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Hospital-based antimicrobial stewardship in Denmark, Greenland and the Faroe Islands — current landscape and barriers

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SUMMARY

Objectives: To describe the current organization and implementation of formalized, multi-disciplinary hospital-based antimicrobial stewardship (AMS) structures in Denmark, the Faroe Islands and Greenland.

Methods: A structured electronic questionnaire was sent to all trainees and specialists in clinical microbiology (N=207) and infectious diseases (N=260), as well as clinical pharmacists (N=20) and paediatricians (N=10) with expertise in infectious diseases. The survey had 30 multiple-choice, rating-scale, and open-ended questions based on an international consensus checklist for hospital AMS, adapted to a Danish context.

Results: Overall, 145 individual responses representing 20 hospitals were received. Nine hospitals (45%) reported a formal AMS strategy, eight (40%) a formal organizational multi-disciplinary structure and a multi-disciplinary AMS team, and six (30%) a designated professional as a leader of the AMS team. A majority of hospitals reported access to updated guidelines (80%) and regularly monitored and reported the quantity of antibiotics prescribed (70% and 65%, respectively). Only one hospital (5%) reported a dedicated, sustainable and sufficient AMS budget, three hospitals (15%) audited courses of therapy for

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specific agents/clinical conditions and four hospitals (20%) had a document clearly defining roles, procedures of collaboration and responsibilities for AMS. A total of 42% of all individual respondents had received formal AMS training. Main barriers were a lack of financial resources (52%), a lack of mandate from the hospital management (30%) and AMS not being a priority (18%).

Conclusions: Core elements important for multi-disciplinary hospital-based AMS can be strengthened in Danish hospitals. Funding, clear mandates, prioritization from the hospital management and the implementation of multi-disciplinary AMS structures may help close the identified gaps.

Introduction

Antimicrobial resistance is among the most critical global health threats [1]. Antimicrobial stewardship programmes (ASPs) at all hospitals worldwide are one of five essential global collective actions to address the threat, according to the World Health Organization [2]. Antimicrobial stewardship (AMS) can be defined as "a coherent set of actions which promote using antimicrobials in ways that ensure sustainable access to effective therapy for all who need them" [3]. In 2017, the European Commission published the European guidelines for the prudent use of antimicrobials in human medicine, emphasizing the importance of establishing ASPs in all healthcare facilities [4].

The situation of antimicrobial resistance is very heterogeneous across Europe [5]. Accordingly, the implementation of ASPs differs widely [6]. A recent survey found that only 32% (12/38) of European countries had both guidance and national requirements regarding ASP, and only 18.4% (7/38) had national staffing standards for AMS hospital-based activities [6]. A recent prevalence study by the European Centre for Disease Prevention and Control (ECDC) showed that the availability of an 'antimicrobial stewardship consultant' in European hospitals, measured in full-time equivalents, ranges from 0 (16 of 32 participating EU countries) to 0.5 per 250 beds [7].

In 1995, Denmark was the first country to establish a systematic and continuous monitoring programme of antimicrobial drug consumption and antimicrobial resistance in animals, food, and humans (the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP)) and antimicrobial resistance remains relatively low in Denmark compared with other European countries [8,9]. Formalized ASPs according to European standards, bringing together clinical microbiologists, hospital pharmacists, and infectious disease specialists are not established in most hospitals [6].

Several initiatives have recently defined core elements essential for successful ASPs [10,11]. The most comprehensive approach has been taken by a global group of 15 experts (infectious diseases, clinical microbiology and pharmacists), who conducted a literature review in combination with a Delphi consensus process to create a list of seven core elements and 29 related checklist items [10]. The core elements are senior hospital management leadership towards AMS, accountability and responsibilities, available expertise on infection management, education and practical training, other actions aiming at responsible antibiotic use, monitoring and surveillance, reporting and feedback. Our hypothesis is that the AMS core elements are only partially implemented in Danish Hospitals.

To describe the current organization and implementation of hospital AMS in the Danish Realm (Denmark, Faroe Islands and Greenland), we surveyed physicians and pharmacists in departments of infectious diseases, clinical microbiology and paediatrics in Denmark.

Methods

The questionnaire (Supplementary data) was designed by a group of Danish infectious diseases physicians, clinical microbiologists, paediatricians and pharmacists with expertise in AMS. It was designed according to the consensus checklist mentioned above, published by Pulcini *et al.*, and adapted to a Danish context [10]. Four questions captured basic and demographic information. Eighteen main questions across six domains were included to assess the existing AMS infrastructure. Eight questions assessed individual attitudes towards AMS training, access to guidelines, and current barriers to implementing a formalized, multi-disciplinary ASP. Question types were multiple-choice, rating-scale, and open-ended.

Data collection

Specialists and trainees in infectious diseases (200 specialists and 60 trainees) and clinical microbiology (177 specialists and 30 trainees) in the Danish Realm (Denmark, the Faroe Islands and Greenland) were eligible to participate. The questionnaire was distributed between 10th March and 26th May 2023 to the eligible population with the help of networks of the Danish Society of Infectious Diseases (DSI) and the Danish Society of Clinical Microbiology (DSKM). In addition, the survey was sent to 20 clinical pharmacists with expertise in infectious diseases and 10 paediatricians with subspecialty or clinical experience in paediatric infectious diseases. These clinical pharmacists and paediatricians were selected and approached through personal networks.

Our goal was to include a minimum of 100 participants, covering at least 70% of all hospitals with Departments of Infectious Diseases and/or Internal Medicine (Denmark N=23, Faroe Islands N=1, Greenland N=1) and all departments of clinical microbiology, which are all located in Denmark (N=9). There was no upper limit for the number of respondents per department. The purpose of the survey was clearly stated, and participation was voluntary without financial compensation. Respondents were asked to respond as representative as possible for their specific hospital's situation, if necessary, by inviting other colleagues to help answer specific questions if in doubt. The survey was web-based using REDCap [12].

Definitions

AMS and ASP were defined *a priori* according to the following definitions and shared with the respondents before filling in the questionnaire. AMS: a coherent set of actions which promote using antimicrobials in ways that ensure sustainable access to effective therapy for all who need them. ASP: an organizational or system-wide healthcare strategy to promote appropriate use of antimicrobials through the implementation of evidence-based interventions.

Data analysis

The data were analysed in two ways. First, to describe the existing AMS hospital structures, we identified the most senior respondent represented from each department (clinical microbiology, infectious diseases and clinical pharmacology). The most comprehensive response (fewest 'don't know' or blank responses) was selected in case of a tie. These responses were defined to represent the existing structures at the respective hospital. If several departments from the same hospital responded with diverging answers to the same question, the response for the hospital was recorded as disputed/unknown. Second, we analysed responses to questions regarding AMS training, access to guidelines, and current barriers to implementing a formalized, multi-disciplinary AMS programme individually (including all survey responses without restrictions).

Ethical considerations

This was a descriptive study that did not involve patient data. Therefore, no ethical approval was required. Online questionnaires were archived on a secured online REDCap-based system provided by the University of Southern Denmark (RedCAP Open). The project was registered with the Danish Data Protection Authorities.

Results

A total of 145 participants responded to the questionnaire. The majority of Danish somatic hospitals (N=18/23) and the main hospitals in the Faroe Islands and Greenland were represented among the respondents (Table I, Figure 1).

Existing AMS structures in the Danish Realm

Figure 2 displays the existing AMS structure at Danish hospitals according to 18 questions within six domains. Most hospitals reported that they had access to updated guidelines (80%), that they regularly monitored and reported the quantity of antibiotics prescribed (70% and 65%, respectively), that they monitored and reported the prevalence of a range of key (potentially multi-resistant) bacteria (60%) and had a written policy that required prescribers to document an antimicrobial plan (50%, N=10/20). Only one hospital reported a dedicated, sustainable, and sufficient AMS budget, three hospitals (15%) reported audit courses of therapy for specific agents/clinical conditions, and four hospitals (20%) reported a document clearly defining roles, procedures of collaboration and responsibilities for AMS at the hospital level.

Table I
Demographic information of respondents

		N, (%) of total (N=145)
Region	Capital Region	42 (29.0%)
	Region of Southern Denmark	35 (24.3%)
	Region of Central Denmark	34 (23.4%)
	Region of Northern Denmark	18 (12.3%)
	Region Zealand	14 (9.6%)
	Faroe Islands	1 (0.7%)
	Greenland	1 (0.7%)
Specialty	Infectious diseases	74 (51.0%)
	Clinical microbiology	49 (33.8%)
	Clinical pharmacists	17 (11.7%)
	Paediatrician	5 (3.5%)
Seniority	Head of department	22 (15.2%)
	Senior consultant	42 (29.0%)
	Consultant	36 (24.7%)
	Specialist registrar	24 (16.6%)
	Clinical pharmacist	17 (11.7%)
	(Primarily) researcher	4 (2.8%)

Table II shows the cumulated responses of the most senior representative from each department (clinical microbiology, infectious diseases, clinical pharmacology at a hospital stratified by hospital (if unknown or diverging response, indicated as disputed).

Of the nine hospitals (45%, N=9/20) that reported having a formal/written AMS strategy, two referred to policy documents at a national level, three to the regional level, three to the hospital level, and five to the department level (multiple responses possible). Among the eight hospitals (40%, N=8/20) with a formal organizational multi-disciplinary structure responsible for AMS, three hospitals referred to the regional antibiotic committee, two to the hospital pharmaceutical committee, and only five hospitals reported that a hospital antibiotic committee was responsible for AMS (multiple responses). Six hospitals reported to have a designated professional as an AMS leader: two clinical microbiology physicians and four infectious disease physicians.

Among the eight hospitals that reported a multi-disciplinary AMS team, four had teams consisting of infectious diseases physicians, clinical microbiologists, clinical pharmacists and nurses; two had teams comprising infectious diseases physicians, clinical microbiologists and pharmacists, whereas two teams consisted of clinical microbiologists in combination with internal medicine specialists, intensive care physicians, paediatricians, haematologists and/or surgeons. In addition, one hospital named IT-specialists as members of the AMS team.

Three of the eight hospitals with a formalized, multi-disciplinary AMS team had regular infection and antimicrobial prescribing focused ward rounds conducted by the team. These rounds were conducted by the AMS team in the following departments: orthopaedic surgery (N=3), general internal medicine (N=3), paediatrics (N=3), infectious diseases (N=2), oncology (N=1) and haematology (N=1).

Half of these hospitals reported that they monitored compliance with one or more of the specific interventions put in place by the AMS team (e.g., indication captured in the medical record for all antimicrobial prescriptions).

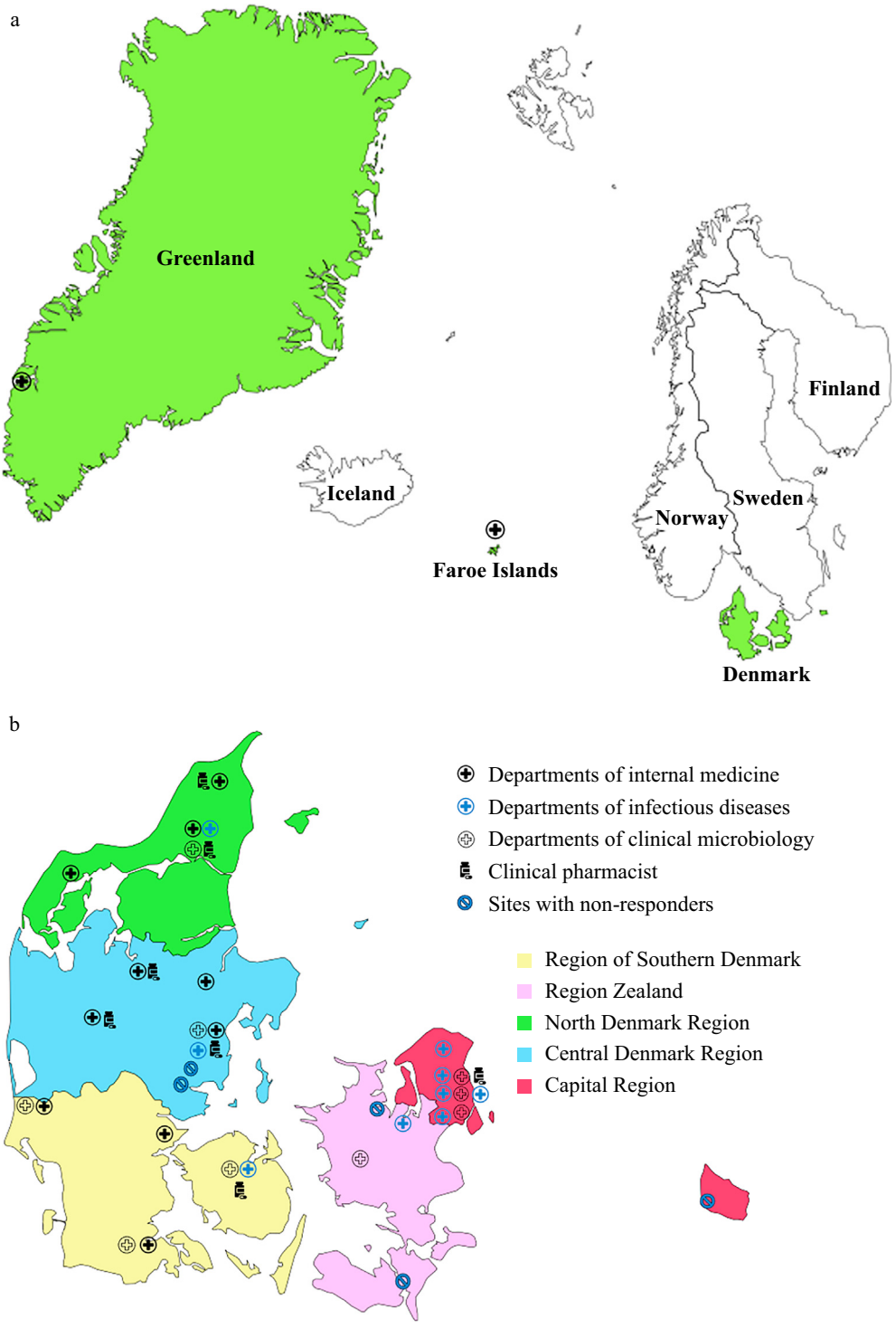

Figure 1. Geographic distribution of departments/hospitals represented in the survey. (a) Antimicrobial stewardship at somatic hospitals in Denmark, the Faroe Islands and Greenland (green). (b) Denmark with geographical distribution of Clinical Pharmacists, Departments of Clinical Microbiology and Internal Medicine/Infectious Diseases.

Twelve hospitals indicated that they monitored a range of key (potentially multi-resistant) bacteria in clinical isolates (e.g., ESKAPEE group). Ten (83.3%) monitored *Pseudomonas aeruginosa*, nine (75.0%) *Staphylococcus aureus*, *Escherichia coli*, *Enterococcus faecium*, *Enterococcus faecalis*, *Acinetobacter* spp. and *Klebsiella pneumoniae*, seven (58.3%) *Streptococcus pneumoniae* and *Candida* spp. Furthermore, all departments of clinical microbiology in Denmark monitor and report specific bacteria to the national AMR surveillance at Statens Serum Institut (carbapenemase-producing

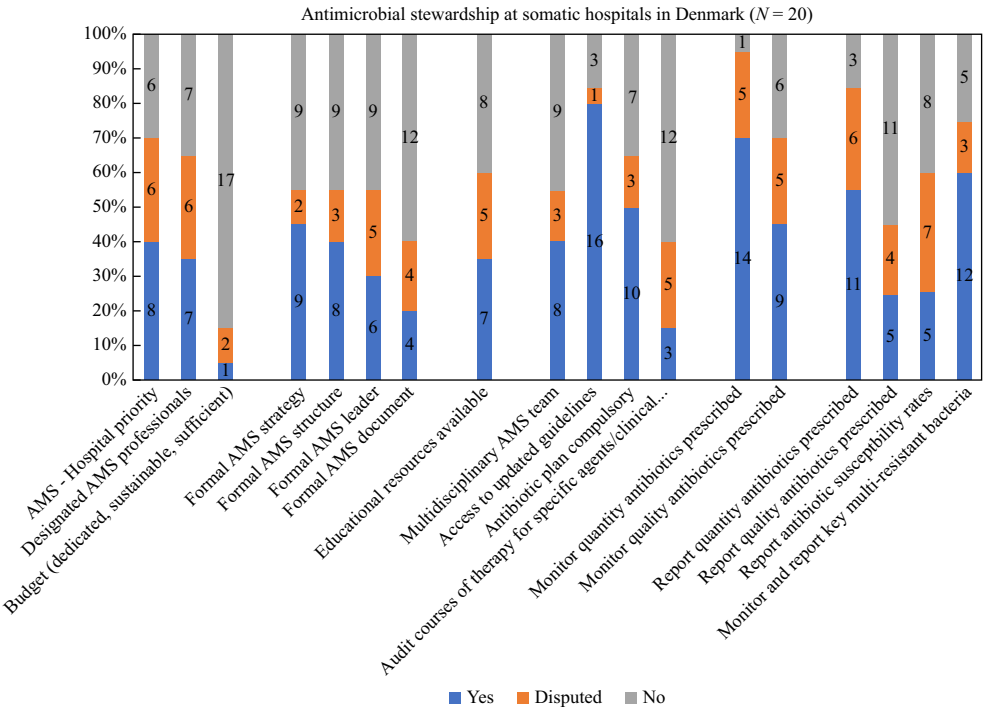

Figure 2. Antimicrobial stewardship (AMS) at somatic hospitals in Denmark, the Faroe Islands and Greenland, responses of most senior representative cumulated across all departments (if unknown or diverging response indicated as disputed).

organisms (CPO), meticillin-resistant *S. aureus* (MRSA), vancomycin-resistant enterococci (VRE), extended-spectrum beta-lactamase (ESBL)-producing organisms.

Differences in self-reported AMS structures by specialty

Figure 3 illustrates AMS at somatic hospitals in Denmark, the Faroe Islands and Greenland, using the same 18 questions from Figure 2 but stratified by department type (if unknown, marked in orange). The responses from departments of clinical microbiology generally showed a more comprehensive perception of the existing AMS structures compared with clinical pharmacists and infectious diseases physicians.

Attitudes among clinical microbiologists, infectious diseases physicians and clinical pharmacists towards AMS

Of the respondents, 42.1% (*N*=61/145) had received formal AMS training. The proportion was highest among clinical microbiologists (87.8%, *N*=43/49), followed by paediatricians (40.0%, *N*=2/5), infectious diseases physicians (20.3%, *N*=15/75) and clinical pharmacists (5.9%, *N*=1/17). Examples of formalized AMS training were self-reported as provided internally through either the department of clinical microbiology, infectious diseases, or clinical pharmacy (*N*=25), through e-learning or other external resources (*N*=8), post-graduate training (e.g., ESCMID AMS certificate *N*=5), through clinical microbiology specialty training (*N*=3) or infectious diseases specialty training (*N*=1).

Of all respondents, 82.1% (*N*=119/145) said they had access to up-to-date and evidence-based recommendations for infection management (diagnosis, prevention and treatment). The majority of antimicrobial treatment guidelines used by the respondents were regional guidelines (68.0%, *N*=99/145), followed by hospital guidelines (53.8%, *N*=78/145), department guidelines (49.7%, *N*=72/145) and national guidelines (42.8%, *N*=62/145). When asked whether local guidelines on antimicrobial treatment were sufficient, 75.2% (*N*=109/145) responded fully or almost fully sufficient (four or five out of five on a ranking scale). 57.2% (*N*=83/145) of the respondents said that AMS was an important or the main focus area of their department (four or five out of five on a ranking scale). That proportion was higher among clinical microbiologists (85.7%, *N*=42/49) than infectious diseases physicians (41.9%, *N*=31/74).

Table III shows barriers to implementing a multidisciplinary, hospital-based ASP at the respective hospital. The most common responses were lack of financial resources and a lack of mandate from the hospital management. In the Faroe Islands, a reported barrier was the lack of clinical microbiologists, and in Greenland, the topic has not been officially discussed.

Discussion

This is the first comprehensive description of hospital-based AMS structures in Denmark, the Faroe Islands and Greenland.

Our results show that all responding hospitals in the Danish Realm have some of the core AMS elements assessed in our survey. However, no hospital reported having them all, and very few reported having a majority. In particular, core elements from the domains 'senior leadership' and 'accountability and responsibilities' are often absent in Danish hospitals. These include making AMS a hospital priority,

Table II
Responses of the most senior representatives from each department per hospital (if unknown or diverging response indicated as disputed)

				Senior leadership			Accountability and responsibilities				Education	Other actions				Monitoring and surveillance		Reporting and feedback			
Hospital	Hospital level (*N*, beds)	Total domains present (unknown/ disputed)	Departments	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
Capital Region																					
Amager-Hvidovre Hospital	U (615)	7 (9)	CM, ID	X	X	—	X	X	(X)	(X)	(X)	(X)	X	—	(X)	(X)	(X)	X	(X)	(X)	X
Bispebjerg-Frederiksberg Hospital	R (446)	2 (6)	ID	—	—	—	—	—	(X)	—	X	—	X	—	—	(X)	(X)	(X)	—	(X)	(X)
Herlev-Gentofte Hospital	R (839)	13 (4)	CM, ID	X	X	—	X	X	X	X	(X)	X	X	X	(X)	X	(X)	X	(X)	X	X
North Zealand Hospital — Hillerød	R (577)	12 (2)	ID	X	X	—	X	X	X	X	—	X	X	X	(X)	X	X	—	X	—	(X)
Rigshospitalet	U (1172)	2 (10)	CM, ID, Ph	(X)	(X)	—	X	—	—	—	—	(X)	(X)	(X)	—	(X)	(X)	(X)	(X)	(X)	X
Region Zealand																					
Zealand University Hospital	U (626)	4	ID	—	—	—	—	—	—	—	X	—	X	—	—	X	—	—	—	—	X
Næstved, Slagelse and Ringsted Hospital [a]	R (377)	16	CM	X	X	—	X	X	X	X	X	X	X	X	X	X	X	X	X	—	X
Region of Southern Denmark																					
Odense University Hospital	U (843)	13 (4)	CM, ID, Ph	(X)	X	—	X	X	(X)	(X)	X	X	X	X	(X)	X	X	X	X	X	X
Lillebælt Hospital — Kolding	R (308)	3 (1)	IM	(X)	—	—	—	—	—	—	—	—	—	—	—	X	—	X	—	X	—
Hospital of South West Jutland — Aabenraa	R (310)	6 (1)	CM	—	—	—	—	—	—	—	X	—	(X)	X	—	X	X	X	—	—	X
Hospital South West Jutland — Esbjerg	R (340)	5 (1)	CM, IM	(X)	—	—	—	—	—	—	X	—	X	—	—	X	—	X	—	—	X
Central Denmark Region																					
Aarhus University Hospital	U (830)	6 (8)	CM, ID, Ph	(X)	(X)	—	(X)	X	—	(X)	(X)	X	X	X	(X)	X	—	(X)	—	(X)	X
Hospital System Midt — Viborg	R (478)	2 (10)	IM, Ph	X	—	—	—	(X)	(X)	—	—	(X)	(X)	(X)	X	(X)	(X)	(X)	(X)	(X)	—
Hospital System Vest — Gødstrup	R (370)	6 (7)	IM, Ph	(X)	(X)	—	(X)	(X)	—	(X)	(X)	X	X	X	—	X	X	X	—	—	(X)
Regional Hospital — Randers	R (209)	11 (2)	IM, Ph	X	—	—	—	X	X	X	X	X	X	X	X	X	X	(X)	—	(X)	—
North Denmark Region																					
Aalborg University Hospital — Aalborg	U (680)	7 (5)	CM, ID, Ph	X	X	—	X	(X)	X	—	(X)	—	X	(X)	—	X	X	(X)	—	(X)	—
Aalborg University Hospital — Thisted	R (65)	3 (1)	IM	—	—	—	—	—	—	—	—	—	X	—	—	X	—	—	—	(X)	X
Regional Hospital Nordjylland — Hjørring	R (223)	8 (1)	IM, Ph	X	—	(X)	—	—	X	—	X	—	X	X	—	X	—	X	—	—	X
Greenland																					
Dronning Ingrids Hospital — Nuuk	R (130)	11 (2)	IM	—	X	X	X	X	(X)	—	—	X	X	X	—	(X)	X	X	X	X	X
Faroe Islands																					
Landssygehus — Torshavn	R (160)	5 (2)	IM	—	(X)	(X)	—	—	—	—	—	—	X	—	—	—	X	X	X	X	—

Q1—Q18: Questions 1 to 18 in the questionnaire (see list below). CM, Clinical Microbiology; ID, Infectious Diseases; IM, Internal Medicine; Ph, Clinical Pharmacist; R, Regional Hospital; U, University Hospital; X, yes; (X), unknown or disputed; —, no. No responses were received from the regional hospitals Bornholm Hospital, Holbæk Hospital, Nykøbing Hospital, Horsens Hospital and Vejle Hospital.

18 main questions (Q1—Q18) by domains (response options: yes, no, don't know):

Senior hospital management leadership towards antimicrobial stewardship

1. Has your hospital management formally identified antimicrobial stewardship as a priority objective for the hospital and included it in its strategic plan?
2. Does your hospital employ any designated antimicrobial stewardship professionals?
3. Is there dedicated budgeted financial support for antimicrobial stewardship activities at your department (e.g., support for salary, training, or information technology support)?

Accountability and responsibilities

4. Does your hospital have a formal/written antimicrobial stewardship programme/strategy accountable for ensuring appropriate antimicrobial use?
5. Does your hospital have a formal organizational multi-disciplinary structure responsible for antimicrobial stewardship (i.e., explicitly in charge of setting and coordinating the antimicrobial stewardship programme/strategy in its mandate/terms of reference)?
6. Is there a healthcare professional identified as a leader for antimicrobial stewardship activities at your hospital and responsible for implementing the programme?
7. Is there a document clearly defining roles, procedures of collaboration and responsibilities for antimicrobial stewardship at the hospital level (e.g., between hospital administration, antibiotic stewardship team, individual departments)?
Education and practical training
8. Does your hospital offer educational resources to support staff training on how to optimize antimicrobial prescribing (locally or not)?
Other actions aiming at responsible antimicrobial use
9. Is a formalized, multi-disciplinary antimicrobial stewardship team available at your hospital?
10. Does your hospital have available and up-to-date recommendations for infection management (diagnosis, prevention and treatment), based on international/national evidence-based guidelines and local susceptibility (when possible), to assist with antimicrobial selection (indication, agent, dose, route, duration) for common clinical conditions?
11. Does your hospital have a written policy that requires/recommends prescribers to document an antimicrobial plan (includes indication, name, dosage, duration, route and interval of administration) in the medical record or during order entry for all antimicrobial prescriptions?.
12. Does an antimicrobial stewardship team (or individual specialties: clinical microbiology, infectious diseases, clinical pharmacists) review/audit courses of therapy for specified antimicrobial agents or clinical conditions at your hospital?
Monitoring and surveillance (on a continuous basis)
13. Does your hospital monitor the quantity of antimicrobials prescribed/dispensed/purchased at the unit- and/or hospital-wide level?
14. Does your hospital regularly monitor the quality of antimicrobial use at the unit- and/or hospital-wide level (e.g., point prevalence survey)?
Reporting and feedback (on a continuous basis)
15. Does your hospital (e.g., stewardship programme) share hospital-specific reports on the quantity of antimicrobials prescribed/dispensed/purchased with prescribers?
16. Are results of audits/reviews of the quality/appropriateness of antimicrobial use communicated directly with prescribers?
17. Does your hospital (e.g., stewardship programme) share department-specific reports on antibiotic susceptibility rates with prescribers?
18. Does your hospital monitor and report the prevalence of a range of key multi-resistant bacteria?
[a] All hospitals in Region Zealand are serviced by the Department of Clinical Microbiology at Slagelse Hospital.

designating AMS officials, providing a dedicated and sustainable budget, formalizing an AMS strategy with a clear multidisciplinary structure, and designating leaders with roles, collaboration procedures, and responsibilities clearly defined in a formal document. Addressing these shortcomings may improve Danish hospital-based AMS programmes and is well in line with the reported barriers of lack of financial resources, a mandate, and prioritization from hospital management.

Our results can be considered representative of the Danish Realm. To the best of our knowledge, there are no similar country-wide assessments of the implementation of AMS structures, precluding a more detailed comparison with other countries. Rates of resistance and consumption of broad-spectrum antibiotics continue to be low compared with many other European countries, although it has begun to increase over the past years [8,9]. Hence, despite the low degree of implementation of multi-disciplinary AMS, 'background' and structural AMS have historically been performed by clinical microbiology (intrinsically related to susceptibility testing, reporting and surveillance), contributing to the current low-resistance rates. This could indicate that Pulcini's domains might not be fully applicable to all healthcare contexts or countries.

Interestingly, infectious diseases physicians, clinical microbiologists and clinical pharmacists perceived existing AMS structures differently, with infectious diseases physicians describing the existing AMS structures as less present than their colleagues from clinical microbiology and partly clinical pharmacy. This may partly be explained by clinical microbiologists' prominent role in AMS in Denmark in the previous decades. Furthermore, departments of clinical microbiology are centralized and mainly located at the largest hospitals. Hospitals without a department of clinical microbiology are usually offered a more limited, telephone- and conference-based service but microbiologists are not continuously present. Therefore, they are likely to preferentially report the circumstances at the largest, better-staffed hospitals. In addition, it cannot be ruled out that specific terms (e.g., AMS-focused ward rounds) could be interpreted differently by the different specialties.

Our study has some limitations. First, the captured information is self-reported, which is prone to reporting bias, with a possible overestimation of existing structures. In addition, definitions of some of the (English) terms used in the questionnaire could be understood differently by respondents. AMS and ASP, however, were defined at the beginning of the questionnaire. Second, some of the questions from the international AMS consensus checklist by Pulcini *et al.* [10] might have been insufficiently adapted to the Danish context, where clinical microbiologists traditionally have had a more prominent role in AMS compared with other (European) countries. This might underestimate or miss some of the existing AMS infrastructure, in particular parts led by clinical microbiologists, if not covered adequately by the questionnaire. Third, there are only 16 paediatricians with sub-specialization in infectious diseases in Denmark, of which 10 are located in the capital region. Only a small number of paediatricians could be included, precluding a generalizability of our results to the paediatric population. As we only received one response from the Faroe Islands and Greenland, respectively, they were merged with responses from Denmark in the analyses. This is, however, in line with clinical practice as guidelines and

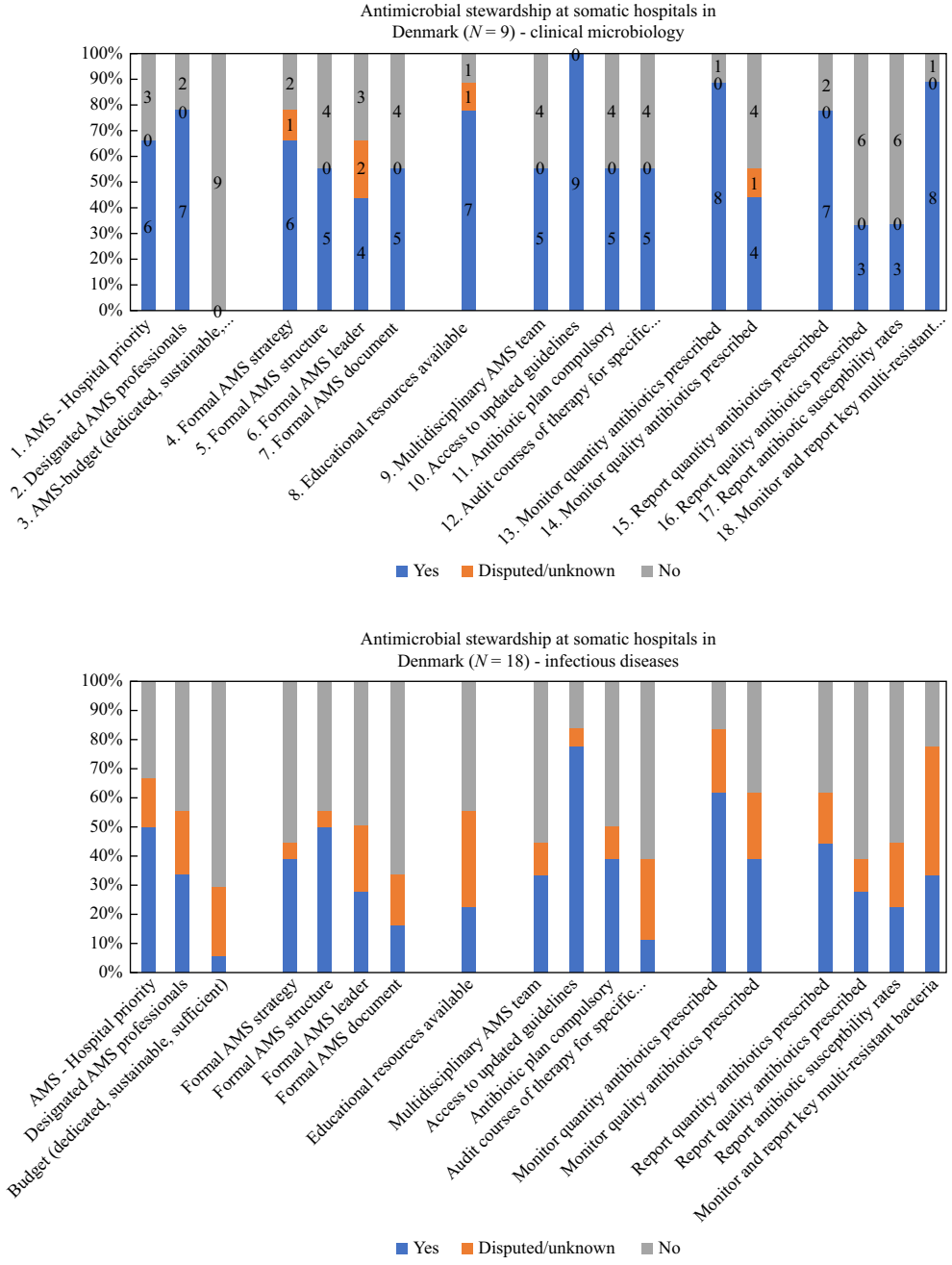

Figure 3. Antimicrobial stewardship (AMS) at somatic hospitals in Denmark, the Faroe Islands and Greenland, responses of most senior representative by department type (if unknown or diverging response indicated as disputed). Departments of Clinical Microbiology: Amager-Hvidovre Hospital; Herlev-Gentofte Hospital; Rigshospitalet; Næstved, Slagelse and Ringsted Hospital; Odense University Hospital; Hospital of South West Jutland — Aabenraa; Hospital of South West Jutland — Esbjerg; Aarhus University Hospital; Aalborg University Hospital — Aalborg. Departments of Infectious Diseases: Amager-Hvidovre Hospital; Bispebjerg-Frederiksberg Hospital; Herlev-Gentofte Hospital; North Zealand Hospital — Hillerød; Rigshospitalet; Zealand University Hospital; Odense University Hospital; Lillebælt Hospital — Kolding; Hospital of South West Jutland — Esbjerg; Aarhus University Hospital; Hospital System Midt — Viborg; Hospital System Vest — Gødstrup; Randers Regional Hospital — Randers; Aalborg University Hospital — Aalborg; Aalborg University Hospital — Thisted; Regional Hospital Nordjylland — Hjørring; Dronning Ingrids Hospital — Nuuk; Landssygehus — Torshavn. Clinical Pharmacists: Rigshospitalet; Odense University Hospital; Aarhus University Hospital; Hospital System Midt — Viborg; Hospital System Vest — Gødstrup; Regional Hospital — Randers; Aalborg University Hospital — Aalborg; Regional Hospital Nordjylland — Hjørring.

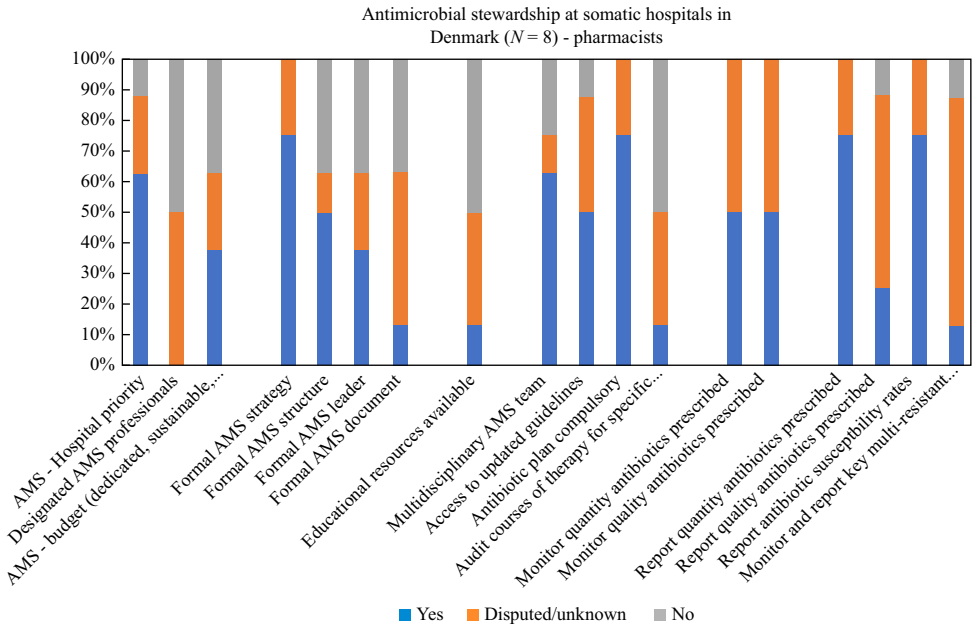

Figure 3. *(continued).*

Table III
Barriers to implementing a formalized, multi-disciplinary antimicrobial stewardship (AMS) team at the hospital, individual responses

	Overall (*N*=145)	Infectious diseases (*N*=74)	Clinical microbiology (*N*=49)
Lack of financial resources	76 (52.4%)	47 (63.5%)	17 (34.7%)
Lack of mandate from the hospital management	44 (30.3%)	28 (37.8%)	9 (18.4%)
AMS not being a priority	26 (17.9%)	18 (24.3%)	3 (6.1%)
Lack of knowledge on how to set up an ASP	22 (15.2%)	15 (20.2%)	1 (2.0%)
Lack of interest from other departments	18 (12.4%)	15 (20.2%)	0
Lack of qualified specialists	17 (11.7%)	14 (18.9%)	0
Lack of interest at their department	18 (12.4%)	7 (9.5%)	0
No perceived need	3 (2.1%)	1 (1.4%)	0
No barriers and/or already implemented by Department of Clinical Microbiology	24 (16.6%)	0	0

ASP, antimicrobial stewardship programme.

organization of healthcare for infectious diseases and clinical microbiology are similar.

The manuscript also has strengths. The questionnaire was based on an international consensus checklist and further adapted by an author group, including infectious disease physicians, pharmacists, paediatric infectious disease specialists and clinical microbiologists with representatives from all regions and major hospitals in the Danish Realm. By distribution through the main professional societies in infectious diseases and clinical microbiology, and personal networks of the authors, virtually all eligible for the survey were contacted. Indeed, all tertiary hospitals and the majority of somatic hospitals in Denmark are represented.

In conclusion, core elements, internationally regarded as an essential foundation of hospital-based AMS are to some extent missing in Danish Hospitals. Our results indicate that formalized, multi-disciplinary hospital-based AMS may be strengthened. Better funding, clear mandates and prioritization from the hospital management and implementation of multi-disciplinary AMS structures could help address the identified gaps. A concerted national strategy with clear goals covering the above-mentioned domains and involving all regions and hospitals could be a potential policy measure to support the implementation and improvement of hospital-based multi-disciplinary AMS structures.

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Author contributions

C.K., K.H., M.H., I.J., T.H., S.D., J.H., M.H., F.R. and I.J. conceived of and designed the study. C.K. and I.J. analysed and interpreted the data. C.K. drafted the manuscript. All authors critically revised the manuscript. All authors contributed to data collection. All authors made a significant contribution in reviewing the manuscript drafting or revision

and accept accountability for the overall work. All authors approved the final version of the report.

Conflict of interest statement

I.J. reports a personal honorary from Pfizer for being chairman for the ECCMID 2023 COVID 19 symposium. All other authors report no potential conflicts of interest in relation to the presented work.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2024.01.018.

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