

SCOPING REVIEW

Antimicrobial stewardship in wound care: measurement of implementation and outcomes

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Abstract

The continuing development of antimicrobial resistance (AMR) is a growing global health threat characterised by the ability of microorganisms to withstand the effects of antimicrobial agents. AMR is of such global concern that the World Health Organization (WHO) has developed a global strategy called Antimicrobial Stewardship to combat this threat. This article presents a scoping review designed to identify what impact the introduction of the AMS has had on working practice. The results of the literature search identified 2458 potential articles, 13 articles identified from other sources, thus a total of 2471 articles to screen. Following screening 120 articles were identified for full-text review and finally 80 articles were retrieved and included in the narrative review. All studies indicated the introduction of specific AMS guidelines and/or protocols that affected treatment regimens with a reduction in surgical site infections and a reduction in antimicrobial resistance development being key clinical outcomes of the introduction of antimicrobial stewardship programmes. Forty percent of studies specifically indicating training/education and 43.8% studies indicating some form of audit/feedback as part of the AMSPs. Additionally, antimicrobial usage was reported in most studies resulting in a de-escalation of antimicrobial use (e.g., intravenous vs. oral, broad- or narrow-spectrum), changes in antimicrobial dosage or duration 25.0% and 46.3% respectively. Overall, this review demonstrates that implementation of AMS does have several positive clinical patient outcomes.

Keywords antimicrobial resistance, antimicrobial stewardship, chronic wounds, surgical site infection, ulcers.

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Introduction

The emergence of microorganisms with antimicrobial resistance (AMR) threatens clinicians' and other healthcare professionals' ability to treat common and more serious infections,¹ and it is a growing global health threat that is characterised by the ability of microorganisms to withstand the effects of antimicrobial agents that once killed or inhibited their growth. There are several concerns associated with AMR (Table 1) and, to combat AMR, areas such as the prudent use of existing antimicrobials, new drug

development, and infection prevention and control measures require attention.²

The "5Rs" of antimicrobial stewardship (responsibility, reduction, refinement, replacement, review)³ are part of a broader framework of continuous improvement for the use of antimicrobials for both human and animal health, and help guide the appropriate use of antimicrobials.

AMR is of such global concern that the World Health Organization (WHO) has developed a global strategy on

AMS which includes a focus on the prevention of infections, ensuring universal access to health services for diagnosis and appropriate treatment.⁴ Part of the WHO’s drive to address AMR is the promotion of antimicrobial stewardship (AMS), a systematic approach to educate and support healthcare professionals to follow evidence-based guidelines for the prescribing and administration of antimicrobial agents.⁵ To improve access to appropriate treatment and reduce inappropriate use of antibiotics, WHO developed the AWaRe (Access, Watch, Reserve) classification of antibiotics which provides concise, evidence-based guidance on the choice of antimicrobials (antibiotics), dose, route of administration, and duration of treatment for more than 30 of the most common clinical infections in both primary health care and hospital settings.⁶ The WHO endeavours to guide countries to develop and implement AMS programmes (AMSPs) as one of the most cost-effective interventions to optimise the use of antimicrobial medicines, improve patient outcomes and reduce AMR and health care-associated infections.⁷

More locally, the Australian Government has recently released a national AMR strategy, *Australia’s National Antimicrobial Resistance Strategy – 2020 and Beyond*,⁸ which sets out a 20-year vision to protect health by minimising the development and spread of AMR while being able to provide effective antimicrobials for treatment. Furthermore, the development of tools (such as the Antimicrobial Stewardship Self-Assessment Tool⁹ designed to help providers and clinicians review their AMSPs in residential aged care environments), is an example new ways to provide standardised, continual AMSP improvement. A recent UK Government Policy Paper, *Confronting Antimicrobial Resistance 2024 to 2029* (Updated 8 May 2024)¹⁰ stated that, as a target, “by 2029, we aim to reduce total antibiotic use in human populations by 5% from the 2019 baseline” (Outcome 4 – Antimicrobial Stewardship and Disposal). Therefore, it is important that interventions are implemented effectively, and that there is also an imperative that there are measures of success in place regarding outcomes. However, there are a number of unique challenges in implementing AMSPs in developing versus developed countries (including those with underdeveloped healthcare

systems, poor supply chains, lack of good professional capability, and unstable local political situations).^{11,12} There are also differences between introducing programmes in metropolitan versus rural areas (for example with less onsite AMS specialist expertise, and more staff recruitment and retention challenges).¹³ Together, there are a number of core elements for any outpatient AMSP in order to deliver the optimal care. These include a commitment to optimising antimicrobial prescribing and patient safety, continual improvement in the prescribing of antimicrobials, the ability to monitor prescribing practices, and the provision of educational resources and access to this information to clinicians and patients.¹⁴

AMSPs have a significant impact on the treatment of infections, including wound infections.^{15,16} These AMSPs aim to optimise the use of antimicrobial agents to reduce microbial resistance, improve patient outcomes, and decrease unnecessary costs associated with improper antimicrobial use,¹⁶ with nurses playing a key role in implementing AMSPs.¹⁷⁻¹⁹ Key areas in which AMSPs impact treatment of wound infections include: the improvement of patient outcomes; enhancement of antimicrobial use including through better use optimisation; reducing inappropriate prescribing; cost savings; and improvements in education and awareness (Table 2).¹⁶ The impact of AMSPs may apply more broadly to infections other than wound infections, and may include microorganisms, such as fungal and viral infections.

Dona et al²⁰ and Davey et al²¹ conducted evidence-based reviews assessing the impact of the implementation of AMSPs. In a scoping review of AMSP implementation in paediatrics, Donà et al²⁰ identified that the introduction of AMSPs had a significant impact on reducing targeted and empiric antimicrobial use and associated healthcare costs and AMR in both in-patients and outpatient settings. Davey et al²¹ performed a review of 16 studies on the impact of AMSPs on hospital prescribing of antimicrobials and the prevalence of AMR. Only four studies provided strong evidence that AMSP’s resulted in improvements in prescribing habits and a decrease in antimicrobial resistance. A further finding of the latter review was that several studies were of poor design,

Table 1. Major concerns associated with antimicrobial resistance

Public health threat	AMR leads to longer illnesses, higher mortality rates, and increased spread of infections. Common infections and minor injuries that were once treatable may become more serious (or fatal)
Increased healthcare costs	Treating resistant infections may require more expensive drugs, longer hospital stays, and additional tests, increasing healthcare costs
Limited treatment options	As pathogens become resistant to multiple drugs, the options for effective treatments reduces, leading to untreatable infections
Impact on medical procedures	AMR affects the success of surgeries which rely on effective antimicrobials to prevent and treat infections
Economic consequences	Wider implications include potential reductions in global GDP and increased poverty due to the health burdens and increased healthcare costs

limiting firm conclusions. The aim of this scoping review is to determine the impact of the implementation of AMS on the effect of antimicrobial use in surgical and chronic wounds.

Review questions

This scoping literature review was undertaken to determine the impact of antimicrobial stewardship implementation in wound care. The specific review question to be addressed was:

- What is the impact of the implementation of antimicrobial stewardship on clinical outcomes

Methods

A scoping review^{22,23} was conducted to map the research to date on the impact of the implementation of antimicrobial stewardship on the treatment of a variety of wound types (acute and chronic). The review was designed to identify what impact the introduction of the AMS strategy had on working practice. The analysis followed the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist published in 2018 by Tricco et al.²⁴

Search strategy

The PICO format was developed to assist with the search strategy:

- P (Patient or population) – infected wounds
- I (Intervention) – implementation of antimicrobial stewardship

- C (Comparison) – not relevant for this review
- O (Outcome) – improvement of clinical outcomes related to infection

The electronic database MEDLINE (PubMed) was searched for relevant articles published between January 1970 and February 2024. We feel that searching only MEDLINE (PubMed), a powerful search tool for medical literature,²⁵ is appropriate for this review. Access to literature databases is often limited and only available on subscription basis.²⁶ Studies have investigated the value of different databases used to search on different topics, and some have concluded only one database can be sufficient^{27,28} particularly in cases of reviews that are not systematic reviews²⁹ where multiple databases are advised.³⁰⁻³² Studies have noted that the vast majority of relevant studies appear within a limited number of databases.³³ Furthermore, Selective searching may not introduce bias³³ and it is not always necessary to find all relevant references to draw valid conclusions.²⁶ To identify further published papers, this search included a search of the reference lists of all identified papers. Additional relevant articles not identified through MEDLINE were added manually.

The search strategy was as follows: “stewardship AND (wound* OR “surgical site” OR postoperative OR perioperative OR surg*)” and with a search date range from 01-Jan-1970 to 28-Feb-2024. Below expands the search strategy as indicated by PubMed:

Table 2. Impact of antimicrobial stewardship programs on treatment of infection

<p>Improve patient outcomes</p>	<ul style="list-style-type: none"> • Reduced resistance: By minimising the use of broad-spectrum antibiotics and promoting use of appropriate narrow-spectrum antibiotics, AMSPs help prevent development of antibiotic-resistant microorganisms • Targeted therapy: AMSPs promote the use of antimicrobials that are effective against specific pathogens
<p>Enhanced antimicrobial use</p>	<ul style="list-style-type: none"> • Optimised dosing: Proper dosing regimens emphasised to ensure therapeutic effectiveness while minimising resistance development • Duration of therapy: AMSPs promote for the shortest duration of antimicrobial therapy, reducing exposure to antimicrobials and lowering the risk of resistance development
<p>Reduction in inappropriate prescribing</p>	<ul style="list-style-type: none"> • Diagnostic stewardship: Encouragement of the use of appropriate diagnostic tools to reduce empirical use antimicrobials to ensure that they are used only when necessary • Guideline adherence: AMSPs promote adherence to evidence-based guidelines, reducing variability in treatment, and ensuring effective antimicrobial usage
<p>Cost savings</p>	<ul style="list-style-type: none"> • Reduced healthcare costs: By preventing overuse and misuse of antimicrobials, AMSPs aid in lowering the costs associated with treating antimicrobial-resistant infections • Economic efficiency: Fewer complications and hospital re-admissions related to wound infections results in cost savings
<p>Education and awareness</p>	<ul style="list-style-type: none"> • Training: Ongoing education for healthcare providers on principles of AMS improves infection treatment practices • Public awareness: Increasing awareness about risks of AMR among patients can lead to better adherence to treatments and fewer demands for unnecessary antimicrobial agents

((“stewardship”[All Fields] OR “stewardships”[All Fields]) AND (“wound*”[All Fields] OR “surgical site”[All Fields] OR (“postoperative period”[MeSH Terms] OR (“postoperative”[All Fields] AND “period”[All Fields]) OR “postoperative period”[All Fields] OR “postop”[All Fields] OR “postoperative”[All Fields] OR “postoperatively”[All Fields] OR “postoperatives”[All Fields]) OR (“perioperative”[All Fields] OR “perioperatively”[All Fields]) OR “surg*”[All Fields])) AND (1970/1/1:2024/2/28[pdat])

To ensure relevant articles were included in the review, inclusion and exclusion criteria were used (Table 3).

Screening

Article titles and abstracts were assessed by two authors (MR and AR) according to the inclusion and exclusion criteria. The full-text versions of potentially relevant studies were obtained and screened against the inclusion criteria. Following screening of the full text articles, consensus between reviewers in relation to the studies to be included was then obtained.

Data extraction

Descriptive data were extracted from the full text versions and added to a pre-designed data extraction table recording author and year, country, setting, design, population, sample and intervention.

Results

Study inclusion

The study selection process is illustrated in the PRISMA flow diagram (Figure 1). The initial search identified 2458 potential articles, and 13 articles were identified from other sources, giving a total of 2471 articles to screen. Following screening of the articles, including a title and abstract review, 120 articles were identified for full-text review. Then 80 articles were retrieved and included in the narrative review.

Table 3. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies focusing on comparing the implementation of antimicrobial stewardship (AMS) in wound care with patients where AMS was not implemented	Studies not related to comparing the implementation of antimicrobial stewardship (AMS) in wound care with patients where AMS was not implemented
English language	Articles not published in English language
Published primary research articles, any study design	Published non-primary research articles (such as reviews, editorials, commentaries, guidelines)
Clinical studies	Non-clinical studies

Of these, 32 (40%) of the articles included in this review were from developing countries (as defined by Australian Government Department of Foreign Affairs and Trade).³⁴

Characteristics of included studies

An overview of the wound types featured in the reviewed studies indicated that the majority^{20,36-41,43-58,66-98,100-119} (76/80, 95.0%) were in relation to surgical wounds. Three (3.75%) studies^{49,61,120} were chronic wound related, and one (1.25%) study⁹⁹ was burn related.

All studies indicated the introduction of specific AMS guidelines and/or protocols that affected treatment regimens with 32 (32/80, 40.0%) studies^{20,36,37,41,43,44,47,49,54,56,57,61,67,68,74,81,82,84,86,87,92,94,95,98,100,101,105,108,110,117} specifically indicating training/education, and 35 (35/80, 43.8%) studies^{36,37,40,41,43,44,47,49,50,53,54,57,61,66-68,72,76,77,80,83-86,89,92,94,99,100,106,108,110,111,114,117} indicating some form of audit/feedback as part of the AMSPs.

Impact of AMSP implementation on antimicrobial usage was reported in most studies^{20,36-41,43,44,47,49-55,57-59,61,66-86,89,91-108,110-114,116-120} (71/80, 88.8%) resulting in a de-escalation of antimicrobial use (such as intravenous versus oral, broad- or narrow-spectrum^{20,36,37,39-41,43,49,51-55,57-59,66,67,69,70,72,75,78-86,89,91-102,104-107,110,112,117-120} (54/80, 67.5%)), changes in antimicrobial dosage^{43,44,50,54,68,71,73,75,80,86,89,91,94,95,102,103,105,108,113,114} (20/80, 25.0%), as well as length of antimicrobial use (37/80, 46.3%).^{20,36-38,40,43,44,47,53,57,61,67-69,71,73,79,80,82,83,85,86,89,92,94,95,97-99,102,103,105,106,108,111,114,116} No studies focused specifically on topical antimicrobials. Table 4 summarises the main clinical outcomes assessed with the introduction of AMSPs.

One of the criteria during the screening of the evidence was that studies should be before-and-after studies in which clinical treatment was assessed prior to and after AMSP implementation. All studies (n=80) introduced AMS guidelines/protocols as part of their study procedures. The introduction of AMSPs has been supported by additional education and training on AMS, and has been specifically noted in a number of studies as being introduced as part of the implementation of AMS (32/80, 40.0%).^{20,36,37,41,43,44,47,49,54,56,57,61,67,68,74,81,82,84,86,87,92,94,95,98,100,101,105,108,110,117} Audits and feedback to enable data-driven improvement were noted in 35/80 (43.8%) to support the introduction of AMSPs.^{36,37,40,41,43,44,47,49,50,53,54,57,61,66-68,72,76,77,80,83-86,89,92,94,99,100,106,108,110,111,114,117}

Discussion

This scoping review examined the evidence regarding the influence of AMS on wound infection management, and wider clinical outcomes. Several clinical studies supported the benefits of AMSP implementation for treatment of wound infections and on clinical outcomes. This review found that surgical wounds were the predominate focus, with other wounds (such as chronic wounds (including diabetic foot ulcers) and burns) being less frequently studied. This review and discussion focuses on two key aspects: first, the impact of AMSP on antimicrobial usage and, second, their effect on a number of important clinical outcomes.

Table 4. Summary of main clinical outcomes assessed in the studies

Clinical outcome	Number of studies	Percentage of studies
Antimicrobial use	71	88.8
Surgical site infections	23	28.8
Healthcare costs	25	31.3
Compliance	28	35.0
Re-admissions	11	13.8
Length of case setting stay	20	25.0
Mortality	20	25.0
Frequency of resistance	12	15.0
Modifications to documentation	4	5.0

Impact of AMS implementation on antimicrobial usage

The studies reviewed assessed various aspects of antimicrobial prescribing, including measuring the way in which antimicrobials are prescribed, reducing the number of antimicrobials used, their dosage, and duration of therapy (Table 5).

Antimicrobial use was measured in 71 of the 80 studies.^{20,36-41,43,44,47,49-55,57-59,61,66-86,89,91-108,110-114,116-120} Changes in antimicrobial use included a revision in the route of antimicrobial administration (e.g., from intravenous injection to an oral path of delivery), and selection of a narrow-spectrum antimicrobial from a broad-spectrum example).

Fifty-four (67.5%) studies^{20,36,37,39-41,43,49,51-55,57-59,66,67,69,70,72,75,78-86,89,91-102,104-107,110,112,117-120} were identified where the implementation of AMSPs led to a modification of antimicrobial usage in terms of changes in choice of administration and de-escalation (Table 5). This review identified 21 (29.6%) studies^{20,36,43,54,66,67,69,78,82-84,86,91,92,96,99,105,107,117,119,120} where the choice of antimicrobial agent was

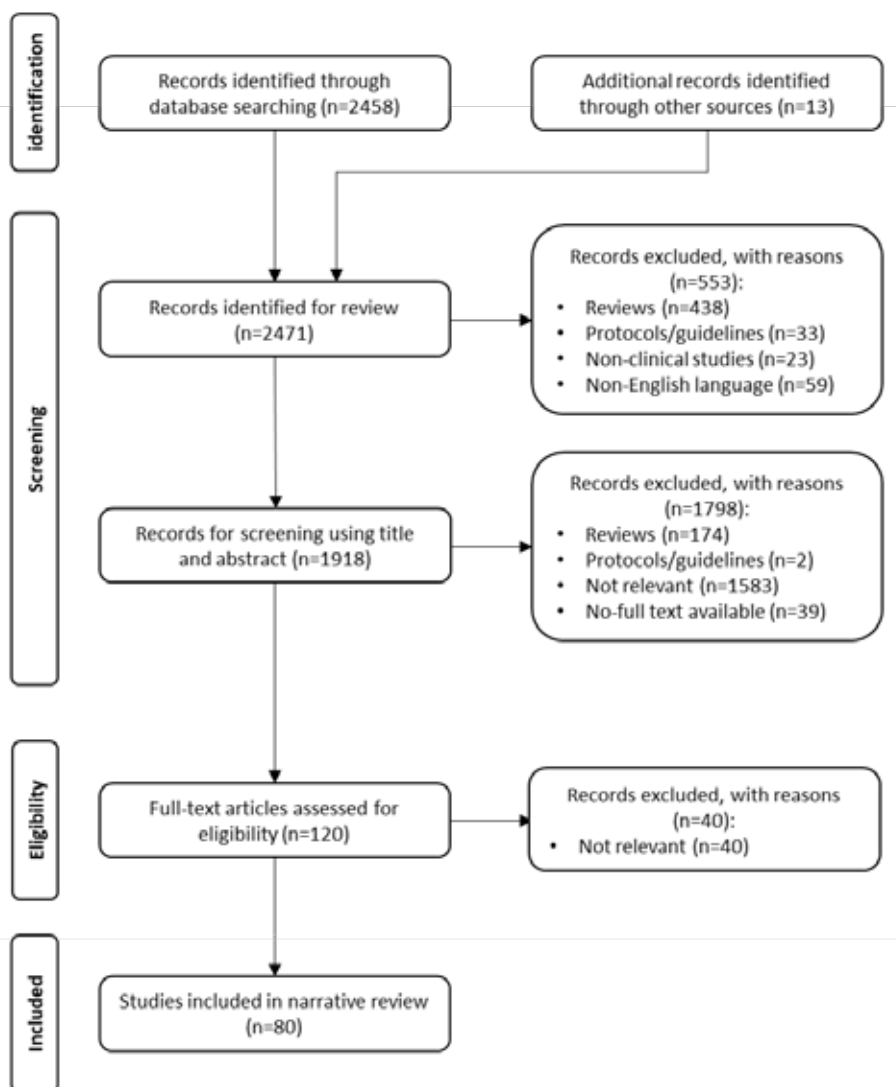


Figure 1. PRISMA flow diagram of literature review

affected by the introduction of AMSPs (Table 5). For example, a retrospective quasi-experimental before-and-after study (n=2439) evaluated antimicrobial selection and duration in surgical prophylaxis prescriptions over six months before and after a five-year AMSP intervention. Results showed an increase in appropriate antibiotic selection (20% to 80%, p<0.001), a decrease in certain antibiotics (p=0.019), and improved duration compliance (69.1% to 78.0%, p<0.001).³⁶ The AMSP included implementation of a surgical prophylaxis guideline, education sessions, prospective and retrospective audits, and the provision of feedback. Notably, no increases in surgical site infections were observed post-intervention. Similarly, a prospective, interventional cohort before-and-after study (n=32,499 surgical patients, with 5458 prescriptions from 3912 patients analysed) found that AMS interventions (included training, creation of stewardship teams and audit and feedback) led to improvements in antimicrobial treatment duration, a maintenance or reduction of antimicrobial treatment, or change in route of application of antimicrobial.³⁷ As a result, recommendations for discontinuation (35%), maintenance (40%) or de-escalation (15.5%) of antimicrobial usage were issued, with a significant decrease in percentage of prolonged treatments (p<0.001).

Surat et al³⁸ conducted a retrospective observational before-and-after study of 767 patients (n=495 pre-AMS, and n=272 in the the AMS period) undergoing intra-abdominal surgery to evaluate the impact of AMS measures. These measures included guideline implementation, antimicrobial usage monitoring, and restricted antimicrobial use. Following AMSP implementation, total days of therapy per 100 patient days decreased from 47 to 42.2 days (p=0.035). The proportion of patients receiving postoperative therapy declined from 56.8% to 45.2% (p=0.002), and there was a significant decline in the rate of inappropriate indications (17.4% to 8.1 %, p=0.015). Additionally, the use of broad-spectrum antibiotics for post-operative therapy fell from 28.8% to 6.5% (p≤0.001), with a shift toward narrower-spectrum agents. Importantly, these reductions in antibiotic use did not negatively impact clinical

outcomes or post-operative wound complications.

De-escalation

De-escalation was a common outcome following AMSP implementation, with 44 studies reporting improvements.^{20,37,39-41,49,51-55,57-59,66,70,72,75,78-82,85,89,91-102,104-106,110,112,117,118} For example, Gruber et al³⁹ analysed 574 patients and found that AMSPs improved de-escalation rates of antimicrobial therapy (p=0.081), and a decrease in overall antimicrobial consumption, without negatively affecting patient outcomes, and that overall antimicrobial usage remained stable where AMS measures were no longer provided. A subsequent study (n=301) that included weekly AMS ward rounds based upon an audit and feedback process underlined these earlier results.⁴⁰ In addition, Gruber et al⁴⁰ also showed an increasing trend for antimicrobial treatment guideline concordance (such as choice of appropriate antimicrobial). In a single-centre retrospective before-and-after study (n=331, 182 and 149 patients for the pre-AMSP and AMSP, respectively) in a surgical intensive care unit (ICU), antimicrobial guidelines, prospective audits, and regular feedback meetings led to significant improvements.⁴¹ De-escalation improved (63.2% vs. 94.6%, p<0.001), while the use of anti-pseudomonal beta-lactams decreased (68.7% vs. 57.7%, OR 0.62, 95% CI 0.40-0.98). The study concluded that AMSPs not only reduced antimicrobial usage but also improved patient outcomes, including mortality and readmission rates).

A key goal of AMSPs is to reduce the use of antimicrobials while ensuring appropriate dosing.⁴² As well as affecting the route of administration, targeting the use of specific antimicrobials, and increasing the use of narrow-spectrum antimicrobial agents, antimicrobial usage can be improved through better management of dosage and length of therapy. This review identified 20 (25%) studies^{43,44,50,54,68,71,73,75,80,86,89,91,94,95,102,103,105,108,113,114} that assessed antimicrobial dosage, and 37 (46.3%) studies^{20,36-38,40,43,44,47,53,57,61,67-69,71,73,79,80,82,83,85,86,89,92,94,95,97-99,102,103,105,106,108,111,114,116} that evaluated duration of antimicrobial use as part of the AMS outcome assessments. In a single-centre prospective

Table 5. Effect of AMSP implementation on antimicrobial use (n=71)

		Studies	Data points		
		n (%)	Improvement n (%)	No change n (%)	Worsening n (%)
(a)	Choice	21 (29.6)	20/22 (90.9)	1/22 (4.5)	1/22 (4.5)
(b)	De-escalation**	44 (62.0)	44/44 (100.0)	0/44 (0.0)	0/44 (0.0)
(a) + (b)*		54 (76.1)	54/56 (96.4)	1/56 (1.8)	1/56 (1.8)
(c)	Dosage	20 (28.2)	19/21 (90.5)	0/21 (0.0)	2/21 (9.5)
(d)	Days of use	37 (52.1)	34/39 (87.2)	3/39 (7.7)	2/39 (5.1)

*(a) + (b) grouping by choice of antimicrobial agent and de-escalation (note that some references appear in both (a) and (b))

** De-escalation: the discontinuation of one or more antimicrobials in empirical therapy³⁵

See Table 6 for definitions for “improvement”, “no change”, and “worsening” for antimicrobial use parameters

before-and-after study of gastrointestinal surgery patients (n=362), AMSP interventions — including the development of surgical antimicrobial prophylaxis guidelines, educational meetings, and the monthly revision of prescriptions — led to improvements in correct antimicrobial use. These included better prescribing of appropriate doses, timings, choice of route of administration, and duration of prophylaxis.⁴³ Singh et al⁴⁴ evaluated the long-term impact of an AMSP in a mixed medical and surgical ICU. AMSP interventions, such as introduction of a program of guidelines, expert consultation, and audit and feedback processes, significantly altered antimicrobial use over nine years (p<0.011). There was a notable decrease in defined daily dose (p<0.0001) and a reduction in the use of most antimicrobial classes.

Additional (clinical and economic) outcomes

In addition to the antimicrobial use outcomes, several clinical and economic outcomes were identified in this review that were affected by the introduction of AMSPs (Table 7).

Table 6. Definitions

	Improvement	No change	Worsening
Choice	Reduction in antimicrobial use: switch from IV to oral administration and from broad- to narrow-spectrum antimicrobials	No change in antimicrobial use: switch from IV to oral administration and from broad- to narrow-spectrum antimicrobials	Increase in antimicrobial use: switch from oral to IV administration and from narrow- to broad-spectrum antimicrobials
De-escalation	Reduction in or discontinuation of antimicrobial use	No change in or discontinuation of antimicrobial use (e.g. number of antimicrobials)	Increase in antimicrobial use (e.g. number of antimicrobials)
Dosage	Reduction in antimicrobial dosage (e.g. defined daily dose)	No change in antimicrobial dosage (e.g., defined daily dose)	Increase in antimicrobial dosage (e.g. defined daily dose)
Days of use	Reduction in antimicrobial usage (e.g. number of days of use)	No change in antimicrobial usage (e.g. number of days of use)	Increase in antimicrobial usage (e.g. number of days of use)

Table 7. Effect of AMSP implementation on clinical outcomes (n=80)

	Studies n (%)	Data points		
		Improvement n (%)	No change n (%)	Worsening n (%)
SSIs	23 (28.8)	11/23 (47.8)	12/23 (52.2)	0/26 (0.0)
Length of Stay	20 (25.0)	9/21 (42.9)	11/21 (52.4)	1/21 (4.8)
Costs	25 (31.3)	24/26 (92.3)	2/26 (7.7)	0/26 (0.0)
Readmission	11 (13.8)	4/11 (36.4)	7/11 (63.6)	0/11 (0.0)
Resistance	12 (15.0)	6/12 (50.0)	6/12 (50.0)	0/12 (0.0)
Mortality	20 (25.0)	8/20 (40.0)	12/20 (60.0)	0/20 (0.0)
Compliance	28 (35.0)	27/28 (96.4)	0/28 (0.0)	1/28 (3.6)
Documentation	4 (5.0)	4/4 (100.0)	0/4 (0.0)	0/4 (0.0)

See Table 6 for definitions for “improvement”, “no change”, and “worsening” for antimicrobial use parameters

Surgical site infections (SSIs)

Of the 80 studies included in this review, 23 monitored changes in SSIs.^{20,36,43,45,46,48,51,54,55,66,72,73,82,85,87,88,90,97,101,109,114-116} Despite significant reductions in antimicrobial use following the implementation of AMSPs, none of these studies reported an increase in SSIs (Table 7). Approximately half (11/23, 47.8%) of SSI-reporting studies found a reduction in infection rates.^{43,45,46,48,54,73,85,87,88,97,101} For example, Brink et al⁴⁵ conducted a prospective observational before-and-after study on 24,206 surgical cases, demonstrating 19.7% decrease in SSI rates after introducing a pharmacist-driven antimicrobial stewardship model for perioperative antimicrobial prophylaxis, which included audit and feedback. The SSI rate dropped from a mean of 2.46 (95% CI 2.18–2.73) pre-intervention to 1.97 post-intervention. Similarly, SSI rates were also reduced with the implementation of an AMSP in a prospective before-and-after study in 327 patients undergoing pancreatoduodenectomy.⁴⁶ Changes in antibiotic prophylaxis policies under an AMSP led to a significant

reduction in the overall SSI rate (26.4% vs. 14.8%, $p=0.01$). The study also found a reduction in the organ/space SSI rate (15.3% versus 8.6%, $p=0.03$).

Length of stay

Length of stay in hospital, which has significant cost implications (see below), was examined as an outcome in 20 studies (Table 7).^{46-50,52,53,59,61,69,83,85,88,89,92,103,106,107,110,117} Among these, 11 studies found no impact of AMSPs on length of stay,^{49,50,52,53,59,61,69,103,106,110,117} while nine studies reported a significant reduction.^{46-48,83,85,88,89,92,107} One single-centre retrospective, observational before-and-after study of 8029 patients across a number of hospital departments including medical, surgical and intensive care unit (ICU) departments, found that AMS interventions (such as guidelines, formulary restriction, antimicrobial use assessments, audits, feedback, education, and infection control measures) reduced the average length of stay from 4.18 days to 1.4 days ($p=0.004$).⁴⁷ Similarly, Sasaki et al⁴⁸ evaluated the impact of AMS protocols as modifications in clinical pathways on SSIs and post-operative hospital stay. Their study showed both a decrease in SSIs, and a significant reduction in length of stay ($p<0.001$). Only one study (1/20, 5%) reported an increase in the length of hospital stay following the introduction of an AMSP.⁴⁹ This retrospective observational study of 2422 ICU patients, found a significant increase in median hospital length of stay ($p=0.04$), though ICU stay remained unchanged.

Cost

The introduction of AMSPs and the associated reductions in outcomes such as antimicrobial use, SSI rates, and length of stay have significant cost implications. In this review, 25 studies assessed the financial impact of AMSPs (Table 7).^{43,47-51,53,57,66,68,71,73,76,78-80,85,92,94,104,107,109,114,118,119} Of these, 24 (96.0%) studies reported cost savings,^{43,47-51,53,57,66,68,71,73,76,78-80,85,92,94,104,107,109,114,119} while two (8%) found no overall cost changes.^{50,118} One study, Taggart et al,⁵⁰ observed cost reductions in a trauma/neurosurgery ICU but no change in a medical/surgery ICU. In a retrospective study,⁴⁷ AMSP implementation led to a 54.2% reduction in antimicrobial use and an 81.7% decrease in parenteral antimicrobial costs. A cluster-randomised controlled trial evaluating a computerised AMS intervention in 2470 surgical patients,⁵¹ compared antimicrobial costs between intervention and control groups. The intervention group had significantly lower median antimicrobials costs ($p<0.01$), reinforcing the financial benefits of AMSPs.

Readmission

Of the 80 studies reviewed, 11 assessed readmission rates as an outcome (Table 7).^{41,49,50,52,61,69,79,92,94,105,107} Seven (63.6%) found no significant change after AMSP implementation,^{41,49,50,61,69,94,105} while four (36.4%) reported a decrease.^{52,79,92,107} Zaffagnini et al⁵² conducted a retrospective/prospective observational study on 467 paediatric surgical patients and found that AMPS implementation reduced the

30-day readmission rate from 4.9 to 2.8 per 100 admissions ($p<0.001$). Similarly, an 11-year study of 61,333 medical/surgical ICU patients showed a reduction in ICU readmission rates within 48 hours of discharge after AMSP implementation (418 versus 372, $p<0.001$).⁷⁹

Antimicrobial resistance

AMSPs have received special support as the prevalence of antimicrobial resistance has increased. Twelve studies assessed antimicrobial-resistant microorganisms as part of a broader impact evaluations.^{41,44,50,52,53,81,87,91,96,97,106,110}

In a retrospective cohort study at a transplant centre, Shafekhani et al⁵³ examined resistance patterns before and after AMSP implementation, focusing on multidrug resistant pathogens such as *Acinetobacter baumannii*, *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, Methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant *enterococci* (VRE). As well as improvements in outcomes, such as a reduction in the use of all classes of antibiotic ($p=0.04$), mean duration of use reduction ($p=0.04$), and antibiotic cost reduction ($p=0.03$), this study found a decrease in multidrug resistant isolates. In addition, a single-centre prospective before-and-after study found significant improvements in antibiotic resistance among gram-negative bacilli.⁹¹ Resistance rates to several antimicrobials in *Enterobacteriaceae* isolates decreased (significant p -values ranged from $p=0.018$ to $p<0.001$), as did resistance in non-fermenting gram-negative rods (significant p -values ranged from $p=0.026$ to $p=0.007$). In addition, the percentage of isolate resistance to several antimicrobials also decreased for non-fermenting gram-negative rods (significant p -values ranged from $p=0.026$ to $p=0.007$). However, resistance levels in gram-positive cocci remained unchanged. No studies reported an increase antimicrobial resistance following AMSP implementation.

Mortality

Mortality was evaluated as a clinical outcome in 20 studies (Table 7).^{41,44,49,50,52-54,59,61,76,79,89,92,94,97,105-107,110,117} No study reported an increase in mortality following AMSP implementation, and 12 (60.0%) found no significant change.

However, some studies reported improved mortality rates. For example, Quirós et al⁵⁴ conducted a prospective, quasi-experimental before-and-after study across 77 medical/surgical ICUs in nine countries ($n=10058$). They found that AMPS implementation, combined with online training, audit and feedback, significantly reduced all-cause ICU mortality from 17.7% to 15.9% ($p<0.0001$).

Compliance

Compliance with established guidelines is a key component of effective clinical care. Education and audits, two common aspects of AMSPs, have been shown to enhance compliance. In this review, 28 (35.0%) studies evaluated compliance with documentation as an AMSP outcome (Table 7).^{36,40,45,47,54-56,58,61,66,67,70,73,74,76,80,85,86,92,93,95,98,99,101,104,106,111,112}

For example, a retrospective/prospective comparative study in elective paediatric surgery assessed compliance before and after AMSP implementation.⁵⁵ Following implementation, perioperative antibiotic prophylaxis (PAP) violations significantly decreased (45.5% vs. 4.8%, $p < 0.001$). Tunio et al⁵⁶ highlighted the complexity of compliance in a prospective before-and-after intervention study of 616 surgical ward patients. Their goal was to achieve 90% compliance with evidence-based perioperative antimicrobial prophylaxis guidelines. AMSP implementation and education increased overall compliance from 38.8% to 59.0% ($p < 0.001$). While agent selection compliance remained unchanged (60.7% to 62.8%, $p = 0.68$), dose compliance improved significantly (39.6% to 89.2% $p < 0.001$).

Documentation

Improvements in documentation following AMSP implementation were observed in four (5%) studies (Table 7).^{57,58,99,100} A single-centre retrospective, quasi-experimental before-and-after study ($n = 269$) assessed the impact of an AMSP incorporating education, audit, and feedback.⁵⁷ Post-implementation, ICU chart documentation became more detailed, with a significant increase in charts specifying antimicrobial regimen and indication (26% versus 71%, $p < 0.0001$). Additionally, there was an 18% absolute increase in regimens with documented stop dates (53% versus 71%, $p < 0.0001$).

Similarly, a single-centre observational before-and-after study ($n = 2135$) in a surgical setting demonstrated improvements in antimicrobial prescribing documentation after AMSP introduction.⁵⁸ Initially, documentation rates were low pre-AMSP (51.6%, 97/188), but by the study’s conclusion, all prescriptions included documentation ($p < 0.001$). Stop/review dates were documented in only 25.5% (48/188) of prescriptions pre-AMSP, increasing to 100% post-AMSP ($p < 0.001$). Significant improvements were also noted in the documentation of prescribing indications ($p < 0.001$) and stop/review dates for surgical antimicrobial prophylaxis ($p < 0.001$).

Chronic wounds and antimicrobial stewardship

Of the 80 studies reviewed, only three evaluated the impact

of AMS on patients with chronic wounds, including diabetic foot ulcers (Table 8).^{59,61,120} All three studies were single-centre, prospective or retrospective before-and-after studies, involving on a total of 627 patients. AMS guidelines were introduced, and outcomes related to antimicrobial use, and broader clinical outcomes were assessed. Although the number of outcomes assessed was limited, AMSP implementation resulted in positive outcomes on antimicrobial use.

For instance, Torvikoski et al⁵⁹ introduced a selective reporting protocol for wound cultures as part of an AMS initiative in a primary care hospital’s wound care ward. This reduced the frequency of antimicrobial escalation from 63% pre-intervention to 37% post-intervention ($p < 0.001$), suggesting that selective reporting is an effective to reduce antimicrobial use. While AMSP implementation showed no significant improvements in length of stay, mortality or readmission rates for patients with chronic wounds, it did improve clinical processes by increasing compliance with treatment guidelines (Table 8).

In another study, a single-centre retrospective analysis of 193 patients with diabetic foot ulcers (DFUs) assessed the impact of AMSP implementation, which included the introduction of new clinical guidelines, education initiatives, audit and feedback.⁶¹ As well as a reduction in number of days of antimicrobial treatment, the study found an increase in adherence to antimicrobial use guidelines from 39% pre-implementation to 68% post-implementation ($p < 0.001$), and a reduction in the duration of antimicrobial use. There was no detrimental effect on other outcomes such as length of stay, readmission, mortality, or amputation rates.

The limited evidence suggests that AMSPs can improve both antimicrobial use and clinical outcomes for chronic wounds, similar to their benefits in surgical wounds. The lack of available evidence for chronic wounds is surprising, and raises the question of why more studies have not been conducted. One possible reason is that while AMS principles are not new, they have only recently gained traction in chronic wound management. The primary focus of chronic

Table 8. Effect of AMSP implementation in clinical outcomes in difficult-to-heal wounds ($n = 3$)

	Studies (n)	Data points		
		Improvement (n)	No change (n)	Worsening (n)
Length of Stay	2	0	2	0
Readmission	1	0	1	0
Amputation	1	0	1	0
Mortality	2	0	2	0
Compliance	1	1	0	0

See Table 6 for definitions for “improvement”, “no change”, and “worsening” for antimicrobial use parameters

wound care has traditionally been on wound healing, and there may be limited awareness among health care providers (HCPs) about how AMS implementation can improve both wound healing and antimicrobial use simultaneously.

To increase AMS adoption in chronic wound management, several strategies can be implemented. These include enhanced and appropriate education and/or training for HCPs on AMS principles, regular audits and feedback to reinforce the benefits of AMSPs, and greater ownership of AMSPs. Furthermore, conducting well-designed before-and-after studies could strengthen the evidence base for AMSP implementation in chronic wound care. If AMS guidelines become standard practice, they could help reduce antimicrobial use while improving wound management outcomes.

The subjective nature of diagnosing chronic wound infections may limit the number of studies on AMSP effectiveness.⁶²⁻⁶⁴ Factors such as the reliance on visual inspection, the subtle signs of infection, and subjective patient reporting make infection diagnosis challenging. That most chronic wounds are treated in the community rather than in hospitals may also contribute to the limited number of studies in this area.⁶⁴

Limitations

A limitation to the methodology is that the literature source for this review was limited to one electronic database, PubMed, a comprehensive free-to-view electronic database of biomedical research; thus, there is the potential to not capture all relevant studies on a topic and can miss research published in other databases which may lead to biased results and incomplete information. However, the authors did hand-search reference lists of included papers, and search relevant journals known not to be included in the PubMed database.

A further limitation with this review is that only three studies were identified related to chronic wounds despite the high infection rates seen in chronic wound management. We recommend that there should be further clinical studies investigating the effect of implementation of AMSPs in chronic wound management.

Conclusions

Antimicrobial resistance is a serious development in wound care as it reduces treatment options for those with wound infections, and is associated with increased risk of severe, extended illness or even death. The introduction of antimicrobial stewardship programs aims to optimise the use of antimicrobial agents to reduce microbial resistance, as well as improve patient outcomes. Evidence on the impact of these programs demonstrates that implementation of antimicrobial stewardship does have several positive clinical patient outcomes, including a reduction in surgical site infections and antimicrobial resistance. But that more research is needed to further understand of the impact of stewardship programs for those with chronic wound infections.

Conflict of interest

The authors declare no conflict of interest.

Ethics statement

An ethics statement is not applicable.

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Author contribution

KO, JB and KW conceived the study design. MGR and AAR developed the review protocol and developed the search strategy and inclusion/exclusion criteria, conducted the review and synthesis of the literature. All authors provided critical revisions and feedback on the manuscript.

Abbreviations

AMR	antimicrobial resistance
AMS	antimicrobial stewardship
AMSP	antimicrobial stewardship programme
DFU	diabetic foot ulcer
HCP	healthcare providers
ICU	intensive care unit
PRISMA	preferred reporting items for systematic reviews and meta-analyses
PRISMA-ScR	PRISMA for scoping review
SSI	surgical site infection
WHO	World Health Organisation

References

1. WHO. Antimicrobial resistance. WHO, 2023. <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance> (accessed 18 October 2024)
2. Shelke YP, Bankar NJ, Bandre GR, Hawale DV, Dawande P. An overview of preventive strategies and the role of various organizations in combating antimicrobial resistance. *Cureus*. 2023;15(9):e44666.
3. Page S, Prescott J, Weese S. The 5Rs approach to antimicrobial stewardship. *Vet Rec*. 2014;175(8):207–208.
4. WHO. *Global Action Plan on antimicrobial resistance*. WHO, 2015. <https://tinyurl.com/mryv96aa> (accessed 18 October 2024)
5. WHO. *Antimicrobial stewardship interventions: a practical guide*. WHO, 2021. <https://tinyurl.com/4dcbzcu> (accessed 18 October 2024)
6. WHO. *The WHO AWaRe (Access, Watch, Reserve) antibiotic book*. WHO, 2022. <https://tinyurl.com/43832arb> (accessed 18 October 2024)
7. WHO. *2021 Antimicrobial stewardship interventions: a practical guide*. <https://tinyurl.com/4dcbzcu> (accessed 18 October 2024)
8. Australian Government, Department of Health/Department of Agriculture, Water and the Environment. (2019) *Australia's National Antimicrobial Resistance Strategy – 2020 and beyond*. <https://tinyurl.com/3vpmz4wv> (accessed 18 February 2025)
9. Australian Government, Aged Care Quality and Safety Commission. *2024 Antimicrobial Stewardship Self-Assessment*

- tool – residential Aged Care Services (AMS SAT) <https://tinyurl.com/mwf7386v> (accessed 18 February 2025)
10. UK Government. Confronting Antimicrobial Resistance 2024 to 2029. 2024. <https://tinyurl.com/48h7hr3u> (accessed 18 October 2024)
 11. Shamas N, Stokle E, Ashiru-Oredope D, Wesangula E. Challenges of implementing antimicrobial stewardship tools in low to middle income countries (LMICs). *Infect Prev Pract*. 2023;5(4):100315.
 12. Harun MGD, Sumon SA, Hasan I, et al. Barriers, facilitators, perceptions and impact of interventions in implementing antimicrobial stewardship programs in hospitals of low-middle and middle countries: a scoping review. *Antimicrob Resist Infect Control*. 2024;13(1):8.
 13. ACSQHC. Chapter 17: Rural and remote hospitals and health services. Australian Commission on Safety and Quality in Health Care. *Antimicrobial Stewardship in Australian Health Care*. Sydney: ACSQHC; 2023, pp. 394–417, <https://tinyurl.com/3kwrk4vh> (accessed 18 February 2025)
 14. Sanchez GV, Fleming-Dutra KE, Roberts RM, Hicks LA. Core elements of outpatient antibiotic stewardship. *MMWR Recomm Rep*. 2016;65(No. RR-6):1–12.
 15. Edwards-Jones V. Antimicrobial stewardship in wound care. *Br J Nurs*. 2020;29(15):S10–S16.
 16. Khadse SN, Ugemuge S, Singh C. Impact of antimicrobial stewardship on reducing antimicrobial resistance. *Cureus*. 2023;15(12):e49935.
 17. Ladenheim D. Role of nurses in supporting antimicrobial stewardship. *Nurs Stand*. 2018;33(6):55–58.
 18. Camerini FG, Cunha TL, Fassarella CS, et al. Nursing strategies in antimicrobial stewardship in the hospital environment: a qualitative systematic review. *BMC Nurs*. 2024;23(1):147.
 19. Bonacaro A, Solfrizzo FG, Regano D, et al. Antimicrobial stewardship in healthcare: exploring the role of nurses in promoting change, identifying barrier elements and facilitators—a meta-synthesis. *Healthcare (Basel)*. 2024;12(21):2122.
 20. Donà D, Luise D, Barbieri E, et al. Effectiveness and sustainability of an antimicrobial stewardship program for perioperative prophylaxis in pediatric surgery. *Pathogens*. 2020;9(6):490.
 21. Davey P, Brown E, Fenelon L, et al. Systematic review of antimicrobial drug prescribing in hospitals. *Emerg Infect Dis*. 2006;12(2):211–216.
 22. Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J*. 2009;26(2):91–108.
 23. Peters MDJ, Marnie C, Tricco AC, et al. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth*. 2020;18(10):2119–2126.
 24. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467–473.
 25. Misra DP, Ravindran V. An overview of the functionalities of PubMed. *J R Coll Physicians Edinb*. 2022;52(1):8–9.
 26. Ewald H, Klerings I, Wagner G, et al. Searching two or more databases decreased the risk of missing relevant studies: a metaresearch study. *J Clin Epidemiol*. 2022;149:154–164.
 27. van Enst WA, Scholten RJ, Whiting P, Zwinderman AH, Hooft L. Meta-epidemiologic analysis indicates that MEDLINE searches are sufficient for diagnostic test accuracy systematic reviews. *J Clin Epidemiol*. 2014;67(11):1192–1199.
 28. Rice DB, Kloda LA, Levis B, Qi B, Kingsland E, Thombs BD. Are MEDLINE searches sufficient for systematic reviews and meta-analyses of the diagnostic accuracy of depression screening tools? A review of meta-analyses. *J Psychosom Res*. 2016;87:7–13.
 29. Marshall IJ, Marshall R, Wallace BC, Brassey J, Thomas J. Rapid reviews may produce different results to systematic reviews: a meta-epidemiological study. *J Clin Epidemiol*. 2019;109:30–41.
 30. Bramer WM, Giustini D, Kramer BM, Anderson P. The comparative recall of Google Scholar versus PubMed in identical searches for biomedical systematic reviews: a review of searches used in systematic reviews. *Syst Rev*. 2013;2:115.
 31. Bramer WM, Giustini D, Kramer BM. Comparing the coverage, recall, and precision of searches for 120 systematic reviews in Embase, MEDLINE, and Google Scholar: a prospective study. *Syst Rev*. 2016;5:39.
 32. Bramer WM, Rethlefsen ML, Kleijnen J, Franco OH. Optimal database combinations for literature searches in systematic reviews: a prospective exploratory study. *Syst Rev*. 2017;6(1):245.
 33. Hartling L, Featherstone R, Nuspi M, Shave K, Dryden DM, Vandermeer B. The contribution of databases to the results of systematic reviews: a cross-sectional study. *BMC Med Res Methodol*. 2016;16(1):127.
 34. List of developing countries as declared by the Minister for Foreign Affairs. Australian Government Department of Foreign Affairs and Trade. <https://tinyurl.com/59pf7wc3> (accessed 18 February 2025)
 35. Tanzarella ES, Cutuli SL, Lombardi G, et al. Antimicrobial de-escalation in critically ill patients. *Antibiotics (Basel)*. 2024;13(4):375.
 36. Díaz-Madriz JP, Zavaleta-Monestel E, Villalobos-Madriz JA, et al. Impact of the five-year intervention of an antimicrobial stewardship program on the optimal selection of surgical prophylaxis in a hospital without antibiotic prescription restrictions in Costa Rica: a retrospective study. *Antibiotics (Basel)*. 2023;12(11):1572.
 37. Batlle M, Badia JM, Hernández S, et al. Reducing the duration of antibiotic therapy in surgical patients through a specific nationwide antimicrobial stewardship program. A prospective, interventional cohort study. *Int J Antimicrob Agents*. 2023;62(5):106943.
 38. Surat G, Vogel U, Wiegner A, Germer CT, Lock JF. Defining the scope of antimicrobial stewardship interventions on the prescription quality of antibiotics for surgical intra-abdominal infections. *Antibiotics (Basel)*. 2021a;10(1):73.
 39. Gruber MM, Weber A, Jung J, Werner J, Draenert R. Impact and sustainability of antibiotic stewardship on antibiotic prescribing in visceral surgery. *Antibiotics (Basel)*. 2021;10(12):1518.
 40. Gruber MM, Weber A, Jung J, Strehlau A, Tsilimparis N, Draenert R. The impact of antibiotic stewardship interventions and patient related factors on antibiotic prescribing in a vascular surgical department. *Infection*. 2024;52(1):83–91.
 41. Kim SH, Yoon JG, Park HJ, et al. Effects of a comprehensive antimicrobial stewardship program in a surgical intensive care unit. *Int J Infect Dis*. 2021;108:237–243.
 42. Worldwide Antimicrobial Resistance National/International Network Group (WARNING) Collaborators. Ten golden rules for optimal antibiotic use in hospital settings: the WARNING call to action. *World J Emerg Surg*. 2023;18(1):50.
 43. Ahmed NJ, Almalki ZS, Alfaifi AA, et al. Implementing an antimicrobial stewardship programme to improve adherence to a perioperative prophylaxis guideline. *Healthcare (Basel)*. 2022;10(3):464.

44. Singh S, Ark R, Tatlock J, et al. Evaluating the long-term impact of an antimicrobial stewardship programme in a Central London mixed medical and surgical intensive care unit. *JAC Antimicrob Resist.* 2022;4(5):dlac108.
45. Brink AJ, Messina AP, Feldman C, Richards GA, van den Bergh D; Netcare Antimicrobial Stewardship Study Alliance. From guidelines to practice: a pharmacist-driven prospective audit and feedback improvement model for peri-operative antibiotic prophylaxis in 34 South African hospitals. *J Antimicrob Chemother.* 2017;72(4):1227–1234.
46. Cengiz TB, Jarrar A, Power C, Joyce D, Anzlovar N, Morris-Stiff G. Antimicrobial stewardship reduces surgical site infection rate, as well as number and severity of pancreatic fistulae after pancreatoduodenectomy. *Surg Infect (Larchmt).* 2020;21(3):212–217.
47. Sallam M, Snygg J. Improving antimicrobial stewardship program using the Lean Six Sigma methodology: a descriptive study from Mediclinic Welcare Hospital in Dubai, the UAE. *Healthcare (Basel).* 2023;11(23):3048.
48. Sasaki Y, Kurishima A, Miyamoto C, Hataji K, Tezuka T, Katsuragawa H. Evaluation after implementation of chemical bowel preparation for surgical site infections in elective colorectal cancer surgery and role of antimicrobial stewardship pharmacist: Retrospective cohort study. *J Pharm Health Care Sci.* 2024;10(1):11.
49. Hohn A, Heising B, Hertel S, Baumgarten G, Hochreiter M, Schroeder S. Antibiotic consumption after implementation of a procalcitonin-guided antimicrobial stewardship programme in surgical patients admitted to an intensive care unit: a retrospective before-and-after analysis. *Infection.* 2015;43(4):405–412.
50. Taggart LR, Leung E, Muller MP, Matukas LM, Daneman N. Differential outcome of an antimicrobial stewardship audit and feedback program in two intensive care units: a controlled interrupted time series study. *BMC Infect Dis.* 2015;15:480.
51. Yuan X, Chen K, Yuan J, et al. Evaluation of the effectiveness and safety of a multi-faceted computerized antimicrobial stewardship intervention in surgical settings: a single-centre cluster-randomized controlled trial. *Int J Antimicrob Agents.* 2023;61(5):106787.
52. Zaffagnini A, Rigotti E, Opri F, et al. Enforcing surveillance of antimicrobial resistance and antibiotic use to drive stewardship: experience in a paediatric setting. *J Hosp Infect.* 2024;144:14–19.
53. Shafiekhani M, Shabani-Borujeni M, Karimian A, et al. Antibiotic stewardship implementation at the largest solid organ transplantation center in Asia: a retrospective cohort study. *BMC Surg.* 2023;23(1):81.
54. Quirós RE, Bardossy AC, Angeleri P, et al. Antimicrobial stewardship programs in adult intensive care units in Latin America: implementation, assessments, and impact on outcomes. *Infect Control Hosp Epidemiol.* 2022;43(2):181–190.
55. Burzyńska J, Jaworski R, Maruszewski B, Kansy A, Dzierżanowska-Fangrat K. Perioperative antibiotic prophylaxis in pediatric cardiac surgery—simple is better. *Antibiotics (Basel).* 2022;12(1):66.
56. Tunio S, Dzioba A, Dhani R, Elsayed S, Strychowsky JE. Auto-substitutions to optimize perioperative antimicrobial prophylaxis: pre-post intervention study. *Laryngoscope.* 2023;133(12):3403–3408.
57. Katsios CM, Burry L, Nelson S, et al. An antimicrobial stewardship program improves antimicrobial treatment by culture site and the quality of antimicrobial prescribing in critically ill patients. *Crit Care.* 2012;16(6):R216.
58. de Guzman Betito G, Pauwels I, Versporten A, Goossens H, De Los Reyes MR, Gler MT. Implementation of a multidisciplinary antimicrobial stewardship programme in a Philippine tertiary care hospital: an evaluation by repeated point prevalence surveys. *J Glob Antimicrob Resist.* 2021;26:157–165.
59. Torvikoski JA, Lehtola LK, Ahava MJ, Pakarinen LM, Tissari PJ, Pätäri-Sampo AS. Impact of selective reporting of wound cultures on microbiology reports and antimicrobial-drug use on a wound-care ward in Finland: a retrospective cohort study. *EBioMedicine.* 2024;100:104992.
60. Langford BJ, Daneman N, Diong C, et al. Antibiotic susceptibility reporting and association with antibiotic prescribing: a cohort study. *Clin Microbiol Infect.* 2021;27(4):568–575.
61. McCreery RJ, Lyden E, Anderson M, Van Schooneveld TC. Impact of a syndrome-specific antibiotic stewardship intervention on antipseudomonal antibiotic use in inpatient diabetic foot infection management. *Antimicrob Steward Healthc Epidemiol.* 2023;3(1):e39.
62. Liu YF, Ni PW, Huang Y, Xie T. Therapeutic strategies for chronic wound infection. *Chin J Traumatol.* 2022;25(1):11–16.
63. Serena TE, Gould L, Ousey K, Kirsner RS. Reliance on clinical signs and symptoms assessment leads to misuse of antimicrobials: post hoc analysis of 350 chronic wounds. *Adv Wound Care (New Rochelle).* 2022;11(12):639–649.
64. Ding X, Tang Q, Xu Z, et al. Challenges and innovations in treating chronic and acute wound infections: from basic science to clinical practice. *Burns Trauma.* 2022;10:tkac014.
65. Beeckman D, Cooper M, Greenstein E, et al. The role community-based healthcare providers play in managing hard-to-heal wounds. *Int Wound J.* 2024;21(1):e14402.
66. Abubakar U, Syed Sulaiman SA, Adesiyun AG. Impact of pharmacist-led antibiotic stewardship interventions on compliance with surgical antibiotic prophylaxis in obstetric and gynecologic surgeries in Nigeria. *PLoS One.* 2019;14(3):e0213395.
67. Alabi AS, Picka SW, Sirleaf R, et al. Implementation of an antimicrobial stewardship programme in three regional hospitals in the south-east of Liberia: lessons learned. *JAC Antimicrob Resist.* 2022;4(3):dlac069.
68. Alemkere G, Tadege H, Getahun W, et al. Optimizing prophylactic antibiotic use among surgery patients in Ethiopian hospitals. *J Infect Public Health.* 2023;16(Sup1):82–89.
69. Algargoosh M, Ritchie S, Duffy E, Van der Werf B, Thomas M, Martini N. The impact of a pharmacist-led intravenous to oral switch of metronidazole: a before-and-after study. *Antibiotics (Basel).* 2022;11(10):1303.
70. Alshehhi HS, Ali AA, Jawhar DS, et al. Assessment of implementation of antibiotic stewardship program in surgical prophylaxis at a secondary care hospital in Ras Al Khaimah, United Arab Emirates. *Sci Rep.* 2021;11(1):1042.
71. Álvarez-Lerma F, Grau S, Echeverría-Esnal D, et al. A before-and-after study of the effectiveness of an antimicrobial stewardship program in critical care. *Antimicrob Agents Chemother.* 2018;62(4):e01825–17.
72. Antonioli P, Formaglio A, Gamberoni D, et al. Hospital discharge in patients at risk of surgical site infection: antimicrobial stewardship at Ferrara University Hospital, Italy. *J Prev Med Hyg.* 2018;59(2):E139–E144.
73. Arulappen AL, Danial M, Haron N, Hau LC, Khan AH. The impact of antimicrobial stewardship program on injudicious use of cefuroxime. *Front Pharmacol.* 2021;11:565818.
74. Atwood R, Benoit P, Hennrikus W, et al. Simple signage and targeted education can lead to process improvement in acute appendicitis care. *BMJ Open Qual.* 2023;12(4):e002327.

75. Bashar MA, Miot J, Shoul E, van Zyl RL. Impact of an antibiotic stewardship programme in a surgical setting. *S Afr J Infect Dis*. 2021;36(1):307.
76. Bhalla N, Hussein N, Atari M, et al. Introducing an antibiotic stewardship program in a humanitarian surgical hospital. *Am J Infect Control*. 2016;44(11):1381-1384.
77. Calò F, Onorato L, Macera M, et al. Impact of an education-based antimicrobial stewardship program on the appropriateness of antibiotic prescribing: results of a multicenter observational study. *Antibiotics (Basel)*. 2021;10(3):314.
78. Cappanera S, Tiri B, Priante G, et al. Educational ICU Antimicrobial Stewardship model: the daily activities of the AMS team over a 10-month period. *Infez Med*. 2019;27(3):251-257.
79. Chen IL, Lee CH, Su LH, Wang YL, Liu JW. Effects of implementation of an online comprehensive antimicrobial-stewardship program in ICUs: a longitudinal study. *J Microbiol Immunol Infect*. 2018;51(1):55-63.
80. Chowdhury SS, Sastry AS, Sureshkumar S, Cherian A, Sistla S, Rajashekar D. The impact of antimicrobial stewardship programme on regulating the policy adherence and antimicrobial usage in selected intensive care units in a tertiary care center - a prospective interventional study. *Indian J Med Microbiol*. 2020;38(3 & 4):362-370.
81. Corcione S, Shbaklo N, Vicentini C, et al. Impact of an empiric antimicrobial therapy manual on antimicrobial usage and multidrug resistant organism trends in a large Italian teaching hospital. *Infect Prev Pract*. 2021;4(2):100187.
82. Donà D, Luise D, La Pergola E, et al. Effects of an antimicrobial stewardship intervention on perioperative antibiotic prophylaxis in pediatrics. *Antimicrob Resist Infect Control*. 2019;8:13.
83. Ertürk Şengel B, Bilgin H, Ören Bilgin B, et al. The need for an antibiotic stewardship program in a hospital using a computerized pre-authorization system. *Int J Infect Dis*. 2019;82:40-43.
84. Fay LN, Wolf LM, Brandt KL, et al. Pharmacist-led antimicrobial stewardship program in an urgent care setting. *Am J Health Syst Pharm*. 2019;76(3):175-181.
85. Fésüs A, Benkó R, Matuz M, et al. The effect of pharmacist-led intervention on surgical antibacterial prophylaxis (SAP) at an orthopedic unit. *Antibiotics (Basel)*. 2021;10(12):1509.
86. Garcell HG, Arias AV, Sandoval CP, Valle Gamboa ME, Sado AB, Alfonso Serrano RN. Impact of a focused antimicrobial stewardship program in adherence to antibiotic prophylaxis and antimicrobial consumption in appendectomies. *J Infect Public Health*. 2017;10(4):415-420.
87. Giacobbe DR, Salsano A, Del Puente F, et al. Reduced incidence of carbapenem-resistant *Klebsiella pneumoniae* infections in cardiac surgery patients after implementation of an antimicrobial stewardship project. *Antibiotics (Basel)*. 2019;8(3):132.
88. Graf K, Sohr D, Haverich A, Kühn C, Gastmeier P, Chaberny IF. Decrease of deep sternal surgical site infection rates after cardiac surgery by a comprehensive infection control program. *Interact Cardiovasc Thorac Surg*. 2009;9(2):282-286.
89. Güerri-Fernández R, Villar-García J, Herrera-Fernández S, et al. An antimicrobial stewardship program reduces antimicrobial therapy duration and hospital stay in surgical wards. *Rev Esp Quimioter*. 2016;29(3):119-121.
90. Holle J, Finger T, Lugonja J, et al. The influence of perioperative antibiotic prophylaxis on wound infection and on the colonization of wound drains in patients after correction of craniosynostosis. *Front Pediatr*. 2021;9:720074.
91. Hou D, Wang Q, Jiang C, Tian C, Li H, Ji B. Evaluation of the short-term effects of antimicrobial stewardship in the intensive care unit at a tertiary hospital in China. *PLoS One*. 2014;9(7):e101447.
92. Hussain K, Khan MF, Ambreen G, et al. An antibiotic stewardship program in a surgical ICU of a resource-limited country: financial impact with improved clinical outcomes. *J Pharm Policy Pract*. 2020;13:69.
93. Jones R, Quartuccio KS, Stern JL, Heintz EV, Pillinger KE, Myers TG. Antibiotic stewardship interventions improve choice of antibiotic prophylaxis in total joint arthroplasty in patients with reported penicillin allergies. *Clin Orthop Relat Res*. 2021;479(7):1484-1494.
94. Jover-Sáenz A, Santos Rodríguez C, Ramos Gil MÁ, et al. Impact of an antimicrobial stewardship strategy on surgical hospital discharge: improving antibiotic prescription in the transition of care. *Antibiotics (Basel)*. 2023;12(5):834.
95. Karaali C, Emiroglu M, Atalay S, et al. A new antibiotic stewardship program approach is effective on inappropriate surgical prophylaxis and discharge prescription. *J Infect Dev Ctries*. 2019;13(11):961-967.
96. Kawamura H, Matsumoto K, Shigemi A, et al. A bundle that includes active surveillance, contact precaution for carriers, and cefazolin-based antimicrobial prophylaxis prevents methicillin-resistant *Staphylococcus aureus* infections in clean orthopedic surgery. *Am J Infect Control*. 2016;44(2):210-214.
97. Le Terrier C, Vinetti M, Bonjean P, et al. Impact of a restrictive antibiotic policy on the acquisition of extended-spectrum beta-lactamase-producing Enterobacteriaceae in an endemic region: a before-and-after, propensity-matched cohort study in a Caribbean intensive care unit. *Crit Care*. 2021;25(1):261.
98. Mohamed R, Wall J, Arumainathan R, et al. Assessing antibiotic stewardship using the surgical site infection prevention bundle. *Br J Hosp Med (Lond)*. 2018;79(11):643-647.
99. Nauriyal V, Rai SM, Joshi RD, et al. Evaluation of an antimicrobial stewardship program for wound and burn care in three hospitals in Nepal. *Antibiotics (Basel)*. 2020;9(12):914.
100. Olivieri R, Vannini P, Corzani A, et al. Rapid decrease in fluoroquinolones consumption following implementation of a simple antimicrobial stewardship bundled intervention in a University Hospital during the COVID-19 pandemic. *Antibiotics (Basel)*. 2023;12(4):694.
101. Ory J, Le Minh Q, Phan Tien H, et al. Impact of infection control on prevalence of surgical site infections in a large tertiary care hospital in Haiphong City. *Antibiotics (Basel)*. 2022;12(1):23.
102. Panditrao A, Shafiq N, Kumar-M P, et al. Impact of an antimicrobial stewardship and monitoring of infection control bundle in a surgical intensive care unit of a tertiary-care hospital in India. *J Glob Antimicrob Resist*. 2021;24:260-265.
103. Patel U, Joshi AS, Ganjiwale J, Ganguly B. Impact of antimicrobial stewardship program on prescribing pattern of cephalosporins in the department of surgery. *Natl J Physiol Pharm Pharmacol*. 2020;10(2):109-115.
104. Phan QTN, Le TD, Do QK, et al. Impact of antimicrobial stewardship intervention in clean and clean-contaminated surgical procedures at a Vietnamese national hospital. *Trop Med Int Health*. 2022;27(4):454-462.
105. Popovski Z, Mercuri M, Main C, et al. Multifaceted intervention to optimize antibiotic use for intra-abdominal infections. *J Antimicrob Chemother*. 2015;70(4):1226-1229.
106. Rupali P, Palanikumar P, Shanthamurthy D, et al. Impact of an antimicrobial stewardship intervention in India: Evaluation of post-prescription review and feedback as a method of promoting optimal antimicrobial use in the intensive care units

- of a tertiary-care hospital. *Infect Control Hosp Epidemiol*. 2019;40(5):512–519.
107. Sadeq AA, Shamseddine JM, Babiker ZOE, et al. Impact of multidisciplinary team escalating approach on antibiotic stewardship in the United Arab Emirates. *Antibiotics (Basel)*. 2021;10(11):1289.
 108. Saied T, Hafez SF, Kandeel A, et al. Antimicrobial stewardship to optimize the use of antimicrobials for surgical prophylaxis in Egypt: a multicenter pilot intervention study. *Am J Infect Control*. 2015;43(11):e67–e71.
 109. Sarang B, Tiwary A, Gadgil A, Roy N. Implementing antimicrobial stewardship to reduce surgical site infections: experience and challenges from two tertiary-care hospitals in Mumbai, India. *J Glob Antimicrob Resist*. 2020;20:105–109.
 110. Schröder S, Klein MK, Heising B, Lemmen SW. Sustainable implementation of antibiotic stewardship on a surgical intensive care unit evaluated over a 10-year period. *Infection*. 2020;48(1):117–124.
 111. Shallal A, Lahoud C, Merhej D, et al. The impact of a post-prescription review and feedback antimicrobial stewardship program in Lebanon. *Antibiotics (Basel)*. 2022;11(5):642.
 112. Shrestha I, Shrestha S, Vijayageetha M, et al. Surgical antibiotic prophylaxis administration improved after introducing dedicated guidelines: a before-and-after study from Dhulikhel Hospital in Nepal (2019–2023). *Trop Med Infect Dis*. 2023;8(8):420.
 113. Singh S, Zhang YZ, Chalkley S, et al. A three-point time series study of antibiotic usage on an intensive care unit, following an antibiotic stewardship programme, after an outbreak of multi-resistant *Acinetobacter baumannii*. *Eur J Clin Microbiol Infect Dis*. 2015;34(9):1893–1900.
 114. Storey DF, Pate PG, Nguyen AT, Chang F. Implementation of an antimicrobial stewardship program on the medical-surgical service of a 100-bed community hospital. *Antimicrob Resist Infect Control*. 2012;1(1):32.
 115. Surat G, Bernsen D, Schimmer C. Antimicrobial stewardship measures in cardiac surgery and its impact on surgical site infections. *J Cardiothorac Surg*. 2021;16(1):309.
 116. Surat G, Meyer-Sautter P, Rüscher J, Braun-Feldweg J, Germer CT, Lock JF. Retrospective cohort analysis of the effect of antimicrobial stewardship on postoperative antibiotic therapy in complicated intra-abdominal infections: short-course therapy does not compromise patients' safety. *Antibiotics (Basel)*. 2022;11(1):120.
 117. Vecchia M, Colaneri M, Sacchi P, et al. Implementation of an antimicrobial stewardship program in the Vascular Surgery ward of a university tertiary care hospital in Pavia, Northern Italy. *BMC Infect Dis*. 2023;23(1):138.
 118. Wu Z, Li Y, Li R, et al. Secular trend analysis of antibiotic utilisation in some hospitals in Southern Sichuan from 2010 to 2020. *Sci Rep*. 2023;13(1):8111.
 119. Zhou H, Liu L, Sun X, et al. The impact of pharmacist intervention on prophylactic antibiotics use in orthopedic surgery at a hospital in China. *Medicine (Baltimore)*. 2021;100(52):e28458.
 120. Reitan RL, McBroom RM, Gilder RE. The risk of infection and indication of systemic antibiotics in chronic wounds. *Wounds*. 2020;32(7):186–194.



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