

Guideline recommendations for antimicrobial stewardship education for clinical nursing practice in hospitals: A scoping review

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Background. Antimicrobial stewardship (AMS) is a proactive healthcare intervention to improve patient outcomes by optimising antimicrobial use. Although nursing involvement is a recognised necessity, bedside nurses may not yet possess competencies to fulfil this role.

Objectives. To identify recommendations for AMS education for the bedside nurse in key global AMS guidelines.

Methods. Scoping review methodology was used to systematically search published and 'grey' literature in PubMed, EBSCOhost, Google Scholar, government websites and websites of professional societies and organisations. Search dates were from 1990 to 2020. Inclusion criteria were English language AMS guidelines for hospitals.

Results. Literature searches retrieved 1 824 articles, with 43 meeting the review inclusion criteria. Reference was made to AMS nursing education in 23 (53.4%) of the articles. Educational opportunities for nurses were recommended: inclusion of AMS concepts/content into undergraduate and postgraduate nursing curricula ($n=12$; 27.9%), in-hospital training ($n=14$; 32.5%) and continuing professional development ($n=6$; 13.9%). Recommendations for nursing education were as follows: role of AMS in preventing antimicrobial resistance ($n=7$; 16.2%), infection prevention and control ($n=3$; 6.9%), diagnostics in AMS ($n=5$; 11.6%), pharmacology ($n=11$; 25.5%) and collaboration ($n=2$; 4.6%). Identified nursing educational gaps were: nurses not recognising their role within AMS ($n=5$; 11.6%), inadequate nursing resources and expertise for dosing, pharmacokinetic/pharmacodynamic strategies and managing possible drug incompatibilities with extended/prolonged infusions ($n=3$; 6.9%), and inappropriate nurse disposal of antibiotic waste ($n=1$; 2.3%).

Conclusions. Although recommendations for nursing education were found in many key AMS guidelines, few guidelines provided detailed descriptions of the nursing competencies that were required for this role.

Keywords. antimicrobial stewardship; education; guidelines; bedside nurse; scoping review.

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Contributions of the study. This study serves to compile and highlight previously little-known recommendations within key international antimicrobial stewardship (AMS) guidelines for the education of clinical nurses in their AMS role. It provides a summary of expected clinical nurse competencies. It adds to current discussion within the literature on how to improve and support this critical nursing role.

The use of antibiotics has allowed enormous advances in human healthcare; however, antimicrobial resistance (AMR) threatens to counteract these lifesaving medications. Strategic objectives to address AMR in the World Health Organization (WHO) 'Global action plan on antimicrobial resistance' aim to: improve awareness and understanding of AMR through effective communication, education and training; improve knowledge about the extent of the problem through surveillance and research; reduce the incidence of infection; improve the use of antimicrobials; and implement sustainable programmes to reduce AMR.^[1] Changing the manner in which antibiotics are used is acknowledged as the most important way to reduce AMR;^[2] the primary goals of antimicrobial stewardship (AMS) are therefore to prevent or slow the emergence of AMR; optimise the selection, dose and duration of therapy; reduce adverse drug events, including secondary infection (e.g. *Clostridium difficile* antibiotic-associated diarrhoea); reduce morbidity and mortality; reduce length of stay; and reduce healthcare expenditures.^[3]

To provide optimal evidence-based care of the patient, the nurse needs to understand that the nursing role within AMS is aimed at the

prevention of AMR. Ongoing education forms the foundation of AMS programmes,^[2,4,5] and is a 'key factor in empowering nurses to take responsibility for AMS'.^[6] Unfortunately, nurses' knowledge of AMS and antibiotics continues to be suboptimal, despite it being identified as an important aspect of the AMS role for nurses,^[7-15] affecting both nursing practice and communication with others within the multidisciplinary AMS team,^[4,10,15-22] possibly due to a historical focus on nursing documentation rather than interpretation.^[10]

The importance of preparing nurses to support AMS strategies was acknowledged by the Royal College of Nursing (RCN) (UK) (2014) in a position paper, 'Antimicrobial resistance. RCN position on the nursing contribution: Antimicrobial resistance is an increasing global priority and one where nursing has a key contribution to make'.^[23] A systematic scoping review was chosen as the appropriate methodology to map the literature^[24] for other key AMS guidelines offering educational recommendations for AMS clinical nursing practice in the hospital setting. A preliminary search of PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews and the Joanna Briggs Institute (JBI)

Database of Systematic Reviews and Implementation Reports was conducted and no current or ongoing scoping reviews or systematic reviews on the topic were identified. This review title is registered with JBI Systematic Review and Open Science Framework (OSF).

Methods

Study design

The scoping review was conducted in accordance with the JBI (2015) methodology for scoping reviews,^[24] based on the Arksey and O'Malley framework,^[25] with improvements by Levac *et al.*^[26] A five-stage protocol for the scoping review was compiled by three reviewers, guided by the PRISMA Extension for Scoping Reviews (PRISMA-ScR):^[27] (i) identifying the research question; (ii) identifying relevant studies; (iii) study selection; (iv) charting the data; and (v) collating, summarising and reporting results.^[24-26]

Identifying the research question

Following an initial research question aiming to map AMS guideline recommendations for bedside nursing practice in acute-care hospitals, described in 'Guidelines for the hospital role of the clinical nurse in antimicrobial stewardship: A scoping review',^[28] a second research question was defined as: 'Do key antimicrobial stewardship guidelines and policies include recommendations for AMS education for bedside nursing practice, and what are these recommendations?' Objectives of the review were to describe: (i) nursing AMS gaps identified by AMS guideline documents; (ii) recommendations for AMS education for the bedside nurse; and (iii) recommendations for AMS educational opportunities for the bedside nurse.

Identifying relevant studies

Inclusion and exclusion criteria

English language documents published from 1990 to 2020 were considered and included publications prior to the first known AMS guideline (1997)^[29] (Table 1). The search strategy aimed to locate both published and unpublished ('grey' literature)^[24-26] guidelines specific to AMS (including recommendations, policy statements, position statements, white papers, standards, strategies, protocols, action plans or briefs) authored by government bodies, national healthcare organisations, interested healthcare societies, and medical, pharmacy and nursing professional bodies.

Search strategy

Database and manual searches were conducted in 2018 and updated in 2020 using a three-step search strategy:^[24,30] (i) a limited PubMed

search was conducted to identify articles on the topic; (ii) text words contained in the titles and abstracts of relevant articles and index terms used to describe the articles were then used to develop a full search strategy. The search strategy, including all identified keywords and index terms, was adapted for each included information source and for electronic literature databases (PubMed and EBSCOhost (academic search complete), CINAHL, HealthSource, MEDLINE, Nursing/Academic Edition) (Appendix 1: <http://sajcc.org.za/public/sup/482.pdf>); and (iii) manual searches were carried out on reference lists of identified key articles (Fig. 1).^[31]

Study selection

After the search, all identified records were collated and uploaded to EndNote version X7.8 (EndNote, USA) and duplicates removed. The literature search yielded a total of 1 824 articles, from which 1 325 duplicate and non-relevant articles were removed. The two reviewers used a two-part selection process to exclude 357 articles on the basis of eligibility through first-level screening (using document titles and abstracts), and an additional 99 through second-level screening of the full text. In the case of documents retrieved from websites, which generally did not have abstracts, selection was based on title and full-text read. Any disagreements that arose between the reviewers were resolved through discussion or with a third reviewer. Forty-three documents were finally selected, using inclusion and exclusion criteria (Table 1), and the JBI Population Concept Context (PCC) framework:^[30] (P)opulation - nurses who practise in a hospital setting; (C)oncept - guideline recommendations for clinical nurse education; and (C)ontext - AMS strategies and interventions that have developed to address AMR. The selection process was documented according to PRISMA-ScR (Fig. 1).^[27]

Charting the data

Data were extracted from documents included in the scoping review by two independent reviewers using a data-extraction tool that they developed. Peters *et al.*^[30] suggest that a scoping review should map the literature with regard to time, location, source and origin. The

Table 1. Eligibility criteria

Inclusion criteria	
•	Guidelines published by ministries of health, medical or nursing professional associations or healthcare professional societies
•	Guidelines related to antimicrobial stewardship and/or antimicrobial resistance hospital programmes for the adult patient
•	Guidelines published in English
•	Guidelines published from 1990 to 2020
Exclusion criteria	
•	Hospital-specific guidelines
•	Guidelines published in languages other than English
•	Guidelines published before 1990

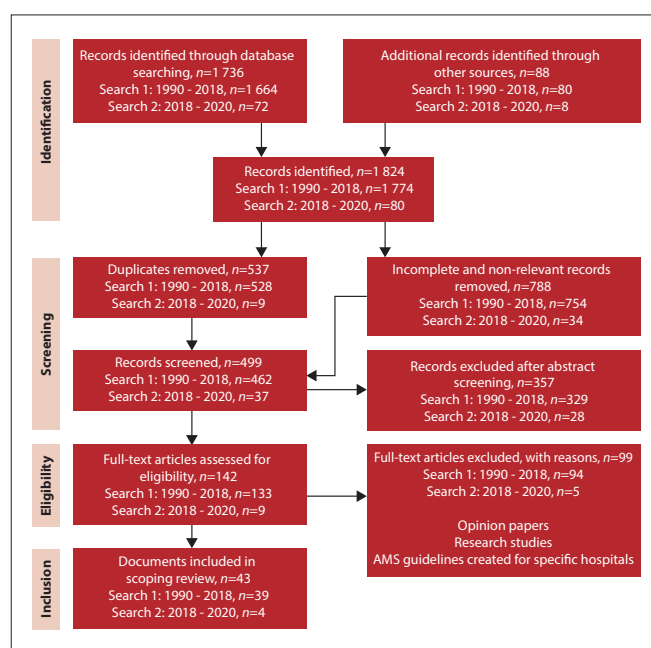


Fig. 1. PRISMA flow diagram showing selection process. (AMS = antimicrobial stewardship.)^[27]

data from the 43 studies that were included were therefore charted according to the authors, organisations/societies that they were representing, year published, country of origin, overall goal and objectives of the guideline document (Table 2).^[30]

Collating, summarising and reporting results

Following scoping review methodology, we applied a common ‘descriptive-analytical’ framework to the reviews.^[24,25] A narrative synthesis^[24] was used to answer the objectives of the study, as described below.

Ethical approval

Ethical approval (ref. no. BE709/18) was obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal, Durban, South Africa. This review forms part of a larger study into clinical nurse practice within AMS.

Results

Origin and purpose of AMS guideline documents

Of the 43 guideline documents identified by the scoping review,^[1,2,23,29,32-70] the majority were from government ministries/departments of health (*n*=23; 53.4%), professional organisations (*n*=6; 13.9%), professional societies (*n*=10; 23.2%), world organisations (*n*=2; 4.6%) and committees and commissions (*n*=2; 4.6%), and were published in professional journals or placed on websites. Five (11.6%) of the selected documents were from professional nursing organisations. Recommendations for AMS education were made by 23 (53.4%) of the guideline documents reviewed: USA (*n*=8; 18.6%), EU (*n*=4; 9.3%), Africa (*n*=4; 9.3%), Australia (*n*=3; 6.9%), Canada (*n*=2; 4.6%), Asia (*n*=1; 2.3%) and international (*n*=1; 2.3%) (Fig. 2).

Educational gaps identified with the AMS role of the bedside nurse

Eight documents (18.6%) referred to specific nursing attitudes and practices, which were viewed as educational gaps. These were: nurses may not recognise/understand the AMS nursing role and that much of their daily clinical practice supports AMS strategies (*n*=5; 11.6%); inadequate expertise with multiple or complex infusions, such as extended/prolonged infusions (*n*=3; 6.9%) to prevent possible drug incompatibilities (*n*=1; 2.3%) and to support dose optimisation (*n*=2; 4.6%); and incorrect disposal of waste items containing residue of antimicrobial medicines, e.g. residue in vials and intravenous (IV) infusion administration lines, as these may have environmental implications for AMR (*n*=1; 2.3%) (Table 2).

Recommendations for AMS education for the bedside nurse

Twenty-three documents (53.4%) made recommendations for AMS education, described in 13 documents (30.2%) as: the role of AMS in preventing AMR (*n*=7; 16.2%), infection prevention and control (IPC in AMS) (*n*=3; 6.9%), diagnostics in AMS (*n*=5; 11.6%), pharmacology in AMS (*n*=11; 25.5%) and collaboration in AMS (*n*=2; 4.6%) (Table 3).

Recommendations for AMS educational opportunities for the bedside nurse

Twenty-one documents (48.8%) made suggestions for educational opportunities to be created for nurses. There were 12 suggestions (27.9%) for the inclusion of AMS concepts/content into curricula: undergraduate education (*n*=8; 18.6%) and

postgraduate education (*n*=4; 9.3%). Fourteen documents (32.5%) suggested that hospitals should provide nurses with AMS training: on induction (*n*=2; 4.6%), in-service education from the AMS team (*n*=4; 9.3%), in-service education on AMS rounds (*n*=2; 4.6%), in-service AMS education from IPC specialist nurses (*n*=2; 4.6%), audit feedback from AMS teams (*n*=6; 13.9%); and six documents suggested that nurses should access AMS information through continuing professional development (CPD) opportunities (*n*=6; 13.9%), although it was not clear from the documents whether this should be provided by hospitals or other forums (Table 2).

Discussion

The need to build expertise in preventing AMR is clear and can only be achieved by a new emphasis on equipping nurses with the knowledge, skills and competencies required to support multidisciplinary engagement of AMS.^[18,71] In a worldwide survey of AMS educational opportunities provided to healthcare students (WHO),^[72] nurses were among the fewest of healthcare groups to be targeted in educational interventions. Our scoping review identified many documents that emphasised the importance of ensuring that nurses who work closely with patients received education and training to equip them to function effectively in the AMS nursing role. However, only 13 documents described specific AMS educational content to develop nursing expertise – two of these were nursing organisations (the RCN and the American Nurses Association (ANA))^[23,56] (Table 2).

Participation in AMS strategies

Training and education of nurses to increase awareness of antimicrobial use facilitate optimal antimicrobial treatment, monitoring and administration,^[16,73-76] and necessitate concerted educational interventions to build expertise.^[18,75] Recommendations for education were categorised into five broad categories (Table 3). It is important that these needs are included in nurse educational programmes. In 2014, a Scottish survey of nurse knowledge of AMS found that only 22% of nurses understood the term ‘antimicrobial stewardship’.^[7] Subsequent studies showed some improvement, with 54% of nurses in the UK (2017),^[14] 65% of Australian nurses (2017)^[8] and, more recently, 64% (2018),^[77] 38% (2018)^[11] and 48% (2019),^[12] respectively, of nurses in the USA recognising this term. In these studies,

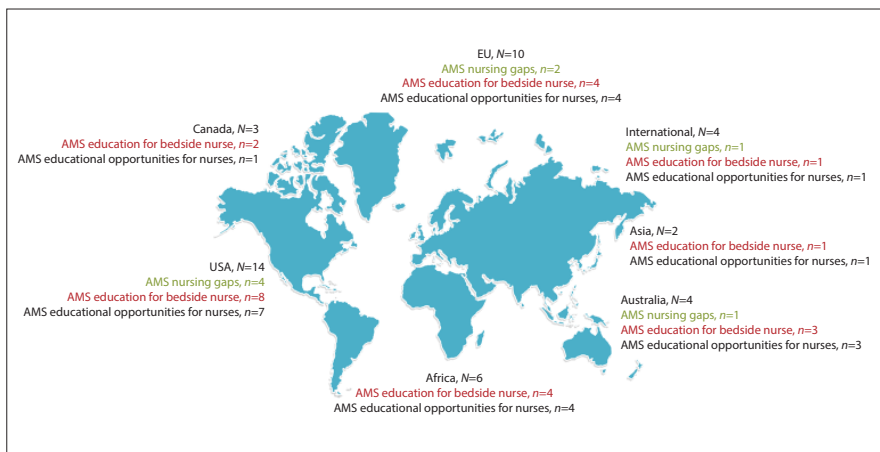


Fig. 2. Geographical distribution of guidelines (N=43). (AMS = antimicrobial stewardship.)

Table 2. Guidelines included in the study (N=43)

Year published	Authors	Country/region of origin	Organisation/society	Overall goal of guideline	Objectives 1: Identification of nursing AMS gaps (n=8) 2: Recommendations for AMS education for the bedside nurse (n=23) 3: Recommendations for AMS educational opportunities for the bedside nurse (n=21)
1997	Shlaes <i>et al.</i> ^[29]	USA	Society for Healthcare Epidemiology of America and Infectious Diseases Society of America	Guidelines for the prevention of AMR in hospitals	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - audit feedback from AMS team
2006	Nathwani ^[32]	Scotland	Scottish Medicines Consortium	Recommendations for antimicrobial use in AMS	1: no 2: nurse education - pharmacology in AMS 3: nurse education opportunities - CPD
2007	Dellit <i>et al.</i> ^[33]	USA	Infectious Diseases Society of America and Society for Healthcare Epidemiology of America	Guidelines for developing AMS programmes in hospitals	1: no 2: no 3: no
2007	Strategy for the Control of Antimicrobial Resistance in Ireland ^[34]	Ireland	Health Protection Surveillance Centre, Ireland	Annual report on AMR	1: no 2: no 3: no
2009	Drew <i>et al.</i> ^[35]	USA	Society of Infectious Diseases Pharmacists	Guidelines for AMS	1: nursing gap - inadequate nursing expertise with extended/prolonged infusions/drug incompatibilities 2: no 3: no
2009	Strategy for the Control of Antimicrobial Resistance in Ireland ^[36]	Ireland	Health Protection Surveillance Centre, Ireland	Guidelines for AMS in hospitals	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - induction training
2011	Duguid and Cruikshank ^[37]	Australia	Australian Commission on Safety and Quality in Health Care, Australian Government	AMS in hospitals	1: no 2: nurse education - role of AMS in preventing AMR; pharmacology in AMS 3: nurse education opportunities - in-service training (from IPC specialist nurses)
2011	Spellberg <i>et al.</i> ^[38]	USA	Infectious Diseases Society of America	Policy recommendations for AMR	1: no 2: no 3: no
2012	Society for Healthcare Epidemiology of America, Infectious Diseases Society of America, and Pediatric Infectious Diseases Society ^[39]	USA	Society for Healthcare Epidemiology of America, Infectious Diseases Society of America, and Pediatric Infectious Diseases Society	Policy statement on AMS	1: no 2: no 3: no
2012	Teng <i>et al.</i> ^[40]	Singapore	Ministry of Health	Guidelines for AMS training and practice	1: no 2: no 3: no
2013	Public Health England ^[41]	UK	Department of Health and Social Care	Guidelines on antimicrobial prescribing and stewardship competencies	1: no 2: no 3: no
2014	Centers for Disease Control and Prevention ^[2]	USA	US Department of Health and Human Services	Core elements of hospital AMS programmes	1: no 2: nurse education - role of AMS in preventing AMR; pharmacology in AMS 3: nurse education opportunities - audit feedback from AMS team

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Table 2. (continued) Guidelines included in the study (N=43)

Year published	Authors	Country/ region of origin	Organisation/society	Overall goal of guideline	Objectives
					1: Identification of nursing AMS gaps (n=8) 2: Recommendations for AMS education for the bedside nurse (n=23) 3: Recommendations for AMS educational opportunities for the bedside nurse (n=21)
2014	National Department of Health ^[42]	South Africa	National Department of Health	Antimicrobial Resistance National Strategy Framework 2014 - 2024	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - undergraduate and postgraduate education
2014	Ministry of Health ^[43]	Malaysia	Ministry of Health	Protocol for implementation of AMS programmes in healthcare facilities	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - induction training; in-service training (from AMS team); CPD
2014	Royal College of Nursing ^[23]	UK	Royal College of Nursing	Royal College of Nursing position on the nursing role in combating AMR	1: nursing gap - unrecognised AMS role of the nurse 2: nurse education - role of AMS in preventing AMR; pharmacology in AMS 3: nurse education opportunities - undergraduate and postgraduate education
2015	National Department of Health ^[44]	South Africa	National Department of Health	Implementation plan for the Antimicrobial Resistance Strategy Framework in South Africa: 2014 - 2019	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - undergraduate and postgraduate education; in-service training (from AMS team); in-service training (from IPC specialist nurses); CPD
2015	Department of Health ^[45]	Western Australia	Ministry of Health	AMS policy	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - audit feedback from AMS team
2015	WHO ^[1]	International	WHO	Global Action Plan on AMR	1: no 2: no 3: no
2016	Communicable and Infectious Disease Steering Committee ^[46]	Canada	Pan-Canadian Public Health Network	Recommendations for AMS	1: no 2: no 3: no
2016	Barlam <i>et al.</i> ^[47]	USA	Infectious Diseases Society of America and Society for Healthcare Epidemiology of America	Guidelines on implementing an AMS programme	1: nursing gap - inadequate nursing expertise in supporting dosing PK/PD strategies 2: nurse education (no specific recommendations) 3: nurse education opportunities - undergraduate education
2016	National Department of Health ^[48]	South Africa	National Department of Health	Background document on AMR	1: no 2: no 3: no
2016	National Department of Health ^[49]	South Africa	National Department of Health	Guidelines for AMS	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - in-service training (on AMS ward rounds); CPD
2016	De With <i>et al.</i> ^[50]	Germany	German Society for Infectious Diseases	Guideline for implementation of AMS	1: no 2: no 3: no
2016	HealthCare CAN and National Collaborating Centre for Infectious Diseases ^[51]	Canada	Public Health Agency of Canada	National action plan on AMS	1: no 2: nurse education (no specific recommendations) 3: no

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Table 2. (continued) Guidelines included in the study (N=43)

Year published	Authors	Country/region of origin	Organisation/society	Overall goal of guideline	Objectives 1: Identification of nursing AMS gaps (n=8) 2: Recommendations for AMS education for the bedside nurse (n=23) 3: Recommendations for AMS educational opportunities for the bedside nurse (n=21)
2016	Healthcare Infection Control Practices Advisory Committee ^[52]	USA	US Federal Advisory Committee	Guidelines for AMS	1: no 2: no 3: no
2016	Levy Hara <i>et al.</i> ^[53]	International	Antimicrobial Stewardship and Resistance Working Groups of the International Society of Chemotherapy	Recommendations for antibiotic use in AMS	1: no 2: no 3: no
2016	Morgan <i>et al.</i> ^[54]	USA	Society for Healthcare Epidemiology of America	Recommendations for AMS	1: no 2: no 3: no
2016	National Institute for Health and Care Excellence ^[55]	UK	Department of Health	Recommendations for antibiotic use in AMS	1: no 2: no 3: no
2017	American Nurses Association/Centers for Disease Control and Prevention Workgroup ^[56]	USA	American Nurses Association/Centers for Disease Control and Prevention Workgroup	White paper recommendations on the role of registered nurses in hospital AMS	1: nursing gap - unrecognised AMS role of the nurse 2: nurse education - IPC in AMS; diagnostic AMS; pharmacology in AMS; collaboration in AMS 3: nurse education opportunities - undergraduate education; in-service training (on AMS ward rounds); in-service training (from AMS team)
2017	American Society of Health-System Pharmacists ^[57]	USA	American Society of Health-System Pharmacists	Guidelines for the implementation of AMS programmes	1: nursing gap - inadequate nursing expertise in supporting dosing PK/PD strategies 2: nurse education - pharmacology in AMS 3: no
2017	Canadian Nurses Association ^[58]	Canada	Canadian Nurses Association	Brief on the use of nurses in combating AMR	1: no 2: nurse education (no specific recommendations) 3: nurse education opportunities - CPD
2017	Department of Health ^[59]	Australia	Ministry of Health	National AMR strategy 2015 - 2019 progress report	1: no 2: no 3: no
2017	European Commission ^[60]	EU	European Commission	Guidelines for antimicrobial use in human health	1: no 2: nurse education - pharmacology in AMS 3: nurse education opportunities - undergraduate and postgraduate education; CPD
2017	European Federation of Nurses Associations ^[61]	EU	European Federation of Nurses Associations	Recommendations for nurses' role in combating AMR	1: nursing gap - unrecognised AMS role of the nurse 2: no 3: no
2017	International Council of Nurses ^[62]	International	International Council of Nurses	Position statement on nurses' role in combating AMR	1: nursing gap - unrecognised AMS role of the nurse 2: no 3: no
2017	Ministerial Advisory Committee on Antimicrobial Resistance ^[63]	South Africa	National Department of Health	Guidelines on implementation of AMS using a One Health approach	1: no 2: no 3: no
2017	The Joint Commission ^[64]	USA	Standards-setting and accrediting body for US healthcare	Standard for AMS	1: no 2: nurse education - role of AMS in preventing AMR; pharmacology in AMS 3: nurse education opportunities - in-service training (from AMS team); audit feedback from AMS team

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Table 2. (continued) Guidelines included in the study (N=43)

Year published	Authors	Country/region of origin	Organisation/society	Overall goal of guideline	Objectives 1: Identification of nursing AMS gaps (n=8) 2: Recommendations for AMS education for the bedside nurse (n=23) 3: Recommendations for AMS educational opportunities for the bedside nurse (n=21)
2018	Australian Commission on Safety and Quality in Health Care ^[65]	Australia	Australian Government	AMS in Australian healthcare	1: nursing gap – unrecognised AMS role of the nurse; nursing disposal of used antibiotic vials/infusion waste 2: nurse education – role of AMS in preventing AMR; IPC in AMS; diagnostic AMS; pharmacology in AMS; collaboration in AMS 3: nurse education opportunities – undergraduate education
2018	Hawkey <i>et al.</i> ^[66]	UK	Joint Working Party of the British Society for Antimicrobial Chemotherapy, the Healthcare Infection Society and the British Infection Association	Recommendations for antibiotic use within AMS	1: no 2: no 3: no
2018	Manning <i>et al.</i> ^[67]	USA	Association for Professionals in Infection Control and Epidemiology and the Society for Healthcare Epidemiology of America	Position paper on the role of infection prevention and control within AMS	1: no 2: nurse education – diagnostic AMS 3: nurse education opportunities – audit feedback from AMS team
2018	WHO ^[68]	International	WHO	WHO competency framework for health workers' education and training on AMR	1: no 2: nurse education – role of AMS in preventing AMR; IPC in AMS; diagnostic AMS 3: nurse education opportunities – undergraduate education; in-service training
2019	Centers for Disease Control and Prevention ^[69]	USA	US Department of Health and Human Services	The core elements of hospital AMS programmes: 2019	1: no 2: nurse education – diagnostic AMS; pharmacology in AMS 3: nurse education opportunities – audit feedback from AMS team
2019	National Department of Health ^[70]	South Africa	National Department of Health	Guidelines for the prevention and containment of AMR in South African hospitals	1: no 2: nurse education – role of AMS in preventing AMR; pharmacology in AMS 3: nurse education opportunities – in-service training

AMS = antimicrobial stewardship; AMR = antimicrobial resistance; CPD = continuing professional development; IPC = infection prevention and control; WHO = World Health Organization; PK/PD = pharmacokinetic/pharmacodynamic.

knowledge of antibiotics was reported as limited: 64% in Scotland,^[7] 57% in Australia,^[8] 63% in the USA^[11] and 68% in the UK.^[14] In the last study, nurses reported that they were unaware that omitted doses of antibiotics were undesirable (40%), adding that although institution AMS guidelines were available, these were not referred to (54%), citing workload and time constraints (79%).^[14]

Time constraints and prescriber ‘pushback’ (described as resistance to nursing contribution) were cited in several US studies in 2018: time constraints (85.5%) and prescriber pushback (70.4%) were both viewed by participants in a ‘knowledge, attitudes and practice’ study as barriers to effective nurse participation in AMS.^[77] This was less evident in a survey of acute-care nurses from five academic hospitals in New York,^[11] where nurses felt that discussions regarding the appropriateness of antimicrobial treatment in relation to culture results were generally difficult, but fewer nurses cited lack of time (35%) and concern that their input would not be well received by prescribers (28%). A complementary

qualitative study conducted simultaneously in New York,^[10] with the aim of examining attitudes towards nurse-driven AMS activities recommended by the ANA/Centers for Disease Control and Prevention (CDC) white paper,^[56] found that nurses were uncomfortable taking responsibility for several AMS strategies, including differentiating between an adverse effect and true allergy to an antibiotic, and initiating an antibiotic ‘timeout’. This situation was attributed to knowledge gaps, workflow considerations, prescriber pushback and perceptions of duplicative work.

Integration of AMS learning into existing education curricula

Reviewed documents suggest that AMS concepts should be integrated into the current requirement for nursing education within microbiology, pharmacology and applied clinical education, starting with pre-registration training. Recommendations also included that consideration

Table 3. Guideline recommendations for AMS education for the hospital-based nurse

Education	Recommendation	Country
AMS	Training on role and use of AMS guidelines and policies (<i>n</i> =3; 6.9%)	Africa, ^[70] Australia, ^[65] international ^[68]
	Information on how to access resources (<i>n</i> =1; 2.3%)	Australia ^[65]
	Education on what AMR is and how it can be contained (<i>n</i> =5; 11.6%)	Australia, ^[37,65] EU, ^[23] USA ^[2,64]
	Education on the link of AMS with patient safety (<i>n</i> =1; 2.3%)	Australia ^[65]
IPC in AMS	Training on infection management and control (<i>n</i> =2; 4.6%)	Australia, ^[65] international ^[68]
	Education on the indications for MC&S testing (<i>n</i> =1; 2.3%)	USA ^[56]
Diagnostic AMS	Education on the risks associated with inappropriate testing (<i>n</i> =1; 2.3%)	USA ^[56]
	Training on optimal timing of collection of microbiological specimens (<i>n</i> =1; 2.3%)	Australia ^[65]
	Education and training on the optimal quality of microbiological specimens (<i>n</i> =4; 9.3%)	International, ^[68] USA ^[56,67,69]
	Training on interpretation of microbiology results (<i>n</i> =3; 6.9%)	International, ^[68] USA ^[56,67]
	Education on the significance of differences between infection and colonisation (<i>n</i> =2; 4.6%)	Australia, ^[65] USA ^[56]
	Training on interpretation of the antibiogram (<i>n</i> =1; 2.3%)	USA ^[56]
Pharmacology in AMS	Education on antimicrobial pharmacotherapy (<i>n</i> =3; 6.9%)	Africa, ^[70] Australia, ^[65] USA ^[69]
	Education on optimal prescribing (<i>n</i> =6; 13.9%)	Australia, ^[37] EU, ^[23,32,60] USA ^[2,64]
	Education on duration of antimicrobial therapy (<i>n</i> =2; 4.6%)	Australia, ^[65] USA ^[56]
	Education on de-escalation linked to patient response (<i>n</i> =2; 4.6%)	Australia, ^[65] USA ^[56]
	Training on considerations for IV-to-PO conversion (<i>n</i> =2; 4.6%)	Australia, ^[65] USA ^[56]
	Information on antimicrobial spectra for various classes of antibiotics (<i>n</i> =1; 2.3%)	USA ^[56]
	Information on antibiotic interactions and incompatibilities (<i>n</i> =1; 2.3%)	USA ^[56]
	Education on common adverse reactions to antibiotics (<i>n</i> =1; 2.3%)	USA ^[56]
	Training on assessment of a patient for a potential allergy to penicillin (<i>n</i> =1; 2.3%)	USA ^[56]
	Training on therapeutic drug monitoring (<i>n</i> =1; 2.3%)	USA ^[56]
Collaboration in AMS	Education on antibiotic pharmacokinetics and pharmacodynamics (<i>n</i> =1; 2.3%)	USA ^[57]
	Assertiveness training to engage in discussions with the healthcare team (<i>n</i> =1; 2.3%)	USA ^[56]
	Training on how to educate patients, family and carers about antimicrobials (<i>n</i> =1; 2.3%)	Australia ^[65]

AMS = antimicrobial stewardship; IPC = infection prevention and control; MC&S = microscopy, culture and sensitivity; IV-to-PO = intravenous to oral.

be given to the inclusion of nursing in interprofessional undergraduate AMS education (Table 2). The provision of appropriate AMS content into teaching curricula in the UK has required extensive consideration of various models of teaching/learning by multiprofessional bodies, including the RCN.^[78] Comparison of undergraduate healthcare students revealed a disparity between medical and nursing student exposure to AMS competency content: IPC (medicine 99%; nursing 86%); AMR and antimicrobials (medicine 99%; nursing 56%); prescribing antimicrobials (medicine 96%; nursing 29%); AMS (medicine 91%; nursing 42%); and monitoring and learning (medicine 63%; nursing 16%).^[79] Although most nursing faculties (63%) integrated AMS in their curriculum, <13% included all the recommended steps of stewardship.^[80] This led to the development of six core AMS domain competencies for nurse education: IPC; antimicrobials and AMR; diagnosis of infection and the use of antimicrobials; antimicrobial prescribing practice; person-centred care; and interprofessional collaborative practice,^[81-83] validated by an international consensus panel of nursing AMS experts from eight countries.^[84] These competencies provide the first AMS framework addressing the needs of this discipline for undergraduate nursing education in the UK.^[83]

AMS nurse education in the clinical environment

Although increasing emphasis is placed on nurse education in AMS, this does not appear to have been translated to hospital settings. It is of concern that in general, nursing leaders and prescribers do not support nurses' involvement in AMS.^[85] Nurses collate clinical and microbiological information about the patients in their care and follow the trends of antimicrobial usage, ideally positioning them to influence decision-making regarding antibiotic use and supporting

AMS.^[86] Questioning the need for antimicrobial treatment therefore falls within nurse patient advocacy,^[9,10,16,17,22,73,87-90] but may be difficult within the hierarchical construct of healthcare dynamics.^[4,10,15,20,91-94] Nurses ability to discuss or even challenge antimicrobial management choices is heavily connected to the construct of power and knowledge, particularly within the acute care context. Nurses may not feel they are in a position to participate in ASPs [antimicrobial stewardship programmes] due to lack of knowledge, closely linked to positions of power.^[16]

The reviewed guidelines recommend that AMS training should be included in induction training for all newly appointed nursing staff (Table 2). A description of stewardship practice in 660 hospitals in 67 countries, across six continents, revealed that although 58% of hospitals surveyed had AMS programmes, bedside nurses received minimal introduction to these programmes, with only 16% of new nurses provided with AMS-related information on induction to a hospital.^[95] These findings were reflected in a 2016 UK survey^[96] of the implementation of AMS interventions recommended by national AMS toolkits, TARGET and Start Smart - Then Focus, where nurses were found to receive less AMS information (27%) than pharmacists (69%) and doctors (63%) on induction in National Health Service (NHS) hospital trusts. A later study conducted in the USA by Abbas *et al.*^[77] found that only 19.5% of nurses reported having received formal training for AMS.

Recommendations have been made for the AMS team to develop a programme of ongoing education for bedside nurses (Table 2). The hospital AMS team has a vital role in providing knowledge to nursing staff to support nursing participation within AMS strategies.^[97] AMS ward rounds are the optimal time to transfer AMS skills to nurses and other members of the healthcare team,^[16,94] with these rounds noted to

occur most commonly in intensive care units (74%).^[95] Audit feedback from the AMS team is described by the Joint Commission as: ‘regularly reporting information on the antimicrobial stewardship programme, which may include antibiotic use and resistance, to physicians and other practitioners, *nurses*, and relevant staff.’^[64] This view supports the first of five strategic AMS goals developed in 1997 by the Society of Healthcare Epidemiology of America/Infectious Diseases Society of America (SHEA/IDSA),^[29] in which recommendations were made to ‘develop a system to recognize trends in antibiotic resistance and to report them promptly to hospital and physician leaders; medicine, *nursing* and infection control and pharmacy staff; and others who need to know’.

Developing safe nurse practice

Although most of the guidelines recommended AMS education for clinical nurse practice (Table 2), they did not make recommendations to address identified medication administration problems.^[35,47,57,65] Specialised nursing expertise is essential for the safe administration of complex IV infusions, such as extended/prolonged infusions^[57] to avoid drug incompatibilities,^[35] and to support pharmacokinetic/pharmacodynamic (PK/PD)-informed dosing strategies for dose optimisation.^[47] The safe disposal of antibiotic waste raised in the guidelines^[65] is corroborated by emerging evidence that antimicrobial-resistant bacteria are found in areas where nurses drain antibiotics from discarded IV fluid bags/sets into hospital sinks.^[98,99]

AMS best practice is founded on the principles of the right drug, the right dose, de-escalation when possible and the right duration,^[33] and there is an obligation for research to identify aspects of clinical nursing practice that fail to support these principles.^[13,74] AMR is a problem that should be viewed by all healthcare professionals in all healthcare settings as relevant to their particular disciplines.^[68] Continued research to identify knowledge needs of the bedside nurse is therefore essential, but the focus may not be entirely where it is needed, e.g. a long overdue examination of the effects of incorrect timing and/or missed doses of antimicrobial medicines.^[23] Where nursing research may not have the capacity to examine these issues, a multidisciplinary collaborative approach should be considered.^[13]

Study limitations

The reviewers decided to include only recommendations indicated specifically for nurses: guidelines that included this role within general recommendations to healthcare professionals might have been excluded, unless it was stated that recommendations were aimed at all healthcare workers. Guidelines published in languages other than English would have been excluded. Search terms that were entered as plurals, may also be a potential limitation.

Conclusions

General lack of recognition of the important AMS roles of the bedside nurse creates a barrier to full nursing participation in AMS processes and their inclusion in the development and implementation of AMS strategies. Nursing representation in AMS is a pressing need, but not all nurses currently possess all the competencies required to fulfil this role. There is an evident need for continued formal recommendations for nurse clinical competencies. The under-acknowledged importance of nurses as partners within key AMS guidelines may be due to the focus on prescription of antimicrobial medicines (medicine/pharmacy), rather than appropriate management of administration once prescribed (medicine/nursing). If the nurse is inadequately prepared by nursing training, the implementation of clinical AMS programmes may not be effective. Recommendations for

AMR/AMS education to be included in undergraduate and postgraduate curricula should therefore be heeded. Until nursing programmes can provide appropriate training in AMR and AMS, hospitals and AMS teams must ensure that nurses are given every opportunity to gain knowledge and skills through induction training programmes, in-service training, and CPD.

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