

SYSTEMATIC REVIEW

What is the knowledge, perceptions, and experiences of nurses regarding antimicrobial stewardship? A systematic review

Joanna Blackburn^{*1}, Pinar Avsar^{2,3}, Declan Patton^{2,3,4,5,6}, Zena Moore^{2,3,4,5,7,8,9,10,11}, Karen Ousey^{1,12}

¹Institute of Skin Integrity and Infection Prevention, School of Human and Health Sciences, University of Huddersfield, UK

²Skin Wounds and Trauma Research Centre, RCSI University of Medicine and Health Sciences, Dublin, Ireland

³School of Nursing and Midwifery, RCSI University of Medicine and Health Sciences, Dublin, Ireland

⁴Fakeeh College of Health Sciences, Jeddah, Saudi Arabia

⁵School of Nursing and Midwifery, Griffith University, Brisbane Australia

⁶Faculty of Science, Medicine and Health, University of Wollongong, Australia

⁷Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Australia

⁸Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Belgium

⁹Lida Institute, Shanghai, China

¹⁰University of Wales, Cardiff, UK

¹¹NHMRC Centre of Research Excellence in Wiser Wound Care, Menzies Health Institute Queensland, Australia

¹²Queensland University of Technology, Brisbane, Australia

*Corresponding author email J.Blackburn3@hud.ac.uk

Abstract

Aims Antimicrobial stewardship (AMS) describes a preventative approach to antimicrobial resistance (AMR). Evidence suggests that nursing knowledge and perceptions of their role in AMS inhibits their involvement in antimicrobial stewardship programmes (ASPs). This systematic review aimed to determine the knowledge and perceptions of nurses regarding AMS.

Methods A systematic search of publications using MEDLINE, CINAHL, and Cochrane databases was conducted and a narrative synthesis undertaken. The study protocol was registered prospectively in the International Prospective Register of Systematic Reviews (PROSPERO): CRD42024524162.

Results This review included seven studies. Limited levels of nurses' knowledge about AMS were significant in all studies, contributing to a lack of nurse engagement and involvement in AMS interventions. An inability to implement AMS protocols in clinical practice was often the result of inadequate knowledge of policies and procedures. Barriers to nurse involvement in AMS included training and education, competing priorities and organisational boundaries.

Conclusion Nurses have a vital role in ASPs and empowering them to challenge inappropriate prescribing practices or antibiotic therapy can contribute towards their success. Future studies should focus on developing targeted educational interventions, enhancing interprofessional collaboration, and exploring the impact of cultural and institutional differences to optimize the role of nurse in ASPs.

Keywords antimicrobial prescribing, antimicrobial resistance, antimicrobial stewardship, education, wound care, nurses

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Introduction

Antimicrobial medications, such as antibiotics, antifungals, antivirals, antimalarials, and antihelminthics, are often used to treat infections in healthcare¹ but an increasing reliance on these medications has escalated the threat of antimicrobial resistance (AMR). AMR occurs when microorganisms undergo genetic modifications due to an overreliance on the use of antimicrobials in humans, animals and plants, and become treatment resistant. Spread through poor hygiene and infection control,¹ AMR is of a global interest, with an estimated 4.95 million deaths being associated with bacterial AMR in 2019.² Worryingly, this figure is expected to increase to nearly 10 million deaths globally each year by 2050³ if appropriate interventions to limit the use of antimicrobial medications are not implemented. The economic impact of AMR is visible through the World Bank predictions estimating 28 million people could face extreme poverty by 2050 if AMR is not managed⁴ with lost global production estimated at \$100 trillion.³

AMR is accelerated by the inappropriate prescribing of antibiotics, which on the current trajectory, could mean that patients undergoing routine surgery and medical interventions will experience poorer outcomes.⁵ In the United Kingdom 20% of antibiotics prescribed in primary care are inappropriate^{6,7,8} twice the figure reported in Europe.⁹ The English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) report¹⁰ found that over 72% of antibiotics were prescribed in General Practice between 2020–2022, with out of hours antibiotic prescribing being responsible for a significant proportion of this prescribing.¹¹ Pressure from patients to receive antibiotics for minor illnesses and infections¹² is also contributing to this figure, reinforcing the need for healthcare professionals (HCPs) to be educated about the significance of AMR and using antibiotics properly.

Antimicrobial Stewardship (AMS)

The appropriate use of antibiotics is vital to preventing AMR and antimicrobial stewardship (AMS) is one way of overcoming this threat. Defined as *'a coherent set of integrated actions, which promote the response and appropriate use of antimicrobials to help improve patient accounts across the continuum of care'*¹³ AMS aims to increase awareness of AMR through educating clinicians in how to use antibiotics and introducing proactive approaches to reducing infection through the implementation of effective procedures, processes and monitoring activities. The WHO¹⁴ provides guiding principles for AMS activities to combat AMR to ensure the optimal use of antimicrobials to improve patient outcomes. The guiding principles include the promotion of the responsible use of antimicrobials, the integration of AMS into existing healthcare systems, prioritisation of activities of most benefit, such as infection prevention, consideration of the local and national context, and coordinating mechanisms and resources to implement integrated AMS strategies. Ensuring collaborations with national diseases and infection

prevention programmes is also recommended. Nurses are recognised as critical stakeholders in the implementation of these principles in AMS due to their close involvement in patient care, infection prevention, and education. They are central in the administration and monitoring of antimicrobials, educating patients and their families about the importance of appropriate antimicrobial use and are important collaborators in multidisciplinary AMS teams. WHO¹⁴ also emphasises the role of nurses in advocating for systemic changes that support AMS, such as the development of institutional AMS guidelines, the integration of AMS principles into routine nursing care and protocols, and their contribution to policy making initiatives.

AMS and appropriate prescribing procedures

AMS is directed by AMS programmes (ASPs), defined as *'an organizational or system-wide health-care strategy to promote appropriate use of antimicrobials through the implementation of evidence-based interventions'*.¹⁵ ASPs aim to ensure effective treatment of infections by introducing strategies to support the judicious use of antimicrobials by HCPs¹⁶ involving cooperation from multidisciplinary teams. ASPs involve developing and following clinical pathways and guidelines to direct appropriate antibiotic choice and duration¹⁷ and have demonstrated reductions in hospital length of stay and infection rates.¹⁸ Firouzabadi and Mahmoudi¹⁹ found that healthcare workers in Iran believed local guidelines that focused on antibiotic use were important for educating staff about the standardisation of AMS practices and helped to reduce the impact of AMR.

There are several key roles of nurses in AMS which include the administration and monitoring of antimicrobials, identifying infections, patient and family education, infection control, data collection and documentation and engaging in AMS policies. Nurses play a vital role in wound management and ASPs due to their role in wound assessment, determining wound severity and infection and documenting wound healing progression. While wound management is increasingly acknowledged as being reflective of a effectively functioning multidisciplinary team, nurses play a pivotal role in coordinating, delivering and monitoring care. Wound care nurses have a vital role in AMR and AMS by advocating for the judicious use of antibiotics to prevent resistance, promoting the use of topical antimicrobials or alternative therapies to minimise systemic antibiotic use and ensuring wound care practices align with AMS principles, such as targeted therapy based on culture results. In addition, specialised wound care nurses often lead in designing individualised care plans and implementing advanced wound therapies to promote wound healing, as well as regularly monitoring patients for signs of infection and advising on ASPs. Regular monitoring and education are recommended strategies proposed by the International Wound Infection Institute (IWII)²⁰ to manage wound infection. However, research has also found that measuring the impact of ASPs is lacking²¹ and competing priorities and limited resources in the nursing profession²²

means that many antibiotics are prescribed inappropriately. Limato et al²³ found that HCPs felt that the effectiveness of ASPs were limited due to organisational constraints and job role and responsibilities, suggesting that understanding how HCPs can contribute to the success of ASPs can strengthen their effectiveness.

Nursing AMS specific knowledge, skills and competencies

To effectively contribute to the success of AMS and ASPs, nurses need specific knowledge, skills, and competencies in the principles of AMS. Adherence to local and national guidelines and frameworks to understand how improving patient outcomes can reduce the impact of AMR, along with basic knowledge of antimicrobial pharmacology, infection pathophysiology, and infection control and prevention, are key competencies to support how nurses can make significant contributions. Nurses have a vital role in AMS through direct patient care, where they assess and monitor patients for signs of infection, administer antibiotics, and evaluate the effectiveness of treatments. Their competencies and skillsets extend to providing patient education on the importance of completing antibiotic regimens and preventing misuse.¹⁶ Nurses also collaborate closely within multidisciplinary healthcare teams including physicians, pharmacists and infection control specialists to ensure the appropriate selection, timing, and dosing of antimicrobial therapies.¹⁹ It is essential that nurses have the right skillsets to support their involvement with ASPs including conducting appropriate clinical patient assessments to identify the early signs and symptoms of infection, monitoring the effectiveness of antimicrobials, educating patients and effectively communicating with healthcare teams.²⁴

Education, knowledge and training are also essential components of engaging all clinicians in AMS and ASPs.²⁵ However, the evidence is mixed regarding how integrated nursing teams feel they are in ASPs. In a systematic review of nurses' engagement with ASPs in the intensive care setting, Padigos et al²⁶ identified that junior nurses were reliant on senior colleagues to make decisions about prescribing practices. From 26 studies included in the review, a lack of knowledge of antimicrobial usage and its importance in managing AMR were key barriers to engagement with, and the implementation of ASPs. Organisational cultural norms were also identified as preventing the optimal use of antimicrobials. These findings are supported by other research on the importance of education and empowerment of nursing staff to make decisions about antibiotic usage²⁷ and challenging inappropriate prescribing.²⁸ For example, Davey and Aveyard²⁹ undertook a review that explored nurses' perceptions of their role in AMS in the hospital environment and found that although many nurses were engaged in AMS, they were reluctant to verbalise their perceptions on specific AMS strategies.

ASPs are often directed by more senior clinicians, including medical staff, pharmacists and consultants, which often limits

the nurse's role in implementing, directing and engaging with AMS.³⁰ Abbas et al³¹ explored knowledge and attitudes of nursing staff towards AMS in a tertiary setting in America and found that from a total of 159 survey responses, there were significant gaps in knowledge. Although most participants were aware of the specific terminology of AMS (62%) only 31 (19.5%) reported having any formal training on AMS. Limited time was considered a barrier to engaging in ASPs for 136 (85.5%) of participants and negative responses from senior physicians were also cited as a barrier, with 111 (69.8%) of nurses describing this as a concern. These findings are supported by Wilcock et al³², who found that in a survey of nursing staff in a UK hospital, time and knowledge were barriers to engagement with over half the nurses lacking confidence in challenging senior clinicians' antibiotic prescribing practices.

The nursing role in ASPs

AMS requires a multifaceted and multidisciplinary approach to ensure ASPs are successful and adopted system wide. Nursing teams equate to a significant proportion of the healthcare workforce and a large proportion of their role requires caring for patients³³ therefore it is imperative their role in ASPs is recognised. Nurses play a crucial role in the success of ASPs by assessing patients for signs and symptoms of infection, monitoring antibiotic treatments, and identifying potential adverse effects.³⁴ There are several key roles of nurses in AMS which include the administration and monitoring of antimicrobials, identifying infections, patient and family education, infection control, data collection and documentation and engaging in AMS policies.²⁷ A key nursing responsibility is ensuring adherence to prescribed antibiotic regimens, which helps reduce the risk of resistance development and supports optimal antibiotic use. Nurses and wound care practitioners contribute significantly to AMS by implementing and adhering to infection control protocols, such as hand hygiene and isolation precautions, to prevent antimicrobial-resistant infections.²⁸ While many nurses feel they have a vital role in AMS there is also the perception that they have limited capacity and capability to contribute to decision making or have a clearly defined position. This belief can be reinforced through the overlap between AMS-related activities and broader responsibilities in patient care such as infection prevention.³⁵ Hamdy et al³⁶ explored this caveat in a qualitative study with 90 paediatric nurses who were non-prescribers. Participants described having a central role in patient care due to their contact with patients, family members and other team members and ability to question inappropriate prescribing or discontinuing antibiotics. However, they also acknowledged the limitations of their role, specifically regarding an inability to prescribe. Other research has demonstrated that knowledge of AMS and AMR and the structure of the organisational culture minimises nurse engagement in ASPs.³⁷⁻³⁹

This is particularly evidence in specialised departments, such as the intensive care unit,^{40, 41} where nursing knowledge of

antibiotic dosage of patients in the intensive care unit has also been found to be limited.^{42,43}

In an integrative review of nurse participation in ASPs, Merrill et al⁴⁴ found that knowledge, education, organisational factors and patient safety, were important factors to enhance nurses' involvement in ASPs. In another study, Abera et al⁴⁵ found that while the nurses in their study (n=210) were aware of AMR as a problem in healthcare, 98% felt they needed further training on AMS. The authors advocated for empowering nurses to be more involved in ASPs by strengthening and formalising their role through education.

There is evidence that nurses have a vital role in ASPs, but the literature also suggests that limited knowledge and education has resulted in inconsistent nurse involvement in AMS activities across healthcare. Understanding the knowledge and perceptions of nurses regarding AMS activities is essential to reducing the impact of AMR.

Methods

This systematic review was conducted following established guidelines for conducting systematic reviews and meta-analyses, specifically based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).⁴⁶ The main steps include: the formulation of the research question using the PICO model,⁴⁷ comprehensive database searches for relevant literature, the application of specific eligibility criteria for study inclusion, a rigorous process of study selection and data extraction, followed by a narrative synthesis of the findings. We also conducted a quality appraisal of the included studies using the Evidence-Based Librarianship (EBL) checklist to assess internal and external validity, ensuring the reliability of the conclusions drawn.

Aim and research question

Using the PICO model,⁴⁷ this systematic review aimed to determine the knowledge and perceptions of nurses regarding AMS. The study protocol was registered prospectively in the International Prospective Register of Systematic Reviews (PROSPERO): CRD42024524162.

Outcomes measured

The primary outcome of interest was knowledge and perceptions of nurses regarding antimicrobial stewardship. The secondary outcomes were adherence to guidelines, barriers and facilitators, education and training, quality improvement initiatives.

Search strategy and eligibility criteria

The following databases were searched to identify relevant literature:

- Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library) (latest issue);
- Ovid MEDLINE (1946 to May 2024);

- Ovid MEDLINE (In-Process & other Non-indexed Citations) (latest issue);
- Ovid EMBASE (1974 to May 2024)
- EBSCO CINAHL Plus (1937 to May 2024);
- Scopus.

Literature was reviewed by PA and selected for inclusion according to the eligibility criteria outlined in Table 1. Key terms, MeSH terms, and subject headings were used. The full search strategy is shown in Table 2. To identify further published, unpublished and ongoing studies the authors:

- Scanned reference lists of all identified articles to assess for further relevant citations;
- Manually searched relevant grey literature, to enhance the capture of relevant and unique literature (such as OpenGrey: www.opengrey.eu);
- Conducted searches of conference proceedings, research reports and dissertations.

Study selection

Articles deemed relevant were examined as full text by two authors (JB and PA) for further analysis. The reference lists of each were screened for further potential eligible articles and the final list of articles was then agreed on and approved by all authors prior to data extraction. Data were extracted using an approved data extraction table by JB and PA and included study design, interventions, sample size, characteristics, method of evaluation, key findings and limitations.

Data analysis and quality appraisal

Meta-analysis statistical synthesis was considered inappropriate. Thus, the data were narratively summarised, giving an overview of the study setting, geographical location, study settings, sample sizes, and primary and secondary outcomes. This was followed by quality appraisal using the evidence-based librarianship (EBL) critical appraisal checklist and a structured narrative synthesis of all the

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Written in the English language	Not written in the English language
Quantitative research design and studies utilising a mixed methods research design	Reviews, conference papers, opinion papers and studies using only a qualitative research design
Reporting the knowledge, perceptions, and experiences of nurses regarding antimicrobial stewardship	Nursing students as participants

Table 2. Search strategy

Search ID#	Search terms
#1	(nurse OR “nursing staff” OR “registered nurse” OR “nursing professionals” OR “clinical nurse”) AND (“antimicrobial stewardship” OR “antibiotic stewardship” OR “antimicrobial management” OR “antimicrobial control” OR “antibiotic management”) AND (knowledge OR understanding OR awareness OR education OR training OR competency)
#2	(nurse OR “nursing staff” OR “registered nurse” OR “nursing professionals” OR “clinical nurse”) AND (“antimicrobial stewardship” OR “antibiotic stewardship” OR “antimicrobial management” OR “antimicrobial control” OR “antibiotic management”) AND (perceptions OR attitudes OR views OR opinions OR beliefs)
#3	(nurse OR “nursing staff” OR “registered nurse” OR “nursing professionals” OR “clinical nurse”) AND (“antimicrobial stewardship” OR “antibiotic stewardship” OR “antimicrobial management” OR “antimicrobial control” OR “antibiotic management”) AND (experiences OR practices OR participation OR involvement OR engagement OR implementation)
#4	(“hospital” OR “clinical setting” OR “healthcare facility” OR “primary care” OR “acute care” OR “long-term care”) AND (nurse OR “nursing staff” OR “registered nurse” OR “nursing professionals” OR “clinical nurse”) AND (“antimicrobial stewardship” OR “antibiotic stewardship”)

studies included, based on the outcome measures. The checklist was used to examine internal and external validity and for the assessment of potential bias throughout the available studies. This tool assesses a variety of domains including; study population, data collection methods, study design, and results and is used to generate a numerical score to reflect quality based on four main steps of the research process: population, data collection, study design, and results. According to this checklist, if the overall validity of the study (Yes/Total) is $\geq 75\%$ or (No+unclear)/Total) is $\leq 25\%$ then the study is deemed valid using this method of evaluation.

Results

Overview of all included studies

Figure 1 outlines the flow of articles through the reviews. Following reviews of titles and abstracts from 101 citations,

53 were excluded. After a review of the full papers of the remaining citations, eight were rejected for the following reasons: ineligible study outcome and non-eligible study participants (Table 3). Table four outlines the seven articles that were deemed to meet the inclusion criteria.^{48,49,50,51,52,53,54}

Study design

Articles included in the final review spanned from 2001 to 2024. A total of 42.86% (n=3) employed a descriptive survey design.^{49,50,53} A further 14.29% (n=1) employed a pre- and post-intervention design,⁴⁸ 14.29% (n=1) adopted a cross-sectional study design⁵⁴ and 14.29% (n=1) used a web-based survey design.⁵¹ Lastly, 14.29% (n=1) employed a descriptive, cross-sectional research design.⁵²

Geographical location and setting

The geographical location of the studies varied between Australia (n=3, 42.86%)^{51,53}; the USA (n=2, 28.57%)^{49,50}; China (n=1, 14.29%)⁵⁴; and New Zealand (n=1, 14.29%).⁵² The study settings included hospitals, academic medical centres, and community care settings. The most common setting was the hospital (n=5, 71.43%).^{48,51,52,53,54}

Population and sample Size

All included participants were nurses with various focuses on AMS, knowledge of antibiotic use, and perceptions and practices regarding AMR. The mean sample size was 636 (SD=1583.42; min=90⁴⁹; max=4514⁵⁴).

Primary outcome results

AMR and AMS knowledge was assessed as a main outcome in four studies^{48,49,50,52} and perceptions of AMS and AMS interventions was the focus of three studies.^{51,53,54}

Knowledge of AMS and AMR

Two studies^{48,50} assessed nurses' knowledge following ASPs, which involved participants receiving education on antibiotic usage and initiation. In the study by Gillespie et al⁴⁸ nurse education increased confidence to challenge inappropriate prescribing from senior colleagues. 100 participants were involved in a pre-post educational intervention involving education focusing on changing practice of intravenous antibiotic use, being delivered to participants over a four or three week period at six different sites. The results showed an increase of 14% of instances where nurses said they would question the need for intravenous antibiotics and a 20% increase in their awareness of the risks of AMR. Knowledge of the associated risk of line-related infection with intravenous therapy, increased from 38% to 70%. Roberts et al⁵⁰ evaluated the knowledge and perceptions of critical care nurses (n=100) regarding antibiotic usage following the implementation of a sepsis protocol advocating intravenous antibiotic initiation within one hour of shock recognition using a validated survey. 65% of participants were aware of the clinical definition of septic shock however, only a small number of participants correctly identified the sequence of the septic shock protocol (40%).

Two studies^{49,51} investigated nurses' current levels of knowledge of AMS, AMR and antibiotic usage using a survey design. Munro and Grap⁴⁹ assessed critical care nurses' knowledge and attitudes (n=90) about appropriate antibiotic use. Participants answered nine questions on a visual analogue scale indicating their agreement with statements in three areas of AMS; knowledge about antibiotic therapy; nurses' role in assessing and measuring laboratory results; and comfort level in interpreting results. Knowledge was not significantly predictive of performance for either laboratory study knowledge (p=0.37) or antibiotic therapy knowledge (p=0.63). Comfort levels regarding antibiotic knowledge and laboratory studies were positively correlated with self-perception of knowledge (p<0.01 for antibiotic knowledge; p<0.01 for antibiotics; p<0.01 for laboratory studies). Respondents reported not having excellent knowledge about AMS and were not completely comfortable with interpreting laboratory studies or discussing antibiotic therapy with

physicians. Padigos et al⁵¹ investigated the knowledge of 298 registered nurses on antibiotics and their understanding of AMS using a descriptive, cross-sectional quantitative survey consisting of 56-items relating to AMS principles, knowledge of AMR and antibiotic usage. 49% of respondents rated their knowledge of AMS as below average or very poor although almost all respondents (92%) agreed that the overuse of antibiotics and not completing a course of antibiotics (85%) contributed to the problem of AMR.

Nurse perceptions and knowledge of AMS interventions

Nurse perceptions, knowledge and involvement in ASPs were the focus of three studies.^{51,53,54} Nie et al⁵⁴ found that nursing knowledge of infection and awareness of AMS policies inhibited nurses' opportunities and motivation for involvement in ASPs. 4514 participants completed the Nurse AMS Engagement Questionnaire (NAEQ); a 39-item questionnaire with four dimensions requiring participants

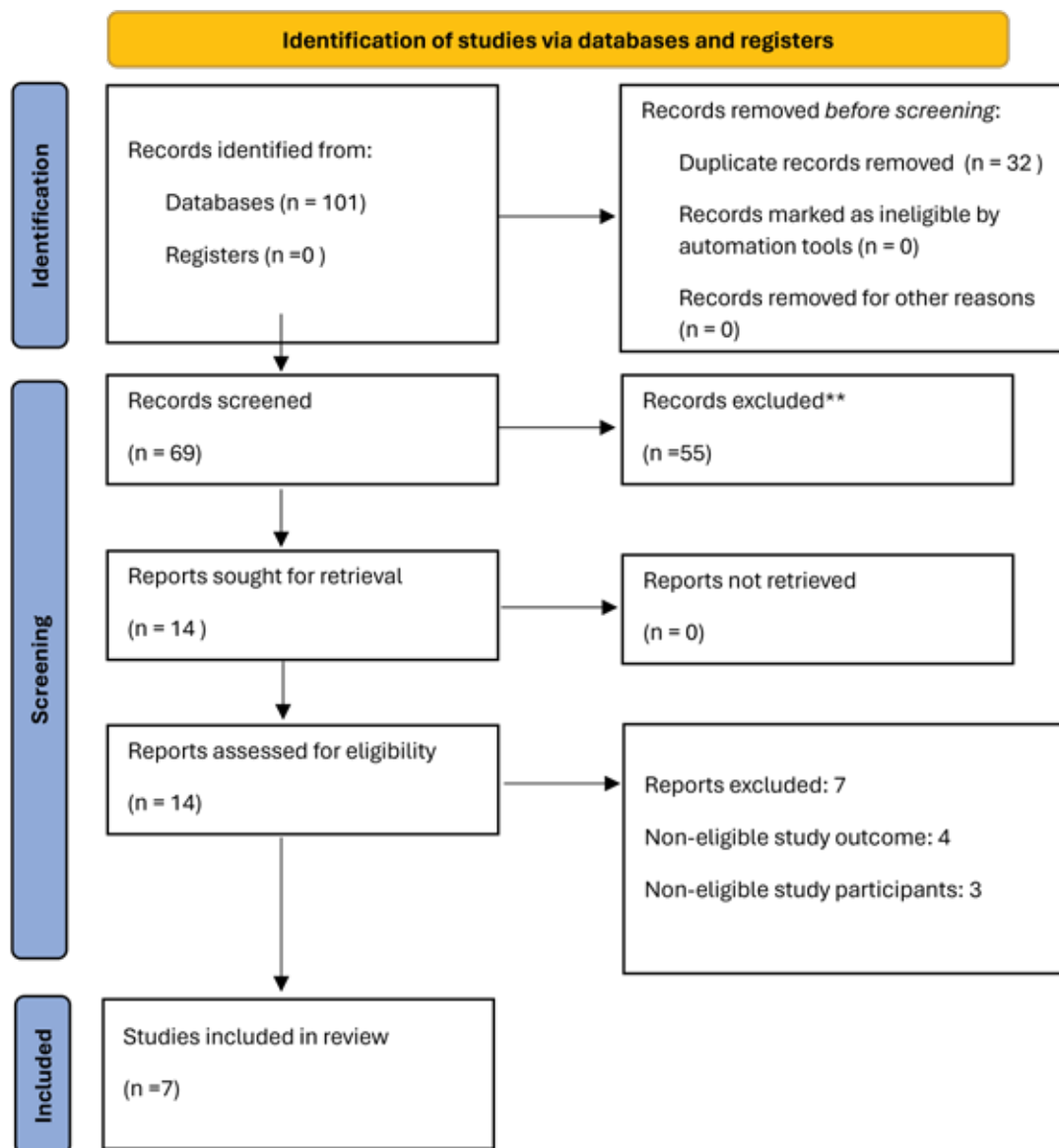


Figure 1. Prisma flow diagram for study selection

Table 3. Excluded studies with reasons

Author	Study title	Reason for exclusion
Olan et al ³⁸	Defining a role for nursing education in staff nurse participation in antimicrobial stewardship	Not focusing on the primary outcome
Bulabula ³⁹	Education and management of antimicrobials amongst nurses in Africa – a situation analysis: an Infection Control Africa Network (ICAN)/BSAC online survey	Not focusing on the primary outcome
Rout et al ⁴⁰	Exploring the role of the ICU nurse in the antimicrobial stewardship team at a private hospital in KwaZulu-Natal, South Africa	Not focusing on the primary outcome
Giblin et al ⁴¹	Clinicians' perceptions of the problem of antimicrobial resistance in health care facilities	Non-eligible study participants
Raybardhan et al ⁴²	Nurse prompting for prescriber-led review of antimicrobial use in the critical care unit.	Not focusing on the primary outcome
Fleuren et al ⁴³	Clinically relevant pharmacokinetic knowledge on antibiotic dosing among intensive care professionals is insufficient: a cross-sectional study	Non-eligible study participants
Abera et al ⁴⁵	Knowledge and beliefs on antimicrobial resistance among physicians and nurses in hospitals in Amhara Region, Ethiopia	Non-eligible study participants:

Table 4. Characteristics of included studies

Authors & Country	Design	Study setting	Study population	Aim
Gillespie et al ⁴⁸ Australia	Pre- and post-intervention design	Hospital	100	To evaluate the effectiveness of an educational intervention in improving nurses' knowledge and attitudes towards antimicrobial stewardship, particularly their ability to question the necessity of intravenous antibiotics and promote the switch to oral antibiotics when appropriate
Munro, Grap ⁴⁹ USA	Descriptive survey study	Academic medical centre	90	To assess critical care nurses' knowledge about antibiotic use in critical care settings and their attitudes concerning the role of nurses in monitoring responses to and appropriate use of antibiotic therapy
Roberts et al ⁵⁰ USA	Descriptive survey design	Academic medical centre	122	To evaluate the knowledge, practices and perceptions of critical care nurses regarding antibiotic initiation in patients with newly recognised septic shock
Padigos et al ⁵¹ Australia	Web-based survey	Hospital and General Practices	226	The objective of this study was to explore nurses' perceptions and experiences of antimicrobial optimisation or stewardship in intensive care units in Australia
Padigos et al ⁵² New Zealand	A descriptive, cross-sectional research design	Hospital, community, rest home and dementia unit	298	To investigate the knowledge of registered nurses of antibiotics, antimicrobial stewardship and their understanding of antimicrobial resistance
Cotta et al ⁵³ Australia	Descriptive survey study	Hospital	105	To describe perceptions and attitudes towards antimicrobial resistance, antimicrobial use, antimicrobial stewardship interventions and willingness to participate
Nie et al ⁵⁴ China	Cross-sectional study	Hospital	4514	To investigate the level and influencing factors of nurses' antimicrobial stewardship (AMS) engagement in China based on the capability, opportunity, motivation and behaviour theory, providing valuable insights for developing effective strategies to improve nursing quality in AMS

to rate their responses on a 5-point Likert scale assessing capability, opportunity, motivation, and behavior in relation to AMS. Junior nurses had higher NAEQ scores than more experienced nurses ($p < 0.05$), as did nurses who spent part of their role as an infection control nurse and were involved with the AMS team ($p < 0.01$). Knowledge of infection, diagnosis, treatment, and awareness of AMS policy were the three lowest-scored items of nurse AMS capability.

Two studies^{51,53} explored nurses' perceptions and knowledge of AMS and ASPs using a questionnaire design. Padigos et al⁵¹ found that only 48% of 226 ICU nurses had the confidence to question prescribers' practices. Although 70% of nurses were aware of the term AMS, 75% reported a lack of involvement in ASPs, specifically for decision making around de-escalating antimicrobial therapy. In contrast, Cotta et al⁵³ found that only 22% of 105 nurses had heard of the term AMS, although 45% of nurses believed AMR affects patients under their care

Secondary outcome results

Barriers and facilitators to AMS engagement

Opportunities to engage in ASPs, lack of commitment and competing priorities were identified as the main barriers in three studies.^{48,53,54} Being unaware of ASPs in their organisations was cited as a reason for a lack of nurse engagement in ASPs in two studies.^{53,54} Nie et al⁵⁴ found that lacking opportunities to engage in AMS policy and multidisciplinary activities were the main barriers for AMS engagement, related to a lack of discussions with senior colleagues about the appropriateness of antimicrobial prescriptions. Commitment to engage in ASPs was identified as a barrier in two studies.^{48,53} Gillespie et al⁴⁸ postulated that a lack of nurse engagement could be responsible for only half of the wards reporting a reduction in line days following their educational intervention. A lack of commitment was reported in the study by Cotta et al⁵³ who found that only 43 of 103 nurses were willing to participate in clinical interventions about antimicrobial use.

Competing priorities was cited as a barrier to AMS engagement in two studies.^{50,51} Padigos et al⁵¹ found that high workload was reported as a barrier to AMS involvement in 75% of participants. Roberts et al⁵⁰ found that the main barriers to nurses engagement in ASPs were patient workload (74%), being unaware that antibiotics had arrived on the unit (69%), being unaware that antibiotic therapy had already been ordered (57%), line access issues (54%) and a lack of any intravenous access (51%).

Training and education

A lack of training and education on AMS and AMR was identified as a limitation to nurse involvement in AMS in five studies.^{50,51,52,53,54} Padigos et al⁵¹ found that only 13% of the 226 nurses who completed their survey had received training or education on AMS, despite over 80% believing limited education was a key barrier to engagement.

Almost all nurses in the study by Padigos et al⁵² viewed education as important to AMS engagement with 84% believing that ongoing training and education on AMS and training on antibiotics (93%) was crucial to ensuring nurse participation. Limited knowledge was also viewed as the most challenging factor by 71% of respondents in enabling nurses to integrate AMS in their clinical practice. Cotta et al⁵³ found that only 22% of 105 nurses were aware of the term AMS. Most respondents felt that ASPs involving formal policies and guidance should be introduced ($n=63$) although only 43% said they would be willing to be involved in such interventions. The study by Roberts et al⁵⁰ found that 80% of participants were aware of an AMS protocol requiring antibiotic initiation within one hour. Only 4% of participants in this study regarded nurse awareness of AMS protocols as a barrier to AMS involvement. Nie et al⁵⁴ found that nurses who had regular training on AMR and AMS had higher NAEQ scores than those without training ($P < 0.01$).

Quality appraisal of included studies

The EBL Appraisal checklist was used to evaluate the methodological quality of the studies included in this review, focusing on four main domains: population, data collection, study design, and results (Table 5). The mean validity score for all studies was 82.24% (SD:2.28; min 79.29%⁵⁴; max 84.0%^{48,52}). Table 5 illustrates that all studies scored 75% or higher, indicating that all included studies were considered valid.

Discussion

This review synthesised the evidence exploring the knowledge and perceptions of nurses regarding AMS. All studies identified limited levels of knowledge about AMS as being a significant factor in a lack of nurse engagement and involvement in ASPs. Knowledge of AMR and AMS was the focus in four studies.^{48, 49, 50, 52} Nurse perceptions and knowledge and involvement in AMS interventions were the focus of three studies.^{51, 53, 54}

An inability to implement AMS protocols in clinical practice was often the result of inadequate knowledge of AMR policies and procedures, attributable to limited training and education. This is consistent with previous research findings which demonstrate a lack of knowledge of AMR and AMS limits the extent to which nurses feel they can engage in ASPs.^{32,42,43,44,45} Nurses perceptions of their role in ASPs was also identified from the studies included in this review as an important factor for engagement and is supported by evidence from the literature which demonstrates that a lack of confidence in their knowledge and skillset, or a clearly defined role,^{36,37,38,39} contributes to a lack of engagement and commitment from this staff group. This highlights the need for education and training that focuses on knowledge building and skills to permit nursing teams to be involved in AMS tasks such as decision making around AMS processes and procedures. The need for greater training opportunities has been identified in the literature as one aspect that is required to create a supportive culture of nurse involvement

in AMS. Giblin et al⁴¹ found that barriers to AMS engagement included a lack of knowledge, organisational culture and educational opportunities. In an integrative review of nurse participation in ASPs, Merrill et al⁴⁴ found that knowledge, education, organisational factors and patient safety, were important factors to enhance nurses' involvement in ASPs. Abera et al⁴⁵ also found that while the nurses in their study (n=210) were aware of AMR as a problem in healthcare, 98% felt they needed further training on AMS. The authors advocated for empowering nurses to be more involved in ASPs by strengthening and formalising their role through education.

Nurses have a major role to play in AMS and they are integral to undertaking tasks such as antibiotic monitoring, infection control and audit and data management. Thus, formalising their role within ASPs with clearly defined responsibilities and duties for patient care, can help foster a supportive culture to maximise engagement and involvement. Gillespie et al⁴⁸ discussed the importance of involving nurses in the monitoring and implementation of ASPs to demonstrate progression or changes in practice. Research highlighting the need for empowering nurses to make decisions about antibiotic therapy suggests that reinforcing the important role nurses can play in AMS can positively contribute towards

ASPs success.^{26,27,28} Expanding the boundaries of the nursing role can also build confidence to maximise nursing teams' involvement.

Time constraints and workload demands have been identified as common barriers in embedding AMS in clinical practice.⁵⁵ Education and training regarding AMR and AMS should be embedded into all under and post graduate healthcare curricula to raise awareness. Padigos et al⁵² advocate for senior clinicians to encourage training and education on AMS mandatory for all nursing staff to allow them to be more involved in AMS activities. Consistently, Bulabula et al³⁹ explored nurses involvement and training in AMS in Africa and found that although nurses perform AMS activities as part of their job role they acknowledged they would like to be more involved in activities such as developing prescribing policies and guidelines, and prescribing antimicrobials. Furthermore, Rout and Brysiewicz⁴⁰ undertook a qualitative study to examine perceptions of the role of the ICU nurse within ASPs and found that the nurses felt they played a key role in monitoring antibiotic use, performing infection control procedures, and effectively communicating concerns about antimicrobial therapy to colleagues to ensure the ASPs were effective, further reinforcing the important role of nursing teams in ASPs.

Table 5. EBL scores for included studies

Author Year	Total Score	Population	Data Collection	Design	Results
Gillespie et al ⁴⁸	84%	83.3% Population bias	85.71% Data collectors did not provide patient care	100%	83.33% Confounding variables accounted for
Munro, Grap ⁴⁹	81.82%	80% Population bias	85.71% Data collectors did not provide patient care	100%	66.67% Confounding variables accounted for. Ethics approval unclear
Roberts et al ⁵⁰	83.33%	75% Sample size may be limited	90% Standardised survey instruments, reduced bias	100%	85% Efforts to account for confounding variables, but some residual confounding possible
Padigos et al ⁵¹	83.7%	70% Population may not be fully representative	85% Use of validated tools, potential for response bias	90% Data collectors did not provide patient care	80% Consideration of confounding variables, but some residual confounding possible
Padigos et al ⁵²	84%	83.3% Population bias	85.71% Data collectors did not provide patient care	100%	83.33% Confounding variables accounted for. Ethics approval unclear
Cotta et al ⁵³	82.14%	75% Potential population bias due to hospital setting	85% Well-defined data collection methods, minimal bias	90% Data collectors did not provide patient care	80% Confounding variables considered, but some residual confounding
Nie et al ⁵⁴	79.29%	70% Potential for population bias in specific settings	80% Use of standardised instruments, some risk of response bias	85% Data collectors did not provide patient care	75% Efforts to account for confounding variables, but some residual confounding

No studies included in this review focused on the knowledge of nurses working in wound care, AMS and wound management, despite it being a critical component in combating AMR and ensuring effective patient care. Wound care nurses have a critical role in AMR and the literature emphasises this in ASPs in several areas of wound care including managing patients with burns⁵⁶ and implementing alternatives to antibiotic therapy for wound infections.⁵⁷ Furthermore, the British Society for Antimicrobial Chemotherapy position paper stresses the collaborative role of nurses in AMS, particularly in chronic wound care and the importance interdisciplinary team working to maximise the success of such interventions. Applying principles of AMS to the care of patients with wounds can help to reduce the unnecessary use of systemic or topical antibiotics and ensure the safest and most clinically effective therapy for infected wounds. Ensuring nurses working in wound care have sufficient knowledge and understanding of AMR and AMS can facilitate their involvement in ASPs to identify the early signs and symptoms of infection, monitor the effectiveness of antimicrobials, deliver patient education and effectively communication with healthcare teams.²⁴

Limitations

A potential limitation is that only studies in the English language were used for evidence. However, this review has identified a extensive range of national and international studies exploring the knowledge of nurses regarding AMS and therefore is considered a thorough review of the available evidence. The search was restricted to exclude nursing students as participants. However, it is likely that nursing students would not have the same knowledge base as those who are qualified and registered nurses, which may have biased the findings.

Conclusions

The aim of this review was to determine the knowledge and perceptions of nurses regarding AMS. The findings suggest that while nurses generally recognise the importance of AMS there are significant gaps in their knowledge and confidence regarding AMS practices. Educational interventions have shown to improve nurses' confidence and awareness, but many still feel inadequately involved in AMS decision-making and some nurses lack the motivation and opportunities to engage fully in ASPs. For ASPs to be fully integrated into practice specific nurse targeted education is needed. ASPs should be developed and formalised with the input from nursing teams to ensure they feel fully integrated into the development and operational running of ASPs. National and local organisations have a responsibility to support staff to understand this and to have clear metrics to measure AMS adherence and reduction in inappropriate use of antimicrobials

Recommendations for future research

Nurses have a vital role in ASPs and empowering them to

challenge inappropriate prescribing practices or antibiotic therapy can contribute towards their success. Future studies should explore the effectiveness of targeted educational interventions designed to enhance nurses' knowledge and involvement in AMS, focusing on different formats such as workshops or e-learning.

Research should investigate the impact of interprofessional collaboration and nurse-led initiatives on improving prescribing practices and patient outcomes. Finally, examining the influence of cultural and institutional differences on nurses' roles in AMS could provide valuable insights for tailoring programmes to specific healthcare settings.

Conflict of interest

The authors declare no conflicts of interest.

Ethics statement

An ethics statement is not applicable.

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Author contribution

All authors made significant contributions to the manuscript. JB and PA were involved in article screening and selection for eligibility. The article titles were assessed by two authors (JB, PA) independently, and their abstracts (when available) were screened for their eligibility, according to the criteria for considering studies for this review. The full-text version of potentially relevant studies was obtained and two authors independently screened these against the inclusion criteria. Where discrepancies were identified a consensus between the two authors was reached through discussion.

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