed core strategies for effective AMS implementation [21–23]. The development of clinical guidelines and policies can aid physicians with prescribing appropriate therapies, while prospective audits and routine feedback can improve compliance [24, 25]. These qualitative and quantitative measures have successfully reduced the inappropriate use of antibiotics [24].

AMS programs, essential for combating AMR, faced setbacks during the pandemic due to resource diversion, staff reassignment, and challenges distinguishing viral from bacterial infections [26]. Studies exploring AMS in children are sparse and are further impacted by the COVID-19 pandemic. The existing literature has reported a rise in the use of antibiotics during the COVID-19 pandemic and a low incidence of secondary bacterial infection among COVID-19 patients [25, 27, 28]. In this scoping review, we aimed to evaluate how the COVID-19 pandemic influenced the implementation of specific AMS components assessed through clinical audits in hospitalised children. We discussed the implications for developing and strengthening a robust AMS system for children during global health crises.

2 | Methods

This review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-Scr) [29].

3 | Information Sources and Search Strategy

Databases searched include MEDLINE, Embase, Cochrane Library and CINAHL. An initial search was performed using a combination of Medical Subject Headings (MeSH) and free text for 'Children' AND 'antimicrobial stewardship' for the years 2000–2022. A proximity search with various combinations of words describing antimicrobial stewardship strategies was performed. This data were used to study the trend of research output in paediatric AMS over the last 23 years. Following this, a systematic search based on PRISMA-Scr criteria was conducted using a combination of MeSH and free text for 'Children' AND 'antimicrobial stewardship' AND 'COVID-19' (Supporting Information) The search was performed in July 2023 and was restricted to the studies reporting data collected during COVID-19 from December 2019 to December 2022. Any additional studies were identified through the snowball technique involving examining the references of the articles selected for full-text review.

4 | Inclusion/Exclusion Criteria

The AMS program comprises of several elements to promote the appropriate use of antimicrobials. Studies were analysed for the key AMS components such as audit and feedback, formulary restriction and pre-authorisation of antibiotics, and measure of antibiotic use [22, 23]. For this review, the audit and feedback component was sub-categorised into documentation of reason for antibiotic use, antibiotic timeout, adherence to guidelines, Intravenous (IV) to oral switch, request for microbiological cultures and surgical prophylaxis. The measure of antibiotic use was sub-categorised into qualitative and quantitative methods.

Studies involving hospitalised children were included. All primary published studies reporting patient-level data that covered at least one of the AMS components as listed were considered for full-text review. Studies conducted on all age groups and where it was difficult to distinguish the data from children, or children's data (based on age range) was missing were excluded. Inclusion was restricted to articles published in English language. Randomised controlled trials, cohort studies, audits, surveys, pre-post studies, short editorials, brief communications and cross-sectional studies were included. Case-reports, case-series, review articles, comments, abstracts, clinical trial protocols and opinions were excluded. Any published studies reporting the data collected before December 2019 or after December 2022 were excluded as the authors intended to study the AMS activities in hospitalised children during the COVID-19 pandemic.

5 | Study Selection

MZA and SK independently assessed the inclusion of studies based on the title, abstract and full text. Any difference of opinion was resolved through mutual discussion between MZA and SK.

6 | Data Collection and Data Analysis

We used a standardised data collection form that comprised study design, duration of data collection, region, study setting, sample size, AMS component and key findings. The economic categorisation of the countries was based on the World Bank classification [30]. The data were presented in two different tables. Table 1 reports the conduct of AMS components in hospitalised children during the COVID-19 pandemic and their quality assessment as per the Infectious Diseases Society of America (IDSA)/Society for Healthcare Epidemiology of America (SHEA) recommendations [31]. Table 2 presents the characteristics of the AMS studies performed in hospitalised children during COVID-19 pandemic.

7 | Results

Research output on paediatric AMS has increased, with 448 articles published in 2000–2389 in 2022. The annual change in the number of articles published pre-pandemic has shown a rising trend, with counts of 159, 213, and 302 for 2017, 2018 and 2019, respectively. However, the COVID-19 pandemic has slowed the trend and resulted in an eventual decline with an annual change of 283, 133 and −118 for 2020, 2021 and 2022, respectively (Table S1). The research output and the trend in the percentage change over the last 23 years are depicted in Figure 1.

An initial database search yielded 677 articles, of which 612 were excluded as 91 were duplicates and 521 were irrelevant. Among the 65 studies included for full-text review, 50 were excluded: 23 were difficult to distinguish paediatric data, 12 were irrelevant, 11 were wrong population and 4 were wrong study design. Finally, 18 eligible studies were included, 15 from the initial search and 3 through the snowballing technique (Figure 2).

All the included studies were observational in design and can be broadly categorised as clinical audits. Two of the studies performed an audit for documentation of reason for antibiotic use, while one study performed an audit for microbiological cultures and surgical prophylaxis [32, 33]. All of the studies performed a quantitative measure of antibiotic use [4, 6, 28, 32–46]. However, none of the studies incorporated other AMS components, such as formulary restriction and pre-authorisation. Only one prospective multicentre study evaluated more than two sub-categories of AMS [33]. The studies were compared to the IDSA/ SHEA recommendations for quality assessment. Only one study performed the audit and feedback component, which was in line with the recommendations. In terms of measure of antimicrobial use, two studies reported the Days of Therapy (DOT), while the others did not report consumption according to the recommendations (Table 1).

The review included studies performed in high-income countries (Greece, Poland, Saudi Arabia, Spain, United Kingdom, United States of America), upper-middle-income countries (Argentina, Colombia, Costa Rica, Mexico, Peru, Serbia), lower middle-income countries (India, Pakistan) and lower income countries (Bangladesh) [30]. Twelve studies were retrospective, and six were prospective in design. Sixteen studies evaluated the use of antibiotics during the ongoing pandemic, whereas two studies compared the usage of antibiotics between the pre-pandemic and pandemic periods. Table 2 summarises the included studies.

Measure of antibiotic use was the commonly conducted sub-category, which was predominantly reported as the prevalence of antibiotics prescribed for hospitalised children (Figure 3). Among the studies comparing antibiotic use before and during the COVID-19 pandemic, the antibiotic prescription rate was significantly higher in the early months of pandemic (March and April 2020) compared to the previous year [36]. Similar study conducted in the USA among status asthmaticus patients reported an 11% decrease [35], while other studies reported a decrease of an average of 0.6% from April to October 2020 [32], and a decrease of 5.5% from March 2020 to March 2021 [28]. Zombori has measured antibiotic use in terms of DOT/1000 Patient Days and Antibiotic Spectrum Index/Antibiotic Day (ASI/AD) and reported that ASI/AD is less variable and better explains the use of broad-spectrum antibiotics during a specific time or in a patient group [46]. Another study reported antibiotic use in terms of WHO AWaRe (Access, Watch, Reserve) classification and found that most antibiotics belong to the Access category [45]. A study that compared the use of antibiotics in hospitals reported a lower rate of antibiotic prescription (83.1% vs. 91.2%) in hospitals where the clinicians adhered to the national clinical guidelines for managing children with COVID-19 [6].

The indication for prescribing antibiotics was sepsis (Spain: 31.1%, Pakistan: 26.5%, Latin America: 22.6%), urinary tract infection (Spain: 40%), pneumonia (Pakistan: 31.6%, Spain: 28.1%, Latin America: 13.6%) and gastroenteritis (Spain: 16%, Pakistan: 9.3%) [28, 32, 33]. Ceftriaxone was prescribed: 81% in Poland [39], 53.9% in Spain [28], 40.6% in USA [44], 29.6% in Saudi Arabia [34], 24.3%–46.8% in Pakistan [33, 45], 22.8% in Serbia [41], 17.3% in Latin America [32], 4% in Mexico [40], and its use was doubled as compared to pre-COVID-19 in Spain [36]. Studies conducted in Spain and the USA reported a 7% incidence of secondary bacterial infection [28, 44]. With ongoing changes in antimicrobial usage, authors from Spain have also evaluated the rationality based on guideline concordance and appropriateness of dose and duration, and reported the quality of antimicrobial prescriptions has not decreased compared to the pre-pandemic period, but the prevalence of antimicrobials remains high [36, 37].

8 | Discussion

This scoping review evaluates the impact of the COVID-19 pandemic on key components of paediatric AMS within the

TABLE 1 | Conduct of AMS components in hospitalised children during the COVID-19 pandemic and their quality assessment as per the IDSA/SHEA recommendations.

AMS components sub-categories	Aguilera-Alonso	Alavudeen	Chowdhury	Loannou	Kumar	Kumar	Moffitt	Murillo-Zamora	Mustafa	Mustafa	Nusrat	Panesar	Prijic	Swann	Toczyłowski	Velasco-arnaiz	Yock-corrales	Zombori
Audit and feedback																		
Documentation of reason for antibiotic use	—	—	—	—	—	—	—	—	✓	—	—	—	—	—	—	—	✓	—
Antibiotic timeout	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Adherence to guidelines	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
IV to oral switch	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Request for microbiological cultures	—	—	—	—	—	—	—	—	✓	—	—	—	—	—	—	—	—	—
Surgical prophylaxis	—	—	—	—	—	—	—	—	✓	—	—	—	—	—	—	—	—	—
Measure of antibiotic use																		
Qualitative	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	✓	—	—
Quantitative	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Formulary restriction and pre-authorisation	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quality of conduct of AMS components against the IDSA/SHEA recommendations																		
Measure of antibiotic use																		
Quantitative																		
DOT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	✓	—	✓
DDD	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Others																		
Prevalence	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	—	✓	✓
AWaRe	—	—	—	—	—	—	—	—	—	✓	—	—	—	—	—	—	—	—
ASI/AD	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	✓

Note: '—' did not address the component; ✓ addressed the component; AMS-Antimicrobial Stewardship; DOT-Days of Therapy; DDD-Defined Daily Dose, AWaRe-Access, Watch and Reserve classification, ASI/AD-Antibiotic Spectrum Index/Antibiotic Day.

TABLE 2 | Characteristics of the AMS studies performed in children during COVID-19 pandemic.

Author	Publication year	Duration of data collection	Region	Design	Study setting	Sample size patients (hospitals)	AMS component	Results	Take away points
Aguilera-Alonso	2022	Mar 21 to Mar 22	Spain	Retrospective Cohort Multi-centre	Inpatient with COVID-19	640 (76)	Measure of antibiotic use	54.2% (347/640) were prescribed an antibiotic. Ceftriaxone was the most used (53.9%). Bacterial infection was seen in 7%.	Moderate rates of antibiotic prescription. Low coinfection with secondary infection. Rate of antibiotic prescriptions reduced over time.
Alavudeen	2021	Oct 20 to Mar 21	Saudi Arabia	Retrospective Cohort Single centre	Inpatient with urinary tract infection	132 (1)	Measure of antibiotic use	100% were prescribed an antibiotic. Ceftriaxone was the most used (29.55%), followed by vancomycin (25%).	High rates of antibiotic prescription.
Chowdhury	2022	July 21 to Nov 21	Bangladesh	Prospective Cross-sectional Multi-centre	Inpatient with COVID-19	146 (24)	Measure of antibiotic use	86.3% (126/146) were prescribed an antibiotic. Almost all antibiotics were administered empirically (98.4%—124/126).	High rates of antibiotic prescription. Majority are indicated for empirical usage.
Ioannou	2022	Mar 22 to Apr 22	Greece	Prospective Cross-sectional Multi-centre	Inpatient	35 (8)	Measure of antibiotic use	34.3% were prescribed an antibiotic.	Moderate rates of antibiotic prescription.
Kumar	2021	July 21 to Nov 21	India	Prospective Cross-sectional Multi-centre	Inpatient with COVID-19	243 (30)	Measure of antibiotic use	75.3% were prescribed an antibiotic. Azithromycin was the most used (76.7%). 68.3% were empirical	High rates of antibiotic prescription High prevalence of Azithromycin use Majority were indicated for empirical use.
Kumar	2021	Aug 21	India	Retrospective Cross-sectional Multi-centre	Inpatient with COVID-19	36 (5)	Measure of antibiotic use	69.4% were prescribed an antibiotic.	Moderate rates of antibiotic prescription.
Moffitt	2023	Mar 20 to Dec 20	USA	Retrospective Cohort Multi-centre	Inpatient with COVID-19	532 (52)	Measure of antibiotic use	63.3% were prescribed antibiotics. Ceftriaxone was the most used (40.6%), followed by vancomycin (28.4%). Bacterial infection was seen in 7%.	Moderate rates of antibiotic prescription. Low coinfection with secondary infection.
Murillo-Zamora	2022	Mar 20 to Dec 21	Mexico	Retrospective Cohort Multi-centre	Inpatient with COVID-19	1601 (-)	Measure of antibiotic use	13.2% were prescribed an antibiotic. Ceftriaxone was the most used (4%).	Low rates of antibiotic prescription.

(Continues)

TABLE 2 | (Continued)

Author	Publication year	Duration of data collection	Region	Design	Study setting	Sample size patients (hospitals)	AMS component	Results	Take away points
Mustafa	2022	Oct 20 to Nov 20	Pakistan	Prospective Cross-sectional Multi-centre	All Inpatient	607 (16)	Measure of antibiotic use. Audit and feedback	97.5% were prescribed an antibiotic. Ceftriaxone was the most used (24.3%). Azithromycin was used in 2.4%. Majority (87.4%) of antibiotic prescriptions lacked a reason on medical records. All antibiotics were prescribed without any request for microbiological culture. Surgical prophylaxis in 19% of children.	High rates of antibiotic prescription. Majority are indicated for empirical usage and lacked a reason on medical records. Not a single culture result was requested in any child.
Mustafa	2023	March 22 to Dec 22	Pakistan	Retrospective Cohort Multi-centre	Inpatient with COVID-19	433 (4)	Measure of antibiotic use	85.5% were prescribed an antibiotic. Azithromycin was the most used (49.5%), followed by ceftriaxone (46.8%). As per WHO AWARE classification: Watch (80.4%), Access (16.7%), Reserve (2.9%).	High rates of antibiotic prescription. Majority of antibiotic were in WATCH group of WHO AWARE classification.
Nusrat	2021	July 21 to Aug 21	Bangladesh	Retrospective Cross-sectional Multi-centre	Inpatient with COVID-19	52 (8)	Measure of antibiotic use	100% were prescribed an antibiotic. All antibiotics administered were empirical.	High rates of antibiotic prescription. Majority were indicated for empirical use.
Panesar	2022	(March to June) 2017–2020	USA	Retrospective Cross-sectional Single centre	Inpatient with Status asthmaticus	Variable for each year	Measure of antibiotic use	About 30% of all status asthmaticus inpatients were prescribed an antibiotic.	Moderate rates of antibiotic prescription. Number of inpatients for status asthmaticus significantly reduced, but the trends in antibiotic prescribing remained the same.
Prijic	2020	Mar 20 to May 20	Serbia	Prospective Cross-sectional Single centre	Inpatient with COVID-19	127 (1)	Measure of antibiotic use	47.2% were prescribed an antibiotic. Azithromycin was the most used (37.8%).	Moderate rates of antibiotic prescription. High prevalence of Azithromycin use.
Swann	2020	Jan 20 to July 20	UK	Prospective Cohort Multi-centre	Inpatient with COVID-19	651 (138)	Measure of antibiotic use	69% were prescribed an antibiotic.	Moderate rates of antibiotic prescription.
Toczyłowski	2022	June 20 to Apr 21	Poland	Retrospective Cohort Multi-centre	Inpatient with COVID-19	345 (-)	Measure of antibiotic use	90% were prescribed an antibiotic. Ceftriaxone was the most used (81%).	High rates of antibiotic prescription.

(Continues)

TABLE 2 | (Continued)

Author	Publication year	Duration of data collection	Region	Design	Study setting	Sample size patients (hospitals)	AMS component	Results	Take away points
Velasco-arnaiz	2021	Feb, Mar, Apr 19 Feb, Mar, Apr 20	Spain	Retrospective Cohort Single centre	All Inpatient	210 (1)	Measure of antibiotic use	Antimicrobial use (DOT/100 DP) in March and April 2020 was +1.6 and +35.5 times the consumption in 2019. Increase in use of azithromycin (+5.1) and ceftriaxone (+0.2). 79.5% of antibiotic prescriptions were optimal in 2020, compared to 79% in 2019.	High rates of antibiotic prescription. Despite significant changes in antimicrobial use, no critical deterioration of antimicrobial prescription quality was observed.
Yock-corrales	2021	Apr 20 to Oct 20	Latin-America (Peru, Costa Rica, Argentina, Colombia, Mexico)	Retrospective Cohort Multi-centre	Inpatient with COVID-19	990 (5)	Measure of antibiotic use. Audit and feedback	24.5% (243/990) were prescribed an antibiotic. Ceftriaxone was the most used (13.2%), followed by azithromycin (5.3%). All antibiotics had a reason in medical records.	Low rates of antibiotic prescription. COVID-19 is often a milder disease in children than in adults, but the rates of antibiotic use did not differ much between the two groups.
Zombori	2023	Apr 19 to Apr 21	UK	Retrospective Cohort Single centre	All Inpatient	NA (1)	Comparison of antibiotic usage measuring tools	Age (year) / ASI/AD Median (IQR) / DOT/1000 PD Median (IQR) < 1 / 4.1 (4–4.3) / 1313 (1120–1553) 1–5 / 4.4 (4–4.6) / 1507 (1228–2061) > 5 / 4.5 (4.1–4.6) / 1903 (1567–2924) AMS input / 4.4 (4.3–4.5) / 1468 (1251–1802) No AMS input / 3.5 (3.3–3.7) / 1418 (1802–1587)	ASI is less variable as compared to DOT. Useful in highlighting the usage of broad-spectrum antibiotics.

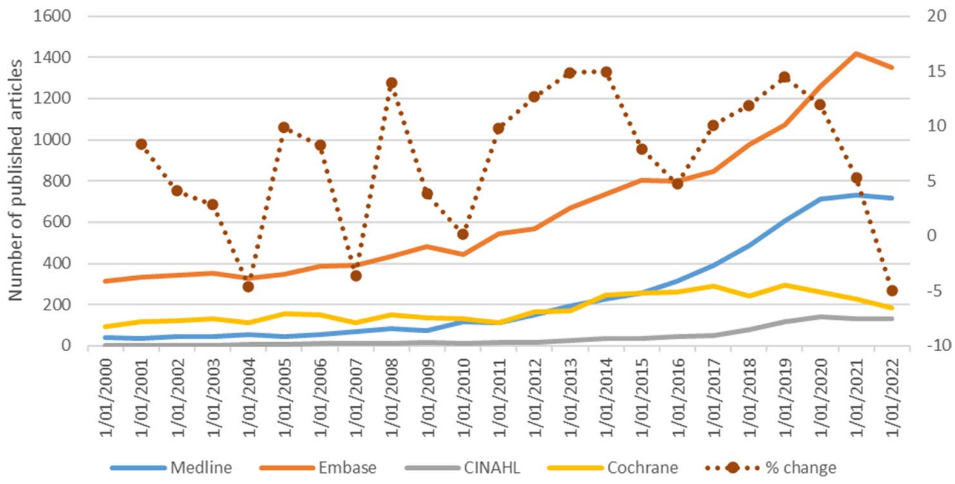

FIGURE 1 | The trend in research output on paediatric AMS in the last 23 years.

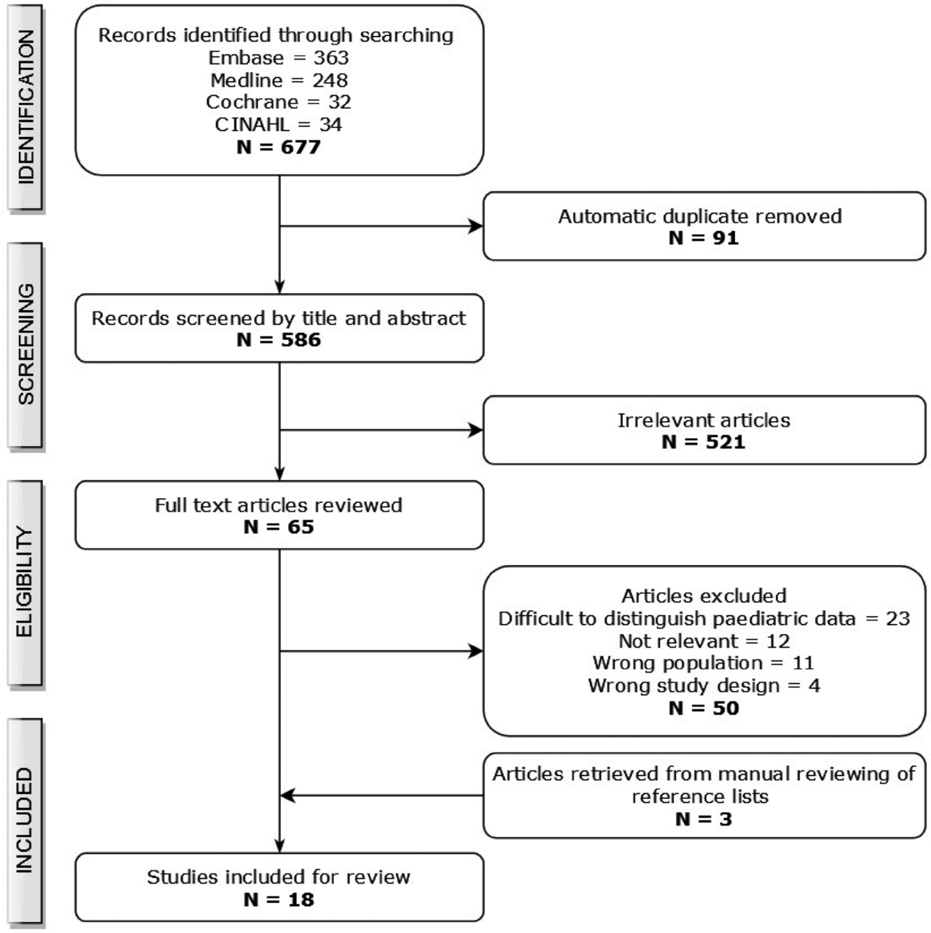

FIGURE 2 | Flowchart of the study selection process.

context of clinical audits. The review found a decrease in stewardship activities during the pandemic compared to the pre-pandemic period. All studies included in the review were observational and represented countries from all income levels. A quantitative measure of antibiotic use was the commonly evaluated AMS component, with two studies conducting more than one component of AMS. The proportion of children prescribed antibiotics varied widely, with a higher use during the early phase of the pandemic and a decrease in the later phase. The occurrence of COVID-19 pandemic may have disrupted the paediatric AMS across the world. Its impact on the quality of antimicrobial prescription is yet to be assessed, but the studies highlight that the use of antibiotics is still high. Therefore, it is essential that the implementation of AMS is not eased during the pandemic and that alternative approaches be considered.

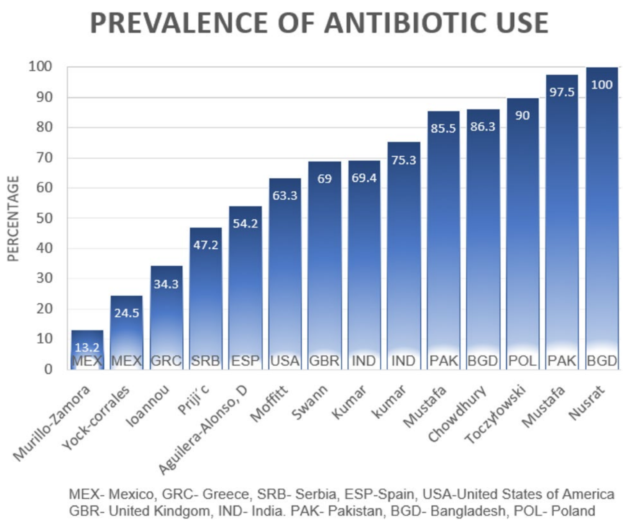

FIGURE 3 | Prevalence of antibiotic use among the included studies and their respective country.

The field of AMS has expanded with its implementation in children, but the pandemic has slowed its progress. There has been a noticeable decline in research output during the pandemic, which could be attributed to a shortage of staff, the AMS team being reassigned to the COVID-19 team, changes in healthcare delivery priorities, restricted access to wards and patient records and restrictions in counselling and educational activities [3]. The resulting paucity of data on the conduct of AMS infers a relaxation in its implementation and warns about its potential impact on antimicrobial use [47].

AMS components such as documentation of the reason for the antibiotic use, quantitative measure of antibiotic use, request for microbiological cultures and surgical prophylaxis do not necessarily relate to individual patient care. However, they are broader practice indicators in tackling AMR. These processes assist in benchmarking hospital-wide practice and encourage quality antimicrobial usage. Most studies assessed antibiotic use quantitatively, primarily through prevalence measures, with only two utilising DOT, consistent with recommendations [48]. More recently developed tools, AWaRe and ASI/AD, were used in two studies to quantify antimicrobial use. Despite multiple methods of measurement, this review observed an increase in antimicrobial use during the beginning of the pandemic, followed by a consistent decrease. The use of antibiotics is linked to the hospitalisation rate, and the reduced number of consultations during the pandemic might have contributed to the decline in the use of antibiotics [32]. As a result, the impact of this change in use is difficult to explain at this stage and also emphasises the importance of evaluating qualitative antimicrobial use [49]. It would also be valuable to stratify and measure the use of antibiotics during a pandemic. None of the studies reviewed reflected such measures, raising concerns about the quality, accuracy and generalizability of the results.

Among the other AMS components, formulary restriction, preauthorisation and prospective audit and feedback are directly associated with individual patient care. These interventions improve care and contribute to the broader goal of tackling AMR. Studies have shown that these interventions significantly improve clinical outcomes, reduce adverse effects and lower costs. However, none of these interventions was conducted during the pandemic [21]. A survey of regional infectious diseases experts showed a similar reduction or suspension of AMS activities during the pandemic [26].

Current guidelines do not provide a clear direction for treating SARS-CoV-2 in children. This could challenge the conduct and evaluation of the AMS program. The use of antibiotics is only recommended if a secondary bacterial infection is suspected or confirmed [50]. However, studies showed a low risk of secondary bacterial infection in patients with SARS-CoV-2, but overuse of empirical antibiotics has been reported [28, 32, 51]. Given the large number of studies that quantitatively measure the use of antibiotics, it is crucial to re-evaluate existing tools and understand and compare the newer tools for reliability.

The studies during the pandemic commonly reported prevalence to measure antimicrobial use, whereas antimicrobial consumption-specific metrics such as DOT were less utilised. Although DOT is a widely used conventional tool, studies on newer tools such as the Antibiotic Spectrum Index (ASI) and Days of Antibiotic Spectrum Coverage (DASC) have shown less variability and promising results, which could better evaluate the impact of AMS on clinical practice [52–54]. Including clinical decision support systems in selecting the antibiotic regimen could promote rational prescription, optimise antibiotic strategy and improve prognosis during the pandemic [55–57]. These strategies can enhance physicians' care but not replace or overwrite their decisions. In instances where there is a shortage of qualified practitioners, a rapid change in the resistance profile, or an outbreak of a pandemic, telemedicine can be an invaluable asset in integrating AMS with the tech infrastructure of the healthcare system, which would function at the physician's discretion [3].

Our study has some limitations. Firstly, the search was restricted to specific databases. Secondly, we assumed that the research output is related to the implementation of AMS in hospitals. Thirdly, although the search criteria were drafted robustly, it is possible that some studies were missed as various word combinations are used to discuss the same topic. Fourthly, limiting the data only to hospitalised patients may have resulted in missing AMS strategies targeted at primary care centres and healthcare practitioners. Lastly, measures such as the use of antibiotics were not standardised.

In conclusion, this review highlights the health service-related adverse impact of the COVID-19 pandemic on the execution of AMS programs in children. It is concerning to note that the research output in this area has declined, with the focus solely on quantitative antibiotic use and other quality components related to AMS that could be assessed using clinical audits were being unaddressed and unreported. During the early stages of the pandemic, the use of antibiotics increased, followed by a decrease in the later stages. In the event of global healthcare uncertainty, it is imperative to develop a comprehensive and strategic plan for the paediatric AMS program to promote rational antimicrobial usage and adherence to quality stewardship parameters.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.