JAC Antimicrob Resist
https://doi.org/10.1093/jacamr/dlac094

JAC-Antimicrobial Resistance

Gaps and barriers in the implementation and functioning of antimicrobial stewardship programmes: results from an educational and behavioural mixed methods needs assessment in France, the United States, Mexico and India

Patrice Lazure [1]*, Monica Augustyniak [1], Debra A. Goff [2], Maria Virginia Villegas[3], Anucha Apisarnthanarak[4] and Sophie Péloquin [1]

[1]*AXDEV Group Inc., Brossard, Quebec, Canada;* [2]*The Ohio State University, College of Pharmacy, Columbus, OH, USA;* [3]*Thammasat University, Faculty of Medicine, Pratumthani, Thailand;* [4]*Resistencia Antimicrobiana y Epidemiología Hospitalaria (RAEH), Universidad El Bosque, Bogotá, Colombia*

*Corresponding author. E-mail: lazurep@axdevgroup.com
@axdevgroup; @idpharmd

Received 5 May 2022; accepted 19 August 2022

Background: Evidence shows limited adherence to antimicrobial stewardship (AMS) principles.

Objectives: To identify educational gaps and systemic barriers obstructing adherence to AMS principles.

Methods: A mixed-methods study combining a thematic analysis of qualitative interviews (January–February 2021) and inferential analysis of quantitative surveys (May–June 2021) was conducted. Participants from France, the USA, Mexico and India were purposively sampled from online panels of healthcare professionals to include infectious disease physicians, infection control specialists, clinical microbiologists, pharmacologists or pharmacists expected to apply AMS principles in their practice setting (e.g. clinic, academic-affiliated or community-based hospital). A gap analysis framework guided this study.

Results: The final sample included 383 participants ($n = 33$ interviews; $n = 350$ surveys). Mixed-methods findings indicated suboptimal knowledge and skills amongst participants to facilitate personal and collective application of AMS principles. Survey data indicated a gap in ideal versus current knowledge of AMS protocols, especially amongst pharmacologists ($\Delta 0.95/4.00$, $P < 0.001$). Gaps in ideal versus current skill levels were also measured and were highest amongst infectious control specialists ($\Delta 1.15/4.00$, $P < 0.001$), for convincing hospital executives to allocate resources to AMS programmes. Already existing systemic barriers (e.g. insufficient dedicated time/funding/training) were perceived as being aggravated during the COVID-19 pandemic (72% of survey participants agreed). Reported gaps were highest in India and France.

Conclusions: The educational needs of professionals and countries included in this study can inform future continuous professional development activities in AMS. Additional funding should be considered to address perceived systemic barriers. Local assessments are warranted to validate results and suitability of interventions.

Introduction

Antimicrobial stewardship (AMS) programmes are increasingly being implemented by healthcare professionals (HCPs) to improve prescribing practices of antibiotics, reduce the threat imposed by MDR organisms (MDROs) and altogether increase patient safety and health outcomes.[1] This approach was recommended by the WHO as part of national action plans in 2016,[2] in line with other expert recommendations, advocating for a high level of collaboration across disciplines (e.g. pharmacy, infectious disease, epidemiology, microbiology) and countries to ensure proper safety measures are followed.[3] However, this can be complicated by national variations in the precise role of each profession group, and as such, the nature of their involvement in AMS.[4]

Although few high-income countries, such as the USA and France, have made it mandatory for hospitals to follow AMS protocols,[5] implementation and adherence to such efforts have been lagging in other countries, where political systems may

not prioritize patient safety and/or cannot afford costs associated with training and capacity-building interventions.[6,7] However, the lack of policies and mandates enforced at the national, regional or hospital level should not deter individual stewards from providing their colleagues with mentoring opportunities that promote best practices in one's setting.[3] A recent study found that local, evidence-based AMS guidelines were used in 96% of North American hospitals, compared with 77% in Latin America, 72% in Europe and 76% in Asia.[8] AMS facilitators' efforts were in-person training for a range of HCPs, locally relevant evidence-based guidelines and the establishment of a multidisciplinary team who monitor and manage AMS.[8] Given education is a known facilitator to implementation, it is essential to gain a better understanding of the educational needs and current practice gaps that might hinder the implementation of strategies aimed to enhance adherence to AMS principles.[9] To identify the educational needs of HCPs in AMS, this study assessed the current knowledge, skills and beliefs of HCPs, in addition to systemic barriers that obstruct adherence to AMS principles, which is the focus of this paper. Knowledge, skills and belief gaps hindering the optimal diagnosis, treatment and management of AMR were also investigated by this study and already covered in a conference presentation at the European Society of Clinical Microbiology and Infectious Disease conference.[10]

Methods

Ethics

This behavioural and educational research study was conducted in accordance with the Declaration of Helsinki and national ethical standards (i.e. the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, TCPS). The research protocol and related documents were reviewed and approved by an independent review board (IRB Veritas, tracking number: 2020-2437-3247-2, study number: GR-24-004). Informed consent was obtained from all study participants prior to participation in the study.

Study design

An exploratory sequential mixed-methods design (Figure 1) was used to conduct a needs assessment of HCPs involved in AMS, in which a qualitative phase was used to explore emerging themes and a quantitative phase was used to validate the extent to which the themes identified in the qualitative phase can be generalized, to identify specific areas where an educational intervention is warranted.[11,12] Findings contextualized in light of the literature and expertise of clinical (co-authors D.A.G., M.V.V. and A.A., and acknowledged contributor D.N.) and educational experts (co-authors P.L., M.A. and S.P.). As neither qualitative nor quantitative data alone provide a complete picture of reality, a mixed-methods design was selected as the most appropriate methodology to achieve the research objectives.[12–15] A gap analysis framework was applied to identify discrepancies in knowledge, skills and beliefs between the current (i.e. 'what is') and ideal state (i.e. 'what should be'), as means to better understand the educational needs of HCPs that can be addressed through continuous medical education (CME)[16] and professional development (CPD) activities.[9] Barriers contributing to identified gaps were explored across multiple levels (i.e. individual, group and systems).[17]

Recruitment

Participants in the qualitative and quantitative phases were recruited sequentially from two discrete international research panels of HCPs eager to share their perspectives on healthcare improvement. Panels operated in compliance with the guidelines of the International Chamber of Commerce and European Society for Opinion and Marketing Research.[18] Eligibility and purposive sampling criteria were identical for both study phases. Potential participants within each panel were identified on the basis of their location and area of healthcare expertise, then invited via e-mail directing those interested towards a secured website for eligibility screening.

Participants were deemed eligible if they selected: (i) infectious disease physician (ID), clinical pharmacologist (CPO), clinical pharmacist (CP), clinical microbiologist (CM), infection control specialist (ICS), infection control professional/practitioner or hospital epidemiologist as their primary profession or specialty; (ii) France, the USA, Mexico or India as their practice location and (iii) at least 3 years of practice in their given profession. ID, CPO or CP were included if they reported being involved in the prescription of antimicrobial agents and caring for a minimum of 30 patients per month with a proven or suspected infection. CM were included if they tested a minimum of 50 specimens per month suspected of an infection and had a minimum of 5% of microbes encountered per month classified as MDROs. ICS had to be involved in an infection control committee and address at least 20 infection outbreaks per year. Those who reported being retired or in a research/teaching role only, not aware of what AMS is, or not knowing the key principles of AMS were excluded. Purposive sampling was used to ensure a variety of HCP profiles were included (e.g. practice settings, locations and years of practice).[19] The honoraria provided following participation was adjusted based on country of practice, profession and nature of participation (interview/survey), which was approved by the ethics review board to ensure fair compensation for time and effort. Qualitative target sample sizes were calculated based on experience with similar projects,[20,21] and expectations towards reaching data saturation.[22] Quantitative target sample sizes were calculated so that χ^2 tests between five subgroups on a dichotomic variable would produce a statistical power of 0.8, assuming $\alpha = 0.05$ and a large effect size (Cohen's $w = 0.5$).

Data collection

An unstructured search of the literature was conducted to inform a 1 h facilitated discussion between co-authors on specific topics for investigation. The discussion led to the development of a semi-structured interview guide in English, consisting of predetermined, open-ended questions and examples of probes (see Appendix S1, available as Supplementary data at *JAC-AMR* Online).[23] Materials were translated into French and Spanish. Professional moderators (with a background in healthcare research) were briefed by the co-authors on the interview guides and trained to ask spontaneous open-ended questions to maximize both flow and richness of data collection.[13] Interviews were 45 min and were conducted via a secured conference call in respective languages between January and February 2021. Recordings were transcribed and translated into English.

Survey development (in English) followed best practices,[24] with items generated from the themes identified from interview data and formulated as closed-ended survey questions to determine the extent to which specific perspectives were shared between different professions, settings and experience levels. Content and face validity were ensured by clinical expert review (co-authors D.A.G., M.V.V. and A.A., and acknowledged contributor D.N.) for appropriate clinical verbiage and relevance. A five-point Likert-type response scale was used to measure participants' perception of their current versus ideal knowledge and skill levels (1, no knowledge/skill; 5, expert knowledge/skill). A Likert scale was also used to assess agreement with statements (1, strong disagreement; 5, strong agreement). Cases with multiple choice answer questions were developed by co-authors D.A.G., M.V.V. and A.A. to obtain a more objective assessment of participants' knowledge and beliefs potentially driving an approach to fostering compliance with AMS compliance recommendations (see full case in Appendix S2). Given the contextual circumstances that can affect clinical practice (e.g. resources), case questions did not always have a

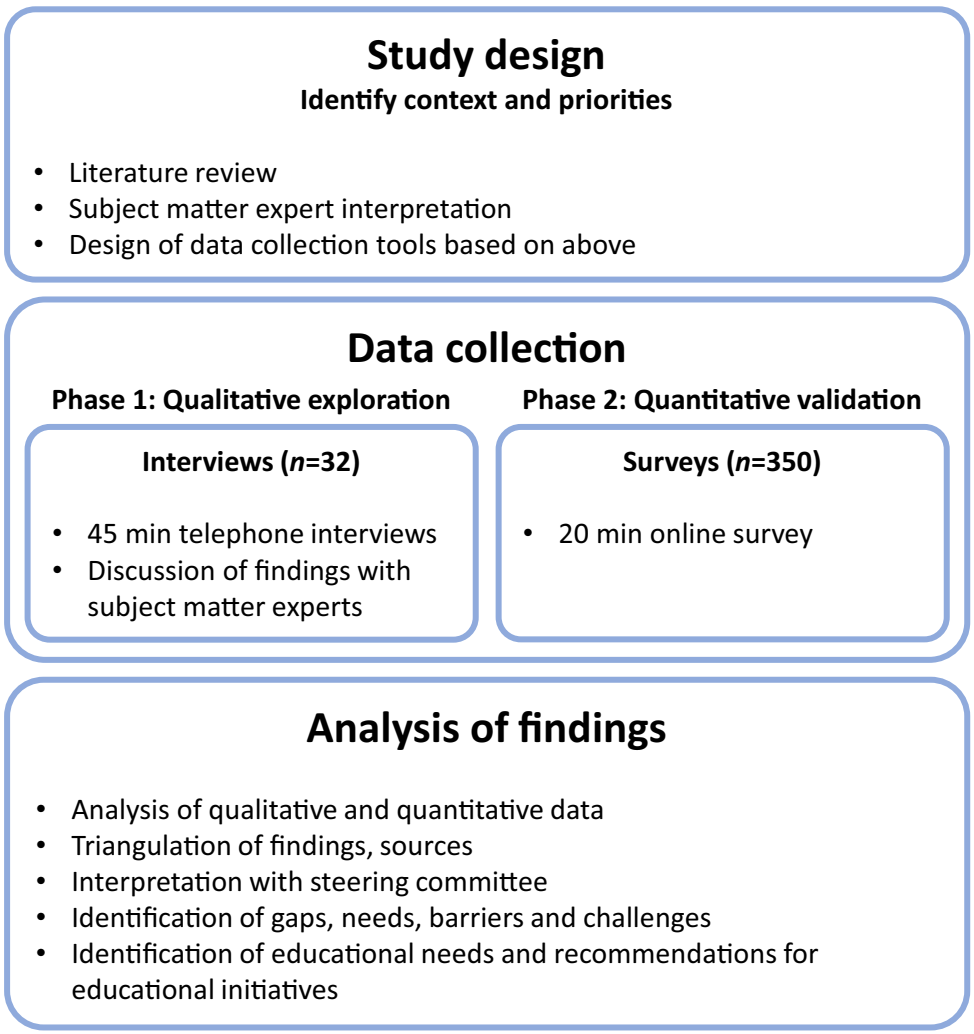

Figure 1. Steps in mixed-methods exploratory sequential study design, data collection and analysis.

right or wrong answer. The survey was translated into other languages (French and Spanish), programmed and beta tested online, before being distributed between May and June 2021.

Analytical plan

A coding tree was developed *a priori* based on what was already known from the literature review, expert consultation, the gap analysis framework, study objectives and interview guide, and used in NVivo software (QSR International Pty Ltd, 2018, v.12.0) to categorize qualitative data from transcribed interviews.[9] An intercoder reliability test was performed on a first transcript among two professional researchers under the supervision of co-author P.L. to ensure consistent coding.[25] Overall, strong agreement between coders was found. Necessary changes in the coding tree (e.g. merging or redefinition of categories) were discussed among researchers to optimize representation of interview content.[26] An inductive revision of the coded content, guided by the grounded theory approach,[27] was then performed to identify emerging themes and patterns across professions and countries.[28]

Quantitative data were analysed in SPSS Statistics (v.27.0, IBM Corp., Armonk, NY, USA). Ideal versus current knowledge/skill were computed as a 'gap' if the ideal rating provided by a participant was greater than their current rating, leading to dichotomized variables (0, no gap; 1, gap). Agreement ratings were grouped into three categories (1 and 2, disagree; 3, neutral; 4 and 5, agree). Descriptive analyses were performed to obtain means and frequencies. Paired *t*-tests were conducted to identify differences between ideal and current mean ratings at $\alpha = 0.05$ for each country or profession subgroup. χ^2 tests were performed on categorical data at $\alpha = 0.05$ to assess differences in distribution between demographics (e.g. countries). The reporting guidelines used for this mixed-methods study are outlined in a recent publication.[29]

Data integration and trustworthiness

Integration of findings was possible as the literature review and qualitative findings set the foundations for the development of quantitative measures.[12] The rich contextual data derived from interviews were validated by quantifying observed patterns and trends in a larger sample (i.e. survey). Findings were compared and contextualized with the perspectives of multiple educational (co-authors P.L., M.A. and S.P.) and clinical experts (co-authors D.A.G., M.V.V. and A.A., and acknowledged contributor D.N.), through a process called 'triangulation'. This helped obtain a more 'complete' and 'trustworthy' understanding of the phenomena, contrary to single-method, single-observer type studies.[12,15]

Results

This study involved 383 participants: 33 in the qualitative phase and 350 in the quantitative phase. This included 96 ID, 54 CPO, 53 CP, 90 CM and 90 ICS, distributed comparably among the four participant countries (Table 1). In the qualitative phase, 88% (29/33) of participants had an AMS programme in their clinical practice and 76% (25/33) were AMS committee members, compared with 85% (296/350) and 57% (200/350) in the quantitative phase. The quantitative sample of participants located in Mexico had a significantly larger proportion of AMS committee members (89%, 73/82), compared with other countries (France 44%, 39/88; India 41%, 34/83; USA 56%, 54/97; $P < 0.001$).

Triangulated data identified individual knowledge and skill gaps affecting the application of AMS recommendations. Gaps in leadership and communication skills to adequately educate colleagues on AMS recommendations and foster compliance with best practices were found. Insufficient funding and number of trained HCPs, especially during the COVID-19 pandemic, were identified as key barriers to the proper implementation and functioning of AMS. Qualitative data presented next are representative of the themes that emerged during the analysis. Additional qualitative data can be found in Appendix S3.

Table 1. Characteristics per sample and profession

	ID, % (*n*)	CPO, % (*n*)	CP, % (*n*)	CM, % (*n*)	ICS, % (*n*)	Total, % (*n*)
Qualitative sample characteristics	(*n* = 9)	(*n* = 4)	(*n* = 4)	(*n* = 8)	(*n* = 8)	(*n* = 33)
Country						
France	22 (2)		50 (2)	25 (2)	25 (2)	24 (8)
India	22 (2)	50 (2)		25 (2)	25 (2)	24 (8)
Mexico	22 (3)	50 (2)		25 (2)	25 (2)	27 (9)
USA	22 (2)		50 (2)	25 (2)	25 (2)	24 (8)
Years of practice						
3–10	11 (1)	50 (2)	25 (1)	37 (3)	25 (2)	27 (9)
11–20	44 (4)	50 (2)	75 (3)	25 (2)	62 (5)	48 (16)
21+	44 (4)			37 (3)	13 (1)	24 (8)
Involvement in AMS committee						
Non-committee members	22 (2)	50 (2)		37 (3)	13 (1)	24 (8)
AMS committee members	78 (7)	50 (2)	100 (4)	62 (5)	87 (7)	76 (25)
Setting						
Academic hospital	67 (6)	50 (2)	75 (3)	62 (5)	50 (4)	61 (20)
Community hospital	33 (3)	50 (2)	25 (1)	37 (3)	50 (4)	39 (13)
Quantitative sample characteristics	(*n* = 87)	(*n* = 50)	(*n* = 49)	(*n* = 82)	(*n* = 82)	(*n* = 350)
Country						
France	23 (20)	28 (14)	26 (13)	24 (20)	26 (21)	25 (88)
India	26 (20)	22 (11)	20 (10)	26 (21)	26 (21)	24 (83)
Mexico	24 (21)	22 (11)	20 (16)	24 (20)	24 (20)	23 (82)
USA	30 (26)	28 (14)	33 (16)	26 (21)	24 (20)	28 (97)
Years of practice						
3–10	35 (29)	46 (23)	31 (15)	35 (29)	38 (31)	36 (128)
11–20	44 (38)	44 (22)	47 (23)	49 (40)	41 (34)	45 (157)
21+	22 (19)	10 (5)	22 (11)	16 (13)	21 (17)	19 (65)
Involvement in AMS committee						
Non-committee members	33 (29)	66 (33)	39 (19)	41 (34)	43 (35)	43 (150)
AMS committee members	67 (58)	34 (17)	61 (30)	59 (48)	57 (47)	57 (200)
Setting						
Academic hospital	38 (33)	10 (5)	22 (11)	32 (26)	26 (21)	27 (96)
Community hospital	29 (35)	46 (23)	43 (21)	49 (40)	50 (41)	43 (150)
Community clinic/healthcare centre	6 (5)	22 (11)	8 (4)	9 (7)	15 (12)	11 (39)
Multi-specialty physician group	15 (13)	16 (8)	8 (4)	10 (8)	9 (7)	11 (40)
Single-specialty physician group practice	8 (7)	4 (2)	2 (1)			3 (10)
Solo practice	5 (4)	2 (1)	14 (7)			3 (12)
Other			2 (1)	1 (1)	1 (1)	1 (3)

ID, infectious disease physicians; CM, clinical microbiologists; ICS, infection control specialists; CPO, clinical pharmacologists; CP, clinical pharmacists.

Table 2. Knowledge and skill gaps in AMS by profession and AMS membership

	ID		CPO		CP		CM		ICS		Member		Non-member	
	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ
Knowledge gap of…														
The role of AMS in emergency response preparedness towards outbreaks[a]	61 (53/87)	0.76[b]	72 (36/50)	0.88[b]	57 (28/49)	0.63[b]	79 (65/82)	1.05[b]	84 (69/82)	1.05[b]	68 (136/200)	0.80[b]	77 (115/150)	1.02[b]
Current AMS protocols in place in my clinical setting (only asked to those with such programmes in place)[a]	46 (35/76)	0.53[b]	71 (30/42)	0.95[b]	58 (22/38)	0.66[b]	67 (49/73)	0.75[b]	84 (56/67)	0.97[b]	57 (114/200)	0.62[b]	81 (78/96)	1.05[b]
Skill gap in…														
Applying AMS protocols in clinical work[a],c	53 (46/87)	0.59[b]	80 (40/50)	0.92[b]	45 (22/49)	0.47[b]	66 (54/82)	0.71[b]	84 (69/82)	1.11[b]	56 (111/200)	0.59[b]	80 (120/150)	1.01[b]
Demonstrating leadership regarding the application of AMS protocols (only asked to AMS committee members)	45 (26/58)	0.50[b]	59 (10/17)	0.59[b]	63 (19/30)	0.63[b]	56 (27/48)	0.65[b]	70 (33/47)	0.91[b]	58 (115/200)	0.66[b]		
Communicating AMS recommendations to surgeons[c]	56 (49/87)	0.63[b]	76 (38/50)	0.90[b]	61 (30/49)	0.76[b]	66 (54/82)	0.80[b]	72 (59/82)	0.88[b]	58 (166/200)	0.69[b]	76 (114/150)	0.91[b]
Convincing hospital executives to allocate resources to AMS programmes (only asked to those with an official AMS programme in place)[a]	66 (50/76)	0.89[b]	81 (34/42)	1.05[b]	71 (27/38)	0.79[b]	64 (47/73)	0.74[b]	85 (57/67)	1.15[b]	71 (142/200)	0.91[b]	76 (73/96)	0.96[b]

% (*n*/*N*) = gap prevalence (i.e. percentage of respondents for which ideal > current).
Δ = size of the gap (i.e. mean ideal − mean current).
[a]Difference by profession in gap prevalence $P < 0.05$.
[b]**Mean ideal > mean current $P < 0.001$.**
[c]Difference by AMS membership in gap prevalence $P < 0.05$.

Individual-level gaps in the application of AMS recommendations

Qualitative data indicated HCPs involved in AMS committees were able to gain knowledge pertaining to best practices in the diagnosis of infections and antibiotic prescription, as it was part of their roles and responsibilities to stay current with emerging evidence. In contrast, acceptance to follow AMS recommendations among non-AMS committee members can be hindered by a lack of 'knowledge' and 'education', which has significant implications on the prescription of antibiotics:

> '...amount of knowledge that one gains because of being in the committee is quite different than generally doing a practice, when you are really into it [being part of an AMS committee] you want to know what exactly antibiogram is and how is the antibiogram basis of collecting these swabs...'

Infectious disease physician, AMS committee member, India

Quantitative data showed significant knowledge gaps ($P < 0.001$) regarding the role of AMS in emergency response preparedness towards outbreaks, especially among CM and ICS (Δ1.05) and non-AMS committee members (Δ1.02, Table 2). Significant knowledge gaps were found for AMS protocols put in place, especially among CPO (Δ0.95), ICS (Δ0.97), non-AMS committee members (Δ1.05, Table 2) or HCPs practising in India (Δ1.03) or France (Δ0.97, Table 3). Knowledge gaps were present among AMS committee members. Similar patterns were found in reported skill gaps (Tables 2 and 3) to apply AMS protocols.

Leadership and communication skill gaps affecting AMS education and compliance

Interviewed participants observed resistance to AMS recommendations in their settings, and described AMS leaders as demonstrating poor leadership and ability to build trust with HCPs when enforcing compliance with best practice:

> 'We need to have very strong, appropriate communication skills and go in as a part of the team, and not come across as telling them how to practice medicine, to try to convince them why this may be an alternative or a better approach. It takes patience, it takes working with them.'

Infection control specialist, AMS committee member, USA

Quantitative data showed significant skill gaps ($P < 0.001$) in leadership among AMS committee members, especially ICS (Δ0.91, Table 2) in the application of AMS protocols. Significant skill gaps in communicating AMS recommendations to surgeons were also found, especially among CPO (Δ0.90) and ICS (Δ0.88, Table 2). Both skill gaps were more pronounced among HCPs practising in India (Δ1.12, Δ0.98) and France (Δ0.91, Table 3). Statistically significant differences in the distributions by country were found for HCPs agreeing with the statement, 'In my clinical setting, there is an overall lack of trust between the AMS team and HCPs': 26% (21/82) in Mexico, 37% (36/97) in the USA, 46% (40/87) in France and 80% (66/83) in India ($P < 0.001$).

When presented with a case of poor compliance with local guidelines for treatment of hospitalized patients with severe community-acquired pneumonia, 71% (248/350) of survey responders selected, as a successful approach to improving compliance, to send an e-mail notification to inform non-compliant physicians they were being reported to their manager/superior. Further, 58% (204/350) indicated they would instruct colleagues to automatically change treatment if deemed inappropriate. χ^2 test results showed statistically significant differences in distributions across countries for the selection of these approaches (Table 4).

Table 3. Knowledge and skill gaps in AMS by country

	France		USA		Mexico		India	
	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ	% (*n*/*N*)	Δ
Knowledge gap of...								
The role of AMS in emergency response preparedness towards outbreaks	75 (66/88)	0.99[b]	69 (67/97)	0.82[b]	66 (54/82)	0.74[b]	77 (64/83)	1.02[b]
Current AMS protocols in place in my clinical setting (only asked to those with such programmes in place)[a]	71 (50/70)	0.97[b]	56 (56/84)	0.62[b]	54 (43/79)	0.51[b]	83 (52/63)	1.03[b]
Skill gap in...								
Applying AMS protocols in clinical work[a]	73 (64/88)	0.91[b]	57 (55/97)	0.66[b]	50 (41/82)	0.48[b]	86 (71/83)	1.04[b]
Demonstrating leadership regarding the application of AMS protocols (only asked to AMS committee members)[a]	67 (26/39)	0.92[b]	46 (25/54)	0.43[b]	47 (34/73)	0.48[b]	88 (30/34)	1.12[b]
Communicating AMS recommendations to surgeons[a]	72 (63/88)	0.91[b]	62 (60/97)	0.78[b]	46 (38/82)	0.46[b]	83 (69/83)	0.98[b]
Convincing hospital executives to allocate resources to AMS programmes (only asked to those with an official AMS programme in place)[a]	70 (49/70)	0.93[b]	73 (61/84)	0.85[b]	58 (46/79)	0.76[b]	94 (59/63)	1.22[b]

% (*n*/*N*) = gap prevalence (i.e. percentage of respondents for which ideal > current).
Δ = size of the gap (i.e. mean ideal − mean current).
[a]Difference by country in gap prevalence $P < 0.05$.
[b]Mean ideal > mean current $P < 0.001$.

Table 4. Selected approaches to addressing poor compliance with AMS recommendations

	France		USA		Mexico		India	
	%	(n/88)	%	(n/97)	%	(n/82)	%	(n/83)
Approaches to address non-compliance with AMS recommendations as a first intervention:								
E-mail informing report to manager/superior[a]	74	(65)	58	(56)	62	(51)	93	(77)
Explain concerns and seek face-to-face meeting	94	(83)	93	(90)	94	(77)	99	(82)
Gain insight into inappropriate behaviour (i.e. understand rationale for behaviour)	90	(79)	90	(87)	84	(69)	95	(79)
Provide and discuss evidence-based educational resources	94	(83)	96	(93)	92	(76)	93	(76)
Approaches to address recurring non-compliance with AMS recommendations as a second intervention:								
Gain understanding of ongoing poor practice and reinforce evidence-based recommendations in face-to-face discussion[b]	97	(85)	93	(90)	87	(71)	99	(82)
Agree on a communication pathway that benefits both parties	93	(82)	87	(84)	93	(76)	94	(78)
Inform physician that you will automatically instruct his colleagues to change treatment if deemed inappropriate[a]	55	(48)	42	(41)	62	(51)	77	(64)
Seek a meeting to share data on 'peer practice' of antibiotic use and formalize meeting through a letter[b]	68	(60)	85	(82)	82	(67)	82	(68)
Agree with all departments for a 6-month audit of CAP treatment with monthly feedback	90	(79)	88	(85)	77	(63)	94	(78)

See Appendix S2 for full question. Participants were asked to respond 'true' or 'false' for each of the above items being appropriate approached to addressing non-compliance with AMS recommendations. The table reports frequency of participants who selected 'true' for each item by country.
[a]Difference by country in distributions $P < 0.001$.
[b]Difference by country in distributions $P < 0.05$.

Systemic barriers affecting the functioning of AMS programmes

Both qualitative and quantitative data indicated a lack of resources (time, funding and trained HCPs) across countries to implement AMS programmes and ensure optimal functioning. Qualitative data highlighted the challenge of prioritizing the functioning of AMS programmes among leaders who have competing roles and responsibilities:

> 'I personally do too many things. So does my colleague, that I work with on the hygiene front, we want to try and target more specific specialties, because we do not have time to manage all that.'

Infection control specialist, AMS committee member, France

Survey respondents reported experiencing a lack of resources to implement AMS programmes in their practice: 37% (30/81) in Mexico, 44% (42/96) in the USA, 52% (43/83) in India and 57% (50/88) in France ($P < 0.001$). Most HCPs agreed there should be more trained HCPs to ensure proper AMS functioning: 75% (71/95) in the USA, 76% (62/80) in Mexico, 86% (76/88) in France and 98% (81/83) in India ($P < 0.05$). Significant skill gaps ($P < 0.001$) to convince hospital executives of the need to allocate resources to AMS programmes were found among HCPs with an official AMS programme in their setting (especially CPO Δ1.05 and ICS Δ1.05, Table 2). This skill gap was significant in all countries, but more pronounced in India (Δ1.22, Table 3).

HCPs who were interviewed reported greater challenges in implementing AMS protocols during the COVID-19 pandemic, validated by 72% (252/348) of survey participants, as there were fewer opportunities to provide feedback in person and certainty about the appropriateness of recommendations of antimicrobial agents:

> '…the educative part is over. That's completely lost, because there's no contact, there's no feedback at all, and it's difficult to meet to explain why. It's feasible, but you can't ask doctors burdened with wards full of patients to spend an hour or an hour and a half to do this. It's unthinkable. So, we've decided to stop that part of the program.'

Clinical microbiologist, AMS committee member, Mexico

Discussion

This study identified numerous gaps preventing HCPs in France, the USA, Mexico and India from optimally adhering to AMS principles, contributing to learning and behaviour change of colleagues, and to the prioritization of AMS at the individual, organizational and systemic level (Figure 2). Consensus among experts in both high- and low-income countries indicates that effective AMS implementation and functioning includes: hospital leadership commitment, accountability, expertise in pharmacy and infection management, education, practical training, monitoring, surveillance, continuous reporting and feedback.[1,30] Given the important role of AMS committee members in role modelling and supporting behaviour change among their peers, the gaps in leadership and communication skills identified among this group need to be addressed to ensure optimal support of AMS implementation at the institutional level.

The large proportion of AMS committee members who recognized their own knowledge gaps of the role of AMS in emergency

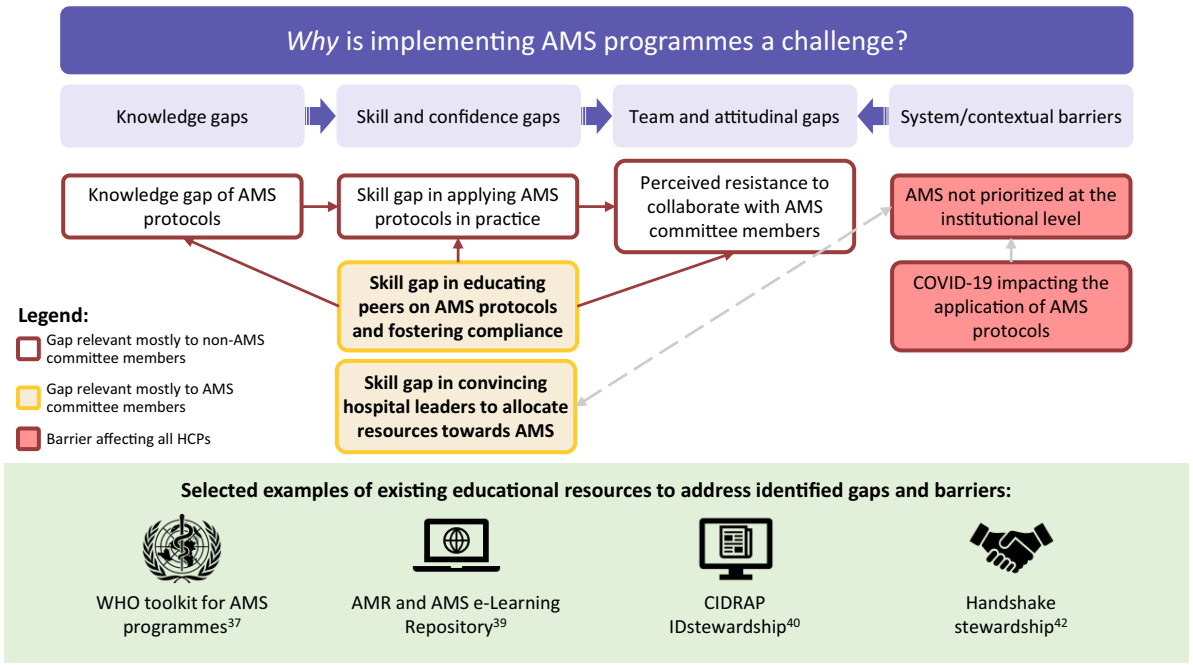

Figure 2. Summary of identified gaps and barriers to AMS implementation and selected solutions (educational resources).

outbreak preparedness probably reflects the fact this study was conducted in an ever-changing landscape during the pandemic. Knowledge and skill gaps (individual-level factors) that hinder the application of AMS protocols were reported by participants (both AMS committee members and non-members). This evidence contrasts with most recent literature that heavily focuses on system and cultural barriers to AMS implementation, rather than individual-level gaps affecting transfer of knowledge from one HCP to another, and mutual behaviour change.[31–33] Although the rationale for such focus is perfectly justified (i.e. behaviour change is quasi-impossible in a system that does not support such change), adherence to the core elements of AMS programmes equally requires a continuous assessment of the professional needs of implementing parties.

Current evidence on antimicrobial resistance (AMR)[34] and AMS suggests that culture has an important influence on behaviour change and national action plans enacted in this field. A 2021 literature review particularly emphasized the need to build a culture of trust 'by providing mutual assurance for action' as a way to enhance implementation of AMS,[32] which is an ongoing need. Other 2021 studies have reported a concerning lack of multidisciplinary commitment and global solidarity in AMR curtailment strategies. This is attributed to 'temporal myopia' (i.e. lack of consideration of long-term outcomes) and influences of capitalism that promote 'perverse antimicrobial prescription' without thorough assessment of need.[35,36] Additionally, a 2014 situational analysis of India by Madhok *et al.*[6] found that 'reporting of incidents related to patient safety is seen as an act of complaining', which 'discourages reporting or owning mistakes'. The authors of this study agree and advocate for a cultural shift 'that holds people accountable without apportioning blame or using punishment'.[6]

These calls for action are particularly relevant considering findings where strategies relying on threat and punishment, rather than trust-building and empowerment, were identified as 'successful approaches' by a higher number of HCPs in India and France than in Mexico and the USA. Fortunately, HCPs who participated in this study reported a need for improvement in their current levels of knowledge and skill for different aspects of AMS implementation, suggesting a recognition of educational needs and openness to receiving education. In general, findings from this study indicate the specific educational needs of HCPs are different depending on the cultural context in which they practice (defined, in part, by their country and practice setting). Perceived differences in current versus ideal levels were highest in India and France, compared with the USA and Mexico, which was corroborated by the objective measures collected from the case questions and information from qualitative data.

Numerous free AMS educational resources that address barriers and enablers of stewardship currently exist, including the WHO practical toolkit to establishing AMS programmes in low- and middle-income countries,[37] recommended division of roles and responsibilities for AMS teams in Asia,[38] the worldwide database of educational resources offered by JAC-AMR and BSAC,[39] the Center for Infectious Disease Research and Policy website,[40] updates on the AMS by IDStewardship[41] and the handshake stewardship approach to providing feedback on antimicrobial prescription.[42] Although these might be helpful in addressing some gaps and barriers identified in this study, co-authors recommend each practice setting conduct their own local gap analysis to find targeted solutions to facilitating the implementation and functioning of their AMS teams.

Limitations

This study remains exploratory in nature. Identified gaps and barriers were mainly based on self-reported data, which can be prone to bias. This was minimized through the use of open-ended

questions during the qualitative phase, the inclusion of cases in the quantitative phase (which assessed knowledge and clinical decision-making more objectively) and the use of triangulation of perspectives and methods.[15] Inclusion of other affected parties involved in AMS, such as hospital executives, could have enhanced assessment and triangulation of factors affecting organizational and systemic behaviour. Published evidence was used to provide partial perspectives from the standpoint of these potentially affected groups. Last, the limited number of participants and countries included in this study prevented identification of robust patterns by low versus high-income countries, which is an important variable in the implementation of AMS programmes.[37,43] Similar distribution by country between AMS and non-AMS committee members was not possible. Given the exploratory nature of this study, no adjustment or correction was applied to the α significance level (<0.05), which could have cause overestimation of subgroup differences.

Conclusions

This exploratory mixed-methods study identified knowledge and skill gaps that can hinder optimal implementation of AMS. Findings from this study will contribute to the emerging pool of evidence on successful factors to support optimal AMS implementation and functioning. Identified gaps can be a starting point for studies of the educational needs of HCPs involved in antibiotic prescribing, especially those working in countries where AMS may not be instituted. Together with other assessments, findings from this study can be used to guide HCPs towards appropriate and currently available resources, and to inform the development of new interventions to meet specific needs of certain subgroups or populations.

Acknowledgements

We would like to acknowledge the support provided by Dr Dilip Nathwani (MD, DTM&H, FRCP, University of Dundee) for providing his subject matter expertise on the research design and interpretation of findings, as well as Suzanne Murray (CEO and Founder of AXDEV Group, AXDEV Global and AXDEV Europe) and Olivier Jacob (Director of Project Management, AXDEV Group) who supported data collection, communications and other aspects of the research. We would finally like to thank all the participants who took part in this study.

Funding

This work was supported with education research funds from bioMérieux SA to AXDEV Group Inc.

Transparency declarations

D.A.G. has received grant support from Merck Sharp & Dohme (MSD) and was a consultant over 2 years ago to MeMEd, as well as an adviser for Becton, Dickinson and Company and Spero Therapeutics. M.V.V. has received educational grants and consultant fees from MSD, Pfizer, WEST and bioMérieux. A.A. received consultant fees from Abbott and bioMérieux. Co-authors P.L., M.A. and S.P. are employees of AXDEV Group Inc.

Supplementary data

Appendices S1 to S3 are available as Supplementary data at *JAC-AMR* Online.

References

1 CDC. *The Core Elements of Antibiotic Stewardship Programs: 2019*. US Department of Health and Human Services, CDC, 2019.

2 WHO, Food and Agriculture Organization of the United Nations, World Organisation for Animal Health. *Antimicrobial Resistance, a Manual for Developing National Action Plans*. WHO, 2016.

3 Goff DA, Kullar R, Goldstein EJ *et al*. A global call from five countries to collaborate in antibiotic stewardship: united we succeed, divided we might fail. *Lancet Infect Dis* 2017; **17**: e56–63. https://doi.org/10.1016/S1473-3099(16)30386-3

4 Nampoothiri V, Bonaconsa C, Surendran S *et al*. What does antimicrobial stewardship look like where you are? Global narratives from participants in a massive open online course. *JAC Antimicrob Resist* 2022; 4: dlab186. https://doi.org/10.1093/jacamr/dlab186

5 Trivedi KK, Dumartin C, Gilchrist M *et al*. Identifying best practices across three countries: hospital antimicrobial stewardship in the United Kingdom, France, and the United States. *Clin Infect Dis* 2014; **59**(Suppl 3): S170–8. https://doi.org/10.1093/cid/ciu538

6 Madhok R, Vaid S, Carson-Stevens A *et al*. Promoting patient safety in India: situational analysis and the way forward. *Natl Med J India* 2014; **27**: 217–23.

7 Tiong JJ, Loo JS, Mai C-W. Global antimicrobial stewardship: a closer look at the formidable implementation challenges. *Front Microbiol* 2016; **7**: 1860. https://doi.org/10.3389/fmicb.2016.01860

8 Pauwels I, Versporten A, Vermeulen H *et al*. Assessing the impact of the Global Point Prevalence Survey of Antimicrobial Consumption and Resistance (Global-PPS) on hospital antimicrobial stewardship programmes: results of a worldwide survey. *Antimicrob Resist Infect Control* 2021; **10**: 138. https://doi.org/10.1186/s13756-021-01010-w

9 Moore DE Jr. Needs assessment in the new health care environment: combining discrepancy analysis and outcomes to create more effective CME. *J Contin Educ Health Prof* 1998; 18: 133–41. https://doi.org/10.1002/chp.1340180302

10 Péloquin S, Goff D, Augustyniak M *et al*. A multi-country assessment of gaps and systemic barriers in the diagnosis of infections. ECCMID 2022, Lisbon, Portugal, 2022. Poster Number: P1942.

11 Gupta K. *A Practical Guide to Needs Assessment*. John Wiley & Sons, 2011.

12 Creswell JW, Klassen AC, Clark VL P *et al*. *Best Practices for Mixed Methods Research in the Health Sciences*. Office of Behavioral and Social Sciences Research, 2011.

13 Wethington E, McDarby ML. Interview methods (structured, semi-structured, unstructured). In: Whitbourne SK, ed. *The Encyclopedia of Adulthood and Aging*. John Wiley & Sons, 2015, 1–5.

14 Mann KV. Not another survey! Using questionnaires effectively in needs assessment. *J Contin Educ Health Prof* 1998; **18**: 142–9. https://doi.org/10.1002/chp.1340180303

15 Turner SF, Cardinal LB, Burton RM. Research design for mixed methods: a triangulation-based framework and roadmap. *Organ Res Methods* 2017; **20**: 243–67. https://doi.org/10.1177/1094428115610808

16 Beović B, Pulcini C, Dumartin C *et al*. Legal framework of antimicrobial stewardship in hospitals (LEASH): a European Society of Clinical Microbiology and Infectious Diseases (ESCMID) cross-sectional international survey. *Int J Antimicrob Agents* 2018; **52**: 616–21. https://doi.org/10.1016/j.ijantimicag.2018.07.019

17 Cochrane LJ, Olson CA, Murray S *et al*. Gaps between knowing and doing: understanding and assessing the barriers to optimal health care. *J Contin Educ Health Prof* 2007; **27**: 94–102. https://doi.org/10.1002/chp.106

18 International Chamber of Commerce (ICC), European Society for Opinion and Marketing Research (ESOMAR). *International Code on*

Market, Opinion and Social Research and Data Analytics. 2016. https://www.iccwbo.be/shop/iccesomar-international-code-on-market-opinion-and-social-research-and-data-analytics-free-ebook/.

19 Etikan I, Musa SA, Alkassim RS. Comparison of convenience sampling and purposive sampling. *Am J Theor Appl Stat* 2016; **5**: 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

20 Lazure P, Tomlinson JW, Kowdley KV *et al*. Clinical practice gaps and challenges in non-alcoholic steatohepatitis care: an international physician needs assessment. *Liver Int* 2022; **42**: 1772–82. https://doi.org/10.1111/liv.15324

21 Péloquin S, Garcia-Velasco JA, Blockeel C *et al*. Educational needs of fertility healthcare professionals using ART: a multi-country mixed-methods study. *Reprod Biomed Online* 2021; **43**: 434–45. https://doi.org/10.1016/j.rbmo.2021.06.020

22 Fusch PI, Ness LR. Are we there yet? Data saturation in qualitative research. *Qual Rep* 2015; **20**: 1408.

23 Crandall SJ. Using interviews as a needs assessment tool. *J Contin Educ Health Prof* 1998; **18**: 155–62. https://doi.org/10.1002/chp.1340180305

24 Boateng GO, Neilands TB, Frongillo EA *et al*. Best practices for developing and validating scales for health, social, and behavioral research: a primer. *Front Public Health* 2018; **6**: 149. https://doi.org/10.3389/fpubh.2018.00149

25 Burla L, Knierim B, Barth J *et al*. From text to codings: intercoder reliability assessment in qualitative content analysis. *Nurs Res* 2008; **57**: 113–7. https://doi.org/10.1097/01.NNR.0000313482.33917.7d

26 Krippendorff K. *Content Analysis: An Introduction to its Methodology*. Sage Publications, 2018.

27 Walker D, Myrick F. Grounded theory: an exploration of process and procedure. *Qual Health Res* 2006; **16**: 547–59. https://doi.org/10.1177/1049732305285972

28 Nowell LS, Norris JM, White DE *et al*. Thematic analysis: striving to meet the trustworthiness criteria. *Int J Qual Methods* 2017; **16**: 1–13. https://doi.org/10.1177/1609406917733847

29 Lee SD, Iott B, Banaszak-Holl J *et al*. Application of mixed methods in health services management research: a systematic review. *Med Care Res Rev* 2022; **79**: 331–44. https://doi.org/10.1177/10775587211030393

30 Pulcini C, Binda F, Lamkang AS *et al*. Developing core elements and checklist items for global hospital antimicrobial stewardship programmes: a consensus approach. *Clin Microbiol Infect* 2019; **25**: 20–5. https://doi.org/10.1016/j.cmi.2018.03.033

31 Broom A, Kenny K, Kirby E *et al*. The modern hospital executive, micro improvements, and the rise of antimicrobial resistance. *Soc Sci Med* 2021; **285**: 114298. https://doi.org/10.1016/j.socscimed.2021.114298

32 Weldon I, Hoffman SJ. Bridging the commitment-compliance gap in global health politics: lessons from international relations for the global action plan on antimicrobial resistance. *Glob Public Health* 2021; **16**: 60–74. https://doi.org/10.1080/17441692.2020.1788623

33 Schouten J, De Waele J, Lanckohr C *et al*. Antimicrobial stewardship in the ICU in COVID times: the known unknowns. *Int J Antimicrob Agents* 2021; **58**: 106409.

34 Tomczyk S, Taylor A, Brown A *et al*. Impact of the COVID-19 pandemic on the surveillance, prevention and control of antimicrobial resistance: a global survey. *J Antimicrob Chemother* 2021; **76**: 3045–58. https://doi.org/10.1093/jac/dkab300

35 Broom A, Kenny K, Prainsack B *et al*. Antimicrobial resistance as a problem of values? Views from three continents. *Crit Public Health* 2021; **31**: 451–63. https://doi.org/10.1080/09581596.2020.1725444

36 Charitonos K, Littlejohn A. Professional learning in healthcare settings in resource-limited environments: what are the tensions for professionals' knowing and learning about antimicrobial resistance? *Stud Contin Educ* 2021; 1–18. Online ahead of print. https://doi.org/10.1080/0158037X.2021.1883577

37 WHO. *Antimicrobial Stewardship Programmes in Health-Care Facilities in Low-and Middle-Income Countries: a WHO Practical Toolkit*. WHO, 2019.

38 Apisarnthanarak A, Kwa AL-H, Chiu C-H *et al*. Antimicrobial stewardship for acute-care hospitals: an Asian perspective. *Infect Control Hosp* 2018; **39**: 1237–45. https://doi.org/10.1017/ice.2018.188

39 Antimicrobial Resistance and Stewardship e-Learning Repository. JAC-AMR and BSAC, 2021. https://bsac-jac-amr.com/jac-amr-resources/.

40 Center for Infectious Disease Research and Policy (CIDRAP). Antimicrobial Stewardship Project. https://www.cidrap.umn.edu/asp.

41 ID Stewardship. Promoting Clinical Pharmacy and Antimicrobial Stewardship. https://www.idstewardship.com/.

42 Hurst AL, Child J, Pearce K *et al*. Handshake stewardship. *Pediatr Infect Dis J* 2016; **35**: 1104–10. https://doi.org/10.1097/INF.0000000000001245

43 Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. *BMJ Glob Health* 2019; **4**: e002104. https://doi.org/10.1136/bmjgh-2019-002104