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Nurses are underutilised in antimicrobial stewardship e Results of a multisite survey in paediatric and adult hospitals

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Abstract

Objectives: Explore perceptions and attitudes of nurses in regard to antimicrobial stewardship (AMS), their roles as nurses, and identify differences in perceptions and attitudes across paediatric and adult settings.

Methods: Electronic survey administered to nursing staff across three public Australian tertiary institutions with AMS facilitated by a shared electronic approval and decision support system. **Results:** Overall 65% (93/142) of nurses who completed the survey were familiar with the term AMS, and 75% recognised that they were expected to have a role alongside other disciplines, including ward pharmacists (paediatric 88%, adult 73%; $p = 0.03$). Hand hygiene and infection control (86%), patient advocacy (85%) and knowledge of antimicrobials (84%) were identified most often as AMS roles for nurses. However, 57% of nurses reported that their knowledge of antimicrobials was minimal or limited. Nurses generally agreed that requirement to obtain approval is an effective way to reduce inappropriate antimicrobial use (median scores: paediatric 2.0 [agree], adult 1.0 [strongly agree]; $p = 0.001$). Only 35% of paediatric and 58% of adult nurses perceived that their role includes ensuring approval for restricted antimicrobials ($p < 0.01$). Most nurses identified AMS teams (85%), pharmacists (83%) and infection control teams (paediatric 68%, adult 84%; $p = 0.04$) as sources of AMS support. Areas of interest for support and education included appropriate antimicrobial selection (73%) and intravenous to oral antimicrobial switch (paediatric 65%, adult 81%, $p = 0.03$). **Conclusion:** Nurses consider AMS activities within their roles, but are underutilised in AMS programs. Further engagement, education, support and acknowledgement are required to improve nursing participation.

Keywords

antimicrobial, underutilised, nurses, multisite, stewardship, adult, e, survey, paediatric, results, hospitals

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Title: Nurses are underutilised in Antimicrobial Stewardship - Results of a Multisite Survey in Paediatric and Adult Hospitals

Running title: Nurses and Antimicrobial Stewardship

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Conclusions: Nurses consider AMS activities within their roles, but are underutilised in AMS programs. Further engagement, education, support and acknowledgement are required to improve nursing participation.

Keywords: Health Personnel, Hospitals, Antimicrobial Stewardship, Antimicrobials, Quality of Health Care

Introduction

Antimicrobial stewardship (AMS) programs provide a multifaceted and systematic approach to optimising antimicrobial use. International guidelines for implementing AMS programs call for a designated AMS pharmacist and Infectious Diseases (ID) physician to act as core members of the AMS team, responsible for engaging relevant stakeholders including other clinicians, pharmacists, nurses, hospital executives and patients,¹ although these may not be available in certain settings (e.g., smaller hospitals in Australia). For this reason it is imperative to consider the role that nurses can play in AMS.

Nurses have a consistent ward presence and are involved in AMS related aspects of care from the point of admission to discharge. Nurses are responsible for patient monitoring, timely and accurate documentation and antimicrobial administration. In addition to facilitating communication between disciplines and departments, nurses provide education and support to patients.² Furthermore, nurses are frequently involved in quality and safety programs and executive committees, and contribute to the overall organisation culture and memory.^{3,2} These activities place nurses in an ideal position to positively impact antimicrobial management.^{4,5,6} However, there is limited evidence on the impact of nurses in AMS and the role of the nurse in hospital AMS programs is not yet defined.^{7,2,4}

There are other unknowns in regard to the role of nurses when considering the differences between paediatric and adult care settings. Paediatric patients are at an increased risk of prescribing and administration errors compared to adult patients due to the vast variation in body size across age groups and need to calculate specific doses according to weight.⁸ Young children may not be able to communicate symptoms in the same manner as adults, and may present with non-specific illness resulting in diagnostic uncertainty.⁹ In the tertiary paediatric setting where organ and bone marrow transplantation takes place there are also fewer paediatric specific antimicrobial guidelines, and these often rely on lower levels of evidence.¹⁰ We believe these factors may differentially influence nurses' perceptions of AMS programs and support required for nursing staff.

We conducted a survey of nursing staff at three Australian institutions with established AMS programs to assess the attitudes held amongst nurses toward AMS programs and their perceptions regarding the role of nurses. A secondary objective was to explore differences in these perceptions and attitudes between paediatric nurses and those working in the adult setting.

Methods:

On 9 December 2015 nursing staff were contacted via local electronic mail distribution lists and invited to participate in an anonymous and voluntary internet-based survey hosted on Survey Monkey® (SurveyMonkey Inc.® Palo Alto, California, USA). Paper surveys were available at one hospital for those who were unfamiliar with electronic surveys and manually entered by a designated investigator. There were no incentives for participation. The survey was closed on 26 January 2016. Approval to conduct the study was granted by the Sydney Children's Hospital and University of Technology Human Research Ethics Committees with research governance approval at each institution (LNR /15/SCHN/430).

Program and setting

The survey was conducted across three tertiary public hospitals in New South Wales, Australia. Hospital A, a 600 bed metropolitan hospital with one paediatric ward, is a referral hospital for eight smaller hospital sites within a non-metropolitan health district. Hospital B is a 660 bed metropolitan hospital with one paediatric ward. Hospital C is a 170 bed tertiary paediatric metropolitan hospital with highly specialised services including haematology, oncology, transplant and a paediatric intensive care. The collective sampling frame (i.e., number of nurses on email distribution lists) is approximately 4345: 2044 in Hospital A, 1670 in Hospital B and 631 in Hospital C.

AMS programs are established in all three institutions. Consultant led AMS rounds are conducted at least once a week at all hospitals with staff access to both ID consultation and endorsed antimicrobial guidelines. Principles of appropriate antimicrobial management are promoted at junior medical staff orientation and across all hospitals during antibiotic awareness week and include appropriate timing

of blood cultures, guideline concordant prescribing, performing an antibiotic “time-out” at 48 hours to re-evaluate antimicrobial therapy.

All hospitals have nurse representation on local AMS Committees, and training is made available to nurses in the form of ward in-services and presentations at hospital nurse education meetings.

A computerised antimicrobial approval system with decision support (CDSS; Guidance MS®, Melbourne, Australia) is shared across the hospitals to facilitate AMS activities, and has been in operation since April 2012 at hospitals A and B, and October 2012 in hospital C. The CDSS contains defined guideline concordant indications for children and adults, with specific patient management recommendations, doses and fixed duration of AMS approval for “restricted” antimicrobials that are frequently prescribed and targeted by the AMS team.¹¹

A traffic light colour coding system has been established as part of the local AMS policy at each hospital in order for staff to easily distinguish the level of restriction for each antimicrobial (based on risk of toxicity, promotion of resistance, or cost). Printed lanyard cards indicating antimicrobial classification are disseminated to all staff at Hospitals B and C. According to the AMS policies “unrestricted” (green) antimicrobials do not require approval for their use, the aforementioned “restricted” (yellow) antimicrobials require approval via the CDSS, and “highly restricted” (red) antimicrobials may only be prescribed after direct consultation and approval from the local ID or AMS team. As such, the CDSS is intended to prompt appropriate antimicrobial selection by prescribers upon initiation prescription and is endorsed as a compendium of antimicrobial guidelines for staff.

New and expiring approvals in the CDSS are reviewed daily by the local AMS team alerting them to any antimicrobial use that may be inconsistent with local guidelines, or require further AMS input. Once alerted, AMS teams undertake “audit and feedback” whereby the AMS team review the appropriateness of antimicrobial prescribing and provide feedback on: relevant patient management,

antimicrobial choice, dose, therapeutic drug monitoring and duration of therapy. AMS team feedback is communicated to treating teams either in person or documented in the medical record. Where ongoing use of “restricted” or “highly restricted” antimicrobials is deemed appropriate, CDSS approval is extended by the AMS team, endorsing further use and supply from Pharmacy.

Survey design

The survey comprised questions adapted from AMS surveys of medical practitioners previously conducted at the study sites and a recent survey of nurses and midwives undertaken by the Scottish Antimicrobial Prescribing Group.¹² The survey was reviewed and tested by two staff nurses prior to dissemination.

The questionnaire (**Supplement A**) included 18 questions, of which three related to participant demographics, qualifications, site of employment and whether participants were based in a paediatric or adult unit. Two questions were open-ended; one was visible only when the respondent indicated familiarity with the term “antimicrobial stewardship” or “AMS”, the other invited participants to comment on AMS in general or their local hospital AMS program.

Likert-type questions canvassed self-perceptions of knowledge about AMS and attitudes about the local AMS program. Response options were based on 5 point scales with options ranging from minimal to excellent (1=minimal, 2=limited, 3=average, 4=good, 5=excellent) and attitudes strongly agree to strongly disagree (1=strongly agree, 2= agree, 3=neutral, 4=disagree, 5=strongly disagree). The remaining 9 questions were multiple-choice answers with an option to add supplementary comments or alternate responses.

Statistical Analysis

Descriptive statistics were performed in IBM SPSS® Statistics for Windows Version 23 (IBM Corp, Armonk, NY) for completed surveys only. Categorical data were reported as percentages rounded to the closest whole number. Five point Likert-type scale responses were considered continuous

variables and reported as the median +/-interquartile range (IQR). Differences between responses from paediatric and adult nurses were explored by using chi-square tests for questions with categorical responses and Mann-Whitney tests for Likert-type scales. All tests were two-tailed, with p values <0.05 considered statistically significant. Responses to open-ended questions were reviewed for key terms or concepts.

Results

One hundred and forty-two surveys were completed and included in the analysis (approximately, 3.3% of the overall sampling frame). Overall 40% (n=57) of participants worked in paediatric settings; primarily based in hospital C (55/57). The largest group of respondents were registered nurses with 2 to 8 years of experience (45%, n=64), followed by clinical nurse specialists (16.2%; n=23) (**Figure 1**). There were no statistically significant differences in qualifications between the two groups.

Knowledge and Awareness

Sixty-five percent of nurses (93/142) had heard of the terms “antimicrobial stewardship” or “AMS” at the time the survey was completed (paediatric 60%, adult 69%; p=0.23). Among those familiar with AMS, the vast majority (82%, 77/93) described the purpose of AMS as promoting “correct”, “proper”, “right”, or “evidence-based” use, or as reducing “unnecessary” or “overuse” of antimicrobials (paediatric 82%, adult 83%; p=0.93).

Overall 76% (108/142) of respondents were aware of the categories in the local antimicrobial restriction policy, correctly indicated that “green” antimicrobials were unrestricted (paediatric 75%, adult 77%; p=0.9).

More than half of all nurses rated their knowledge of antimicrobials as minimal or limited (57%, 82/142). The median rating in both paediatrics and adults was 2.0 (limited) (paediatric IQR 1.5-3.0; adult IQR 2.0-3.0; p=0.9). Only 6% (9/142) rated their knowledge as good or excellent.

Staff Roles and Responsibilities

When asked to select which health care professionals expected to be involved in AMS nurses most often expected doctors to participate. Doctors in general were selected more often than ID doctors. The majority of nurses also expected infection control nurses and ward pharmacists to have a role in AMS; with the latter selected by a significantly greater proportion of paediatric nurses (paediatric 88%, adult 73%; $p=0.03$)(**Table 1**).

Close to 75% of respondents expected nurses and ID or AMS pharmacists to take part in AMS. Microbiologists and dispensary pharmacists were perceived to participate in AMS least often, and fewer than half of respondents selected all the listed roles as being involved in AMS (**Table 1**).

The Nurse's Role in AMS

In keeping with nurses' understanding of how AMS positively contributed to the appropriate use of antimicrobials, nurses rarely excluded AMS from their professional role (Table 2). More specifically, hand hygiene and infection control, patient advocacy and knowledge of antimicrobials were commonly recognised as nursing roles in AMS and selected more often than tasks such as ensuring appropriate indication, dose and frequency, with no significant differences between the two groups (**Table 2**).

Prompting switch from IV to oral formulation (46%), prompting therapeutic drug monitoring (TDM) (51%) and checking restriction category for prescribed antimicrobials and ensuring antimicrobials were approved (49%) were less frequently considered nursing responsibilities in AMS.

In both the adult and paediatric setting, ensuring prescribers had obtained antimicrobial approval was selected less often than ensuring appropriate use (indication, dose and frequency), participating in multidisciplinary discussions and challenging prescribing decisions(**Table 2**).

Compared to adult nurses, those working in paediatrics more often felt that prompting prescribers to perform TDM was an AMS role for nurses (paediatric 61%, adult 45%; $p=0.05$). Respondents working in paediatrics were also less inclined to associate checking restriction and approval status of antimicrobials as a nurse's responsibility (paediatric 35%, adult 58%; $p<0.01$).

Sixty-eight percent of nursing staff agreed that they would question a prescriber if an antimicrobial was prescribed for an inappropriate indication with no significant difference between paediatric and adult nurses (median score paediatric and adult 2.0 [agree], paediatric IQR 2.0-3.0, adult IQR 1.0-3.0; $p=0.37$). Few respondents indicated that they would not question a prescription for an inappropriate indication (paediatric 7%, adult 4.7%).

Scores for the statement "if I think that antimicrobial approval is unlikely I will try to bypass the system" suggested that nurses in both the adult and paediatric setting would not intentionally bypass the CDSS (median paediatric and adult 4.0 [disagree], IQR paediatric and adult 3.0-4.0; $p=0.67$).

Perceptions of the local AMS program

There were significant differences in the perceived impact of the AMS team's input on patient care. Nurses working in adult medicine agreed more often that verbal and written advice from the AMS team had improved their patient's care (median score paediatric 3.0 [neutral], IQR 2.0-3.0, median score adult 2.0 [agree], IQR 2.0-3.0; $p=0.004$). No respondents working in adult medicine strongly disagreed with the statement "verbal and written advice from the AMS team has improved my patients' care".

The majority of respondents (87%) agreed to some extent that the requirement to get antimicrobial approval is an effective way to reduce inappropriate antimicrobial use. Responses from adult nurses were significantly more positive than those working in paediatrics (median score paediatric 2.0[agree], IQR 1.5-2.0, median score adult 1.0[strongly agree], IQR 1.0-2.0; $p=0.001$). Furthermore, no respondents working in adult medicine disagreed with the statement.

Support for nurses in AMS

The preferred form of support for nurse participation in AMS was similar in both groups.

Respondents rated information updates and continued education highly (>90%), followed by expert contacts or mentors (76%) and protected teaching time (77%). Only 2 respondents indicated that they could not, ever, support AMS on the ward.

The majority of nurses were interested in receiving support from the AMS or ID team and pharmacists, and acknowledged the role of nurse prescribers and educators (78% overall). Infection control teams were more likely to be considered a potential source of support in the adult setting (paediatric 68%, adult 84%; $p=0.04$). Of the potential staff members listed in the survey junior doctors were least often recognised as a potential source of support (**Table 3a**).

Common areas for further guidance or support from AMS teams for nurses in the paediatric and adult setting included: appropriate antimicrobial selection and appropriate dosing and frequency. Switch from IV to oral antimicrobial formulation was of marked interest in amongst adult nurses compared to those in paediatrics (paediatric 68%, adult 81%; $p=0.03$) (**Table 3b**). Requests for AMS support to appropriately administer antimicrobials did not differ significantly between the adult and paediatric nurses. Nurses in both groups rated guidance on the use of the CDSS to check antimicrobial approvals, interpretation of microbiology and appropriate duration of therapy least often.

Discussion

To our knowledge, our study is the first to focus on Australian nurses' views of AMS programs across multiple hospitals with similar AMS activities. Furthermore, the comparison of paediatric and adult nurses' survey responses on AMS is novel. These findings provide further insights into nursing roles in AMS, and build on the limited research undertaken in this area. A survey by Cotta et al., conducted in the private sector before AMS implementation, reported that 22% of nurses had heard the term "AMS", and 43% would be willing to participate in clinical interventions.¹³

This study has a number of important findings. Nurses working in hospitals with established AMS programs showed some familiarity with the term AMS and were able to describe the overarching goal of AMS as promoting optimal antimicrobial use. Three out of four survey participants acknowledged that nurses would be expected to have a role in AMS, more so than dispensary pharmacists and microbiologists. It is also encouraging that the overwhelming majority of nurses recognised that patient advocacy, a key competency for nursing staff,¹⁴ embedded within the very definition of nursing,¹⁵ applies to AMS.

Respondents primarily identified traditional nursing roles as nursing functions in AMS such as hand hygiene and infection control, an area where nurses have clearly demonstrated their impact as clinical leaders, researchers and program participants.¹⁶ As patient advocates, nurses recognised the importance of antimicrobial knowledge and their contribution to AMS when monitoring adverse effects from therapy and educating patients and colleagues about antimicrobial use. Effective patient advocacy requires an adequate understanding of risks, training, up-to-date information and a degree of authority.¹⁷ However, self-rated knowledge of antimicrobials was limited, emphasising a need for more education on antimicrobial use for nursing students and staff, particularly when considering the critical need for timely and appropriate antibiotic administration.^{18,19}

Current best practice international guidelines for AMS recommend education on AMS principles as part of undergraduate and postgraduate nurse education.²⁰ Recent surveys of nursing schools in the United Kingdom found that more than half included AMS in their curriculum, but fewer than 13% incorporated all aspects of good antimicrobial prescribing and stewardship.²¹ A recent article by Manning et al., has called for robust education of all nurses, addressing the administration of antimicrobials, risks and benefits of therapy, and most importantly, the role of the nurse in AMS.²² For nurses in the professional environment, our study suggests education promoting AMS principles and antimicrobial knowledge by the AMS team and pharmacists would be acceptable to staff nurses and nurse educators, in accordance with AMS guidelines.^{1,20}

In our survey, 68% of respondents indicated they would question a prescriber if the indication for an antimicrobial was inappropriate. In comparison, more than 90% of nurses surveyed before and after an IV to oral switch campaign in another Australian hospital indicated they would question a prescriber if they thought an antibiotic was inappropriate.²³ This higher rate may be due to numerous factors including greater motivation or confidence amongst those involved in a new initiative, differences in questionnaire design, or local differences amongst participants. Elsewhere, developing nurses' skills and confidence in questioning prescribers on antibiotic use has been highlighted as an area for enhancing nursing involvement in AMS.⁷

There is increasing recognition that nurse involvement in AMS is critical.^{22,2} Areas for potential nurse involvement in AMS have included promoting optimal antimicrobial dose, route and duration by interpreting microbiology, encouraging switch from IV to oral route and prompting transition to outpatient antimicrobial therapy.^{4,7,23} One such mechanism to prompt AMS initiatives by nurses is antimicrobial "time-outs" to re-evaluate antimicrobial therapy.²²

The key area of interest amongst adult nurses in our survey was IV to oral switch, identified by 81% adult nurses as an area for further education or support, compared to only 68% of those in paediatrics. We believe the variation observed in our survey warrants further study and could be related to contextual factors such as the perception that IV therapy in paediatric patients is minimised due to the pain and stress associated with inserting needles,²⁴ or that the duration of therapy is already limited by poor intravenous catheter patency in young children.²⁵ Due to the additional calculations and manipulations required to administer paediatric doses from larger adult dosage forms, and the subsequent risk of error, we expected paediatric nurses to be most interested in appropriate antimicrobial administration. However, there was no statistically significant difference observed.

Three-quarters of the nurses surveyed had adequate knowledge of the local antimicrobial restriction categories and considered their role to involve multidisciplinary discussions, ensuring appropriate indication, dose and frequency, and expressed a willingness to question inappropriate prescribing. Furthermore, the majority of participants agreed that antimicrobial approval is effective in reducing inappropriate antimicrobial use. However, checking antimicrobial restriction category and CDSS approval was of little interest as a current role, or an area for further education, particularly amongst paediatric nurses. These findings suggest a disconnect between the intended role of the CDSS in supporting optimal antimicrobial choice, dose, route and duration, and the perception held by nurses, reiterating the importance of multidisciplinary colleagues in providing tailored AMS support to meet the needs of each unique setting.

This study has a number of limitations. The modest number of responses may not be representative of all nursing staff within these institutions, and likely reflects the views of those most interested in AMS, a finding we believe further reinforces the need for greater nursing engagement. The response rate may have also impacted our secondary objective and precluded our ability to identify more significant differences between paediatric and adult nurses. Due to the study sites selected our findings may not be transferable to other institutions without similar AMS programs (i.e. combining audit and feedback with preapproval via a CDSS). Nevertheless, the findings provide local insights to facilitate greater nurse involvement in the daily management of AMS and have identified initial directions for antimicrobial education by AMS teams. Future questionnaires across the hospitals will aim to further clarify the best approach to involve nurses in the daily management of AMS.

Conclusion

The majority of nurses surveyed recognised that they have some role in AMS. Greater support and targeted education, and clarification of the specific roles for nurses in AMS are required for nursing staff in both the paediatric and adult setting to incorporate AMS into their daily tasks, and to apply AMS principles to their care of patients.

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Conflict of interest

All authors report no conflicts of interest relevant to this manuscript.

Authorship statement

MM designed the study and survey, collected the data, performed statistical analysis and wrote the manuscript.

BB and TS supervised the study design, data analysis and critically revised the manuscript.

SB, AC, SA, PK, BM, CL reviewed the survey design, facilitated data collection and critically revised the manuscript.

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Table 1: Nurses' responses about which health professionals they expect to be involved in Antimicrobial Stewardship

	Overall, n (%)	Paediatric Nurses, n (%)	Adult Nurses, n (%)	P-value
Doctor (General)	126(89)	52(91)	74(87)	0.44
ID Doctor	120(85)	50(88)	70(82)	0.39
Microbiologist	99(70)	37(65)	62(73)	0.30
Nurse	107(75)	44(77)	63(74)	0.68
Infection Control Nurse	112(79)	46(81)	66(78)	0.66
Ward Pharmacist	112(79)	50(88)	62(73)	0.03
Dispensary Pharmacist	86(61)	37(65)	49(58)	0.39
ID/AMS* Pharmacist	104(73)	46(81)	58(68)	0.10

Abbreviations: *ID, Infectious Diseases; AMS, Antimicrobial Stewardship

Table 2: Perceived roles for nurses participating in Antimicrobial Stewardship

	Overall, n (%)	Paediatric Nurses, n (%)	Adult Nurses, n (%)	P-value
Ensuring appropriate antimicrobial use (indication, dose, frequency)	104(73)	44(77)	60(71)	0.38
Knowledge of antimicrobials	119(84)	46(81)	73(86)	0.41
Role model / raising awareness	102(72)	39(68)	63(74)	0.46
Communication / Participation in multi-disciplinary discussions	100(70)	40(70)	60(71)	0.96
Patient advocacy	120(85)	51(90)	69(81)	0.18
AMS* is not the role of the nurse	4(3)	2(4)	2(2)	0.68
Prompting prescribers to consider switching to oral antimicrobials	65(46)	24(42)	41(48)	0.47
Checking restriction category and ensuring antimicrobials are approved	69(49)	20(35)	49(58)	<0.01
Monitoring side effects and response to treatment	115(81)	48(84)	67(79)	0.42
Prompting prescribers to perform TDM#	73(51)	35(61)	38(45)	0.05
Hand Hygiene/ Infection Control	123(86)	50(88)	73(86)	0.75
Challenging prescribing decisions	98(69)	42(74)	56(66)	0.32
Educating colleagues / patients / public	115(81)	43(75)	72(85)	0.17

Abbreviations: *AMS, Antimicrobial Stewardship; #TDM, Therapeutic Drug Monitoring

Table 3: Support required for nurse involvement in Antimicrobial Stewardship

	Overall, n (%)	Paediatric Nurses, n (%)	Adult Nurses, n (%)	P-value
3a: Who would you like support from?				
Nursing colleagues	89(63)	34(60)	55(65)	0.54
Management / senior staff	79(56)	30(53)	49(58)	0.56
Junior Doctors	44(31)	14(25)	30(35)	0.18
Microbiology Lab	68(48)	22(39)	46(54)	0.07
Nurse Educators / Nurse Prescribers	111(78)	42(74)	69(81)	0.29
Senior Doctors	68(48)	24(42)	44(52)	0.26
Infection Control Team	110(78)	39(68)	71(84)	0.04
Pharmacy	118(83)	45(79)	73(86)	0.28
ID*/AMS** team	120(85)	46(81)	74(87)	0.31
3b: Areas where you would like greater input, guidelines or education from the AMS** team				
Interpreting microbiology	72(51)	27(47)	45(53)	0.52
Selecting the appropriate duration (De-escalation to narrow	80(56)	29(51)	51(60)	0.28
TDM# (timing of levels, dose adjustment etc.)	93(66)	39(68)	54(64)	0.55
Appropriate use of IV ^s or oral (including IV ^s to oral switch)	106(75)	37(65)	69(81)	0.03
Appropriate administration	88(62)	32(56)	56(66)	0.24
Antimicrobial dosing and frequency	94(66)	35(61)	59(69)	0.32
I do not need input from the AMS** team	5(4)	3(5)	2(2)	0.36
Appropriate antimicrobial selection	104(73)	40(70)	64(75)	0.5
Checking cAAS [^] for antimicrobial approvals	71(50)	26(46)	45(53)	0.39

Abbreviations: *ID, Infectious Diseases; **AMS, Antimicrobial Stewardship; #TDM, Therapeutic Drug Monitoring; \$IV, Intravenous; ^cAAS, computerised Antimicrobial Approval System

Figure 1: Respondent Qualifications and Training

Footnotes

Clinical Nurse Specialists = Registered Nurse with ≥ 12 months experience in a specific clinical area PLUS post-registration qualifications, OR 4 years of post-registration experience with ≥ 3 years of experience in their relevant clinical area.

Clinical Nurse Consultant = Registered Nurse with ≥ 5 years of experience post-registration with approved post-registration qualifications relevant to their clinical area

Supplement A: Survey questions used across all hospitals

1. Have you heard of the term “Antimicrobial Stewardship” or AMS?
2. If yes, in your opinion, what is the purpose of Antimicrobial Stewardship (AMS) in hospitals?
3. According to local antimicrobial restriction policy “green” antimicrobials are (select one)
 - Highly restricted -Infectious Diseases approval required
 - Unrestricted
 - Electronic approval required
4. How would you rate your knowledge of antimicrobials?
 - Minimal
 - Limited
 - Average
 - Good
 - Excellent
5. Who would you expect to be involved in antimicrobial stewardship in your area?(check all that apply)
 - Doctor
 - Infectious Diseases Doctor
 - Microbiologist
 - Nurse
 - Infection Control Nurse
 - Ward Pharmacist
 - Dispensary Pharmacist
 - Infectious Diseases/AMS Pharmacist
 - Other
6. What do you think the nurse’s role in antimicrobial stewardship should involve? (check all that apply)
 - Ensuring appropriate antimicrobial use (indication, dose, frequency)
 - Knowledge of antimicrobials
 - Educating colleagues / patients / public
 - Challenging prescribing decisions
 - Role model / raising awareness
 - Communication / Participation in multi-disciplinary discussions
 - Hand Hygiene/ Infection Control
 - Patient advocacy
 - Monitoring side effects and response to treatment
 - AMS is not the role of the nurse
 - Checking restriction category and ensuring antimicrobials are approved
 - Prompting prescribers to consider switching to oral antimicrobials
 - Prompting prescribers to perform Therapeutic Drug Monitoring (TDM)
7. What ongoing support would you need to take on an AMS role on the ward? (check all that apply)

- Updates of information
 - Expert contacts / Mentors
 - Protected time for teaching / learning
 - Continued education (i.e. online learning, posters, ward sessions/lectures)
 - I could not ever support AMS on the ward
 - Other
8. Who would you like to receive support from? (check all that apply)
- Nursing colleagues
 - Management / senior staff
 - Pharmacy
 - Infection Control Team
 - Infectious Diseases/AMS team
 - Junior Doctors
 - Senior Doctors
 - Microbiology Lab
 - Nurse Educators / Nurse Prescribers
9. Select the areas where you would like greater input, guidelines or education from the AMS team:
(check all that apply)
- Appropriate antimicrobial selection
 - Antimicrobial dosing and frequency
 - Appropriate use of IV or oral (including IV to oral switch)
 - Selecting the appropriate duration (De-escalation to narrow spectrum or discontinuing therapy)
 - Therapeutic drug monitoring (timing of levels, dose adjustment etc)
 - Interpreting microbiology
 - Appropriate administration
 - Checking Guidance MS for antimicrobial approvals
 - I do not need input from the AMS team
 - Other
10. Which of the following do you feel impacts the most on prescribers getting antimicrobial approvals on time for your patients? (select top 3 impacts)
- Waiting for ward rounds to finish
 - Consultant opinion
 - Other ward jobs taking priority for prescribers
 - Limited access to a computer
 - Prescribers having difficulty logging into and navigating Guidance MS
 - They forgot to get an approval
 - They are not sure which patients are prescribed restricted antimicrobials (yellow or red drugs)
 - Requiring input from the ID registrar or consultant

- I do not know
- Other

11. Requirement to get antimicrobial approvals is an effective way to reduce inappropriate antimicrobial use

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

12. Verbal and written advice from the AMS team has improved my patients' care

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

13. I would question a prescriber if an antimicrobial was charted for an inappropriate indication

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

14. If I think that antimicrobial approval is unlikely I will try to bypass the system

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

15. You are invited to share any other comments/issues regarding Guidance MS or AMS below:

16. Which Hospital are you currently working in?*

- *Hospital A*
- *Hospital B*
- *Hospital C*

17. In which area are you currently working?

- Paediatric
- Adult

18. Your current qualifications:

- NUM (Nurse Unit Manager)
- CNC (Clinical Nurse Consultant)
- CNE (Clinical Nurse Educator)

- CNS (Clinical Nurse Specialist)
- RN (Grades 2-8)
- TRN (Transitional RN, used to be new graduates)
- EEN (Endorsed Enrolled Nurse)
- EN (Enrolled Nurse)
- AIN (Assistant in Nursing)

**Response options have been amended according to manuscript*