



A nationwide survey on involvement of clinical microbiologists in antibiotic stewardship programmes in large French hospitals

Marion Le Maréchal¹ · Nelly Agrinier^{2,3} · Vincent Cattoir^{4,5} · Céline Pulcini^{2,6} · on behalf of the ABS-CM working group

Received: 7 May 2019 / Accepted: 29 July 2019 / Published online: 8 August 2019
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

Abstract

Antibiotic stewardship programmes (ASP) are essential to tackle antibiotic resistance. Clinical microbiologists (CMs) play a key role in these programmes; however, few studies describe their actual involvement. Our objective was to explore CMs' involvement in French hospital ASP. In 2018, we conducted a survey among CMs working in large public French hospitals (600 acute care beds or more). The questionnaire focused on the following topics: microbiology department's characteristics, hospital ASP, and CMs' involvement in this programme, including their use of rapid diagnostic tests (RDT). Fifty/74 CMs answered (response rate 68%), with 68% working in a teaching hospital. CMs were leading the ASP in 6% of cases, and 57% of hospitals had a multidisciplinary antibiotic stewardship team. Most microbiology departments (92%) were using specific PCR, processed 24/7 in 74% of hospitals. More than half (58%) were using syndromic panel-based testing, 94% mass spectrometry, and 96% immunochromatographic/colorimetric RDT. Blood cultures were processed 24/7 in 44% of hospitals. CMs were involved in this. Finally, 42% of CMs wished to be more involved in their hospital's ASP, the most frequently reported barrier being lack of time (36%). CMs should be more involved in ASP. RDT are widely used, but not implemented in an optimal way.

Keywords Antimicrobial stewardship · Microbiologist · Rapid diagnostic test

Introduction

Hospital-based antibiotic stewardship (ABS) teams should be multidisciplinary, and it is often recommended that they

include at least an infectious diseases (ID) physician, a clinical pharmacist and a clinical microbiologist (CM), even though their composition can be quite flexible [1–3]. CMs indeed play a key role within hospital ABS programmes [4, 5]. Rapid diagnostic tests (RDTs), such as PCR or MALDI-TOF mass spectrometry, have in the last years considerably decreased the turnaround time for bacterial identification and antibiotic susceptibility results [6], and therefore, the time for selecting targeted antibiotic therapy [7]. Introduction of those new technologies represents a significant cost for the institution, and its benefit on patients' outcomes is greater if ABS teams facilitate the use of these RDTs [6–9]. With the recent development of so many RDTs, CMs' contribution to ABS programmes is even more important to help clinicians and ABS teams use these tests and interpret their results appropriately.

Surprisingly, there are very few data in the literature exploring to what extent and how CMs participate in hospital ABS programmes, and CMs' involvement is extremely variable between countries [10, 11]. Our objective was thus to explore CMs' involvement in ABS programmes in large public French hospitals, including a focus on their use of RDTs, using a cross-sectional questionnaire survey.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10096-019-03665-1>) contains supplementary material, which is available to authorized users.

✉ Marion Le Maréchal
marionlemarechal@gmail.com

- ¹ Département de Santé Publique, Hôpital l'Archet, CHU de Nice, 151 Route de Saint Antoine, 06200 Nice, France
- ² Université de Lorraine, EA 4360 APEMAC, Nancy, France
- ³ Université de Lorraine, CHRU-Nancy, INSERM, CIC-1433, Epidémiologie Clinique, 54000 Nancy, France
- ⁴ CHU de Rennes, Service de Bactériologie-Hygiène hospitalière & CNR de la Résistance aux Antibiotiques (laboratoire associé 'Entérocoques'), Rennes, France
- ⁵ Faculté de Médecine & Unité Inserm U1230, Université de Rennes 1, Rennes, France
- ⁶ Infectious Diseases Department, Université de Lorraine, CHRU-Nancy, Nancy, France

Methods

Background information regarding AMS programmes and RDTs in France

In France, CMs are either medical doctors or clinical pharmacists; both have the same specialized training in microbiology during their residency. However, there is no specific mandatory training on ABS during their specialty training.

In France, certification standards for hospital make mandatory the presence of an AMS programme leader, but not the presence of a multidisciplinary ABS team [12–14].

There are recommendations from the Antibiogram Committee of the French Society for Microbiology (CA-SFM) regarding antibiotic susceptibility testing and reporting, and the SFM also produces a practical handbook (called REMIC) for CMs. However, there are no specific recommendations on which most recent RDTs to prefer and implement in the hospital setting.

In France, CMs' routine duties are to supervise and validate microbiological results, perform antimicrobial susceptibility testing (AST) of bacterial pathogens, provide rapid diagnosis of common infections and communicate critical results to clinical wards with diagnostic and/or therapeutic counselling. They also perform epidemiological surveillance for resistance and provide cumulative susceptibility reports [4, 5].

Participants

Eligible hospitals were large French public hospitals, i.e. any number of beds when part of the *Assistance Publique-Hôpitaux de Paris*, and ≥ 600 acute care beds otherwise, with an on-site microbiology department. The list and number of beds of all French hospitals were available on the French National Hospital Federation (*Fédération Hospitalière de France*) website [15].

Data collection

One CM per hospital was selected to reply to our survey, on behalf of the whole microbiology department, and received an invitation through email including information about the study and a link to the online survey. In the case of non-response, two reminders were sent. The survey was open from March to June 2018.

Survey tool development

The questionnaire was developed by a multidisciplinary team (CM, ID physician and public health specialist), based on the literature [4, 5, 16]. The 80-item questionnaire (supplementary data 1) was formatted in SurveyMonkey® and pilot tested by three CMs, to check for clarity. It was divided in eight

sections: (a) baseline characteristics of participating hospitals, (b) blood cultures and RDTs, (c) recommendations to clinicians, (d) reporting of AST results, (e) participation to an ABS team, (f) educational activities, (g) organization of the ABS programme, and (h) perceptions of CMs' involvement in the ABS programme. A RDT was defined as a test result provided to clinicians within 3 h after starting being processed in microbiology departments [17].

Ethical statement

In accordance with French laws, this survey did not need any ethical approval. Participation in the survey was voluntary, anonymous and without any financial compensation.

Data analyses

Continuous variables were presented as means (and standard deviations), or as medians (and interquartile ranges) depending on the variables' distribution. Categorical variables were described as absolute numbers and frequencies. R® software (version 3.5.1) was used.

Results

Baseline characteristics of participating hospitals

We identified 74 eligible hospitals in France, while 50 CMs replied to the questionnaire (response rate = 68%). Characteristics of respondents and hospitals are presented in Table 1. Almost all CMs (49/50, 98%) declared that there was an ID specialist working onsite. Fourteen respondents (14/50, 28%) were from the Paris teaching group of hospitals.

Participation in the ABS team

Almost all hospitals had an ABS programme leader (49/50, 98%), mostly an ID physician (43/49, 88%), rarely a CM (3/49, 6%). This leader coordinated an ABS multidisciplinary team in 57% (28/49) of hospitals. CMs were part of the ABS multidisciplinary team in all hospitals (28/28).

Among hospitals with a multidisciplinary team, 36% (10/28) and 46% (13/28) of CMs were in contact with the ABS programme leader every day and several times a week, respectively (single choice question (SCQ), mainly through phone calls (22/28, 79%, multiple choice question (MCQ)) and/or face-to-face meeting (24/28, 86%, MCQ) and/or e-mail (15/28, 54%, MCQ). They interacted for instance to discuss blood cultures' results, complex clinical situations or antibiotic prescriptions. CMs and pharmacists were in contact less than once a week in 39% of cases (11/28, SCQ). They interacted to discuss for instance antibiotic prescriptions, especially

Table 1 Characteristics of microbiology departments and hospitals participating to the survey

	<i>N</i> = (/50)	%
Hospital		
Public teaching hospital	34	68
Public non-teaching hospital	16	32
Acute care hospital beds		
Mean (SD)	1160 (676)	–
Median (IQR)	1000 (700–1440)	–
Total hospital beds		
Mean (SD)	1578 (891)	–
Median (IQR)	1481 (1082–1976)	–
Department is processing samples from		
Its own hospital only	17	34
Several nearby hospitals	32	64
National accreditation process engaged		
Yes	45	90
No	5	10
Number of CMs (FTE) in the department		
Mean (SD)	4.6 (2.9)	–
Median (IQR)	4 (3–5)	–
FTE/1000 acute care hospital beds		
Mean (SD)	4.3 (2.1)	–
Median (IQR)	4.0 (3.1–4.7)	–

CMs clinical microbiologists, *FTE* full-time equivalent, *IQR* interquartile range, *SD* standard deviation

those with restricted use, and consistency between antibiotic prescriptions and microbiological results. There was no interaction between CMs and pharmacists in 18% of the hospitals (5/28, SCQ).

CMs reported that their microbiology department produced annually detailed data on local bacterial epidemiology and that they were involved in the local antibiotic prescription guide (supplementary data 2).

Blood cultures and RDTs

Almost all microbiology departments had implemented specific PCR, MALDI-TOF mass spectrometry and immunochromatographic/colorimetric tests (e.g., detection of MRSA, ESBL-E, CPE), except for syndromic panel-based testing implemented in only 29/50 hospitals (58%). Further details are available in Tables 2 and 3.

Recommendations to clinicians

CMs frequently provided advice to clinicians on antibiotic prescribing and infection management through phone calls (36/50, 72%), and sometimes face-to-face during ward rounds

(19/50, 38%). Table 2 describes the way results of a positive test were communicated to clinicians.

Reporting of AST results

Most microbiology departments (39/50, 78%, MCQ) reported written AST results along with a commentary to guide clinicians with their antibiotic prescribing (Table 4).

Thirty-six percent of departments (18/50, yes/no question (y/n)) used selective reporting of AST results, mainly for urine samples. Seventy-four percent of departments (37/50, y/n) did not report AST for samples that looked like contamination (Table 4).

Perceptions of CMs' involvement in the ABS programme

A majority of CMs (21/50, 42%, y/n) wished they were more involved in the ABS programme in their hospital, mainly for educational activities, giving advice to clinicians, and/or promoting more appropriate use of microbiological tests.

The most frequently reported barriers to their involvement were lack of time ($N=18$), conflict with clinicians ($N=5$), mostly ID specialists.

Discussion

Our survey conducted among CMs working in large public hospitals in France provides original findings describing their involvement in ABS programmes, including their use of RDTs. We found that CMs were indeed actively participating in ABS activities and that RDTs' use was widespread but quite heterogeneous. Finally, we also identified areas for improvement.

Participation in ABS activities and ABS team organization

Our results confirm that CMs participate in a wide range of ABS activities and 42% of the respondents declared they wished to be even more involved in ABS programmes. Specific funding to secure dedicated CM time is, however, needed, as none of the surveyed CMs did receive any funding to compensate for CMs' work and since lack of time was the main reported barrier to increased participation.

Our survey provides some insight regarding the distribution of roles within the ABS team in France. The leader is usually an ID physician, and CMs quite rarely interact with clinicians during ward rounds (38% of the cases). Communication within the ABS team is quite good between CMs and ID physicians, with frequent and close face-to-face as well as phone interactions, whereas interactions are much less frequent and mostly by phone between CMs and

Table 2 Blood cultures and rapid diagnostic tests: implementation at hospital level, communication of positive results to clinicians and educational activities

	Blood cultures	Specific PCR	Syndromic panel-based testing	Mass spectrometry	Immunochromatographic/colorimetric tests
Test implemented in the microbiology department		46 (92.0)	29 (58.0)	47 (94.0)	48 (96.0)
The test is processed	^a				
7/7, 24/24	22 (44.0)	6 (13.0)	4 (13.8)	2 (4.3)	9 (18.8)
Every day, during the day only	18 (36.0)	28 (60.9)	13 (44.8)	40 (85.1)	33 (68.8)
From Mondays to Fridays during the day		8 (17.4)	7 (24.1)		
Positive results are communicated ^c	^b				
To the clinician along with diagnostic and/or therapeutic recommendations	36 (72.0)	33 (71.7)	19 (65.5)	22 (46.8)	28 (58.3)
On their own to the clinician	16 (32.0)	17 (37.0)	10 (34.5)	28 (59.6)	24 (50.0)
To the ABS programme leader/team	13 (26.0)	10 (21.7)	2 (6.9)	8 (17.0)	8 (16.7)
Positive results are communicated through phone calls	40 (80.0)	45 (97.8)	25 (86.2)	21 (44.7)	37 (77.1)
Diagnostic and/or therapeutic recommendations (in case of a positive result) are made by ^c					
Clinical microbiologist	33/40 (82.5)	31/45 (68.9)	17/25 (68.0)	21/21 (100.0)	25/37 (67.6)
ABS programme leader	13/40 (32.5)	9/45 (20.0)	4/25 (16.0)	7/21 (33.3)	8/37 (21.6)
ABS programme team	7/40 (17.5)	6/45 (13.3)	3/25 (12.0)	7/21 (33.3)	4/37 (10.8)
Educational sessions were organized when implementing the test, regarding indication, use, interpretation and limitations ^c					
For clinicians		17 (37.0)	17 (58.6)	8 (17.0)	13 (27.1)
For ABS programme leader		15 (32.6)	11 (37.9)	13 (27.7)	13 (27.1)
For ABS team members		11 (23.9)	8 (27.6)	9 (19.1)	10 (20.8)
No training		16 (34.8)	8 (27.6)	26 (55.3)	26 (54.2)

ABS antibiotic stewardship

^a Blood cultures are registered, loaded in the incubators, and positive samples are processed

^b Blood cultures with a positive Gram staining on direct examination

^c Several answers are possible

pharmacists. Having more frequent and balanced interactions within the full ABS team is, however, desirable, and further investigation on this topic would be useful [18].

Communication of positive results

Positive microbiological results were mainly communicated to clinicians by phone. These positive results were accompanied by diagnostic and/or therapeutic recommendations (made half of the time by a CM) in 72% of cases for blood cultures, which is quite high as compared with the literature [19].

We feel that the communication of a result as important as a positive blood culture should ideally be given, within the French context, by both a CM and a physician with ID clinical expertise, since most French CMs have limited practical training on clinical diagnosis and patient management.

Rapid diagnostic tests

RDTs were widely used in the large public hospitals we surveyed, except for syndromic panel-based testing that were

available in only 58% of the cases. The range of tests was amazingly diverse, and this might reflect the absence of national guidance on this topic. Professional societies, national or international, may have a role to play here, to standardize the use of these RDTs.

Several studies have highlighted the positive impact of having blood cultures processed 24/7 on patients' mortality and length of stay [20]. However, providing a 24/7 service requires time and human resources [21]. In our study, only 44% of blood cultures were processed 24/7.

However, education of clinicians and ABS team members regarding the indication and interpretation of these tests' results was suboptimal. Whereas hospital guidelines describing how to perform these tests were almost always (88%) available, such guidelines explaining when these tests are indicated and how to interpret the results were not always in place (57% and 2% respectively). Moreover, CMs organized educational sessions for clinicians and ABS team members/programme leaders in only one third of the cases when implementing RDTs, to provide training on indication, use, interpretation and limitations of the test.

Table 3 Details of rapid diagnostic tests implemented in microbiology departments

	<i>n/N</i>	%
Specific PCR		
MRSA	31/46	67.4
<i>Clostridium difficile</i>	44/46	95.7
CRE	25/46	54.3
VRE	18/46	39.1
<i>Mycobacterium tuberculosis</i>	16/46	34.8
<i>Neisseria meningitidis</i>	10/46	21.7
Syndromic panel-based PCR testing		
Meningitis	18/29	46.2
Bacteraemia	4/29	13.8
Gastroenteritis	8/29	27.6
Respiratory infection	21/29	72.4
Use of MALDI-TOF mass spectrometry		0.0
For bacterial identification	47/47	100.0
Directly on positive blood cultures	18/47	38.3
For rapid detection of ESBL-E, and CPE on blood cultures	1/47	2.1
For rapid detection of ESBL-E and CPE on urine samples	0/47	0.0

CPE Carbapenemase-producing *Enterobacteriaceae*, *ESBL-E* extended-spectrum β -lactamase-producing *Enterobacteriaceae*, *MRSA* methicillin-resistant *Staphylococcus aureus*, *VRE* vancomycin-resistant enterococci

Reporting of AST results

Most microbiology departments (78%) reported AST results along with a commentary to guide clinicians with their antibiotic prescribing, but again, this was not standardized across hospitals.

Selective reporting of AST results was not common practice, since it was reported by 36% of departments. Previous studies have suggested that selective reporting of AST results may improve the quality of antibiotic prescriptions [22], but this practice is implemented in only 42% of European

countries [23] and is not yet widespread in France despite recent encouragements by the SFM [24].

Strengths and limitations

Our results provide original and robust findings (high response rate of 68%). Our work has, however, some limitations. The total number of surveyed hospitals is relatively small ($n = 50$), since we purposefully focused on large public hospitals, which are expected to have the best capacity in CM and ABS in our country; our results are therefore not

Table 4 Antibiotic susceptibility testing results' reporting strategy

	<i>N</i> = (/50)	%
Microbiology Department reported AST results with a commentary to guide clinicians with their antibiotic prescribing		
No commentary	11	22.0
Inducible MLS_B phenotype: avoid clindamycin as single therapy	27	54.0
Group 3 <i>Enterobacteriaceae</i> ^b : prefer cefepime	17	34.0
Nalidixic acid-resistance: avoid fluoroquinolones	7	14.0
Microbiology Department used selective reporting of AST results ^a		
Yes	18	36.0
No	31	62.0
Microbiology Department does not report AST results for contamination/colonization ^a		
Yes	37	74.0
No	12	24.0

AST antibiotic susceptibility testing

^a One missing data

^b AmpC-producing *Enterobacteriaceae*

representative of all French hospitals. The participants are also possibly the ones most interested in ABS and self-reported data can be associated with a social desirability bias; our results might present a more optimistic picture as compared to the reality.

Conclusions

French CMs working in large public hospitals actively participate in ABS activities and have access to a wide range of RDTs. Their participation, however, needs to be reinforced, with appropriate compensation for their time, and we have identified several areas for improvement. ABS teams need to be promoted in France and the distribution of roles needs to be clearer, with more interactions and more synergy between the different ABS team members.

Acknowledgments Three CMs that pilot tested the questionnaire:

Gabriel Auger (CHU de Rennes), Nicolas Degand (CHU de Nice) and Caroline Piau (CHU de Rennes).

Members of the ABS-CM group Olivier Belmonte (Laboratoire de Bactériologie, CHU Réunion), Béatrice Bercot (Département de microbiologie, Unité de Bactériologie, Hôpital Saint-Louis, AP-HP), Anne Cady (Laboratoire de biologie médicale, CH de Vannes), Jocelyne Caillon (Laboratoire de Bactériologie, CHU de Nantes), Christian Cattoen (Centre Hospitalier de Valenciennes), Julie Cremniter (Service de Bactériologie, CHU de Poitiers), Olivier Dauwalder (Centre de Biologie et Pathologie Nord, Plateau de Microbiologie 24/24, Hôpital de la Croix-Rousse, CHU de Lyon), Dominique André De Briel (Fédération des laboratoires, HIA de Bégin), Laurent Dortet (Laboratoire de Bactériologie-Hygiène, Hôpital de Bicêtre, AP-HP), Anabèle Dos Santos (Service de Maladies Infectieuses et Tropicales, CH de Niort), Florence Doucet-Populaire (Hôpital Antoine Béchère, AP-HP), Véronique Dubois (Service de bactériologie, Hôpital Pellegrin, CHU de Bordeaux), Clarisse Dupin (CH Saint-Brieuc), Agnès Ferroni (Laboratoire de Microbiologie, Hôpital Necker-Enfants Malades, AP-HP), Jenny Gallou (Laboratoire de bactériologie, CH Aix-en-Provence), Pauline Garnier (Laboratoire de Biologie médicale, Hôpital Nord Franche Comté), Thomas Guillard (Laboratoire de Bactériologie-Virologie-Hygiène-Parasitologie-Mycologie, Hôpital Robert Debré, CHU de Reims), Jean-Louis Herrmann (Service de microbiologie, Hôpital Raymond Poincaré, AP-HP), Christophe Isnard (Service de microbiologie, CHU de Caen), Hervé Jacquier (Service de Bactériologie-Virologie, Hôpital Lariboisière, AP-HP), Françoise Jaureguy (Hôpital Avicenne, AP-HP), Marie Kempf (Service de Bactériologie-Hygiène, CHU d'Angers), Luce Landraud (Service de Microbiologie et Hygiène, Hôpital Louis Mourier, AP-HP), Jean-Philippe Lavigne (Service de Microbiologie, CHU de Nîmes), Cécile Le Brun (CHU Tours), Florian Lorme (Pôle Médico-Technique et Fonctions Transversales, Centre Hospitalier Sud-Francilien), Alain Lozniewski (Service de microbiologie, CHRU de Nancy).

Jean-Luc Mainardi (Service de microbiologie, HEGP, AP-HP), Marie-Cécile Ploy (Laboratoire de Bactériologie-Virologie-Hygiène, CHU de Limoges), Isabelle Podglajen (Service de microbiologie, HEGP, AP-HP), Charlotte Pujol (Service de bactériologie, CH de Perpignan), Jérôme Robert (Bactériologie-Hygiène hospitalière, Hôpitaux Pitié Salpêtrière-Charles Foix, AP-HP), Anne-Laure Roux (Service de Microbiologie, Hôpital Ambroise Paré, AP-HP), Raymond Ruimy (Service de bactériologie, CHU de Nice), Frédéric Schramm

(Laboratoire de Bactériologie, CHU de Strasbourg), Simon Sunder (Service de Maladies Infectieuses et Tropicales, CH de Niort), Didier Tandé (Laboratoire de Bactériologie-Virologie, CHRU deBrest), Anne Vachée (Laboratoire, CH de Roubaix), Frédéric Wallet (Institut de Microbiologie-Service de Bactériologie, CHRU de Lille).

Author contribution C. P. initiated the study. M. L. M., N. A., V. C. and C. P. contributed to the study design. M. L. M., V. C. and C. P. contributed to the implementation and supervision of the study. M. L. M. analysed the data and takes responsibility for the accuracy of the data analysis. M. L. M. and C. P. drafted the manuscript. All authors read and approved the final manuscript.

Funding The study was carried out as part of our routine work.

Compliance with ethical standards

In accordance with French laws, this survey did not need any ethical approval. Participation in the survey was voluntary, anonymous and without any financial compensation.

Conflict of interest The authors declare that they have no conflict of interest. Each author has fulfilled the Conflict of Interest Disclosure Form.

References

1. Dyar OJ, Tebano G, Pulcini C, ESGAP (ESCMID Study Group for Antimicrobial stewardship) (2017) Managing responsible antimicrobial use: perspectives across the healthcare system. *Clin Microbiol Infect* 23:441–447
2. Pulcini C, Huttner A (2018) CMI policy on antimicrobial stewardship research. *Clin Microbiol Infect* 24:91–92
3. EU Guidelines for the prudent use of antimicrobials in human health [Internet]. European Centre for Disease Prevention and Control (ECDC); 2017. https://ec.europa.eu/health/amr/sites/amr/files/amr_guidelines_prudent_use_en.pdf. Accessed 28 July 2019
4. Morency-Potvin P, Schwartz DN, Weinstein RA (2017) Antimicrobial stewardship: how the microbiology laboratory can right the ship. *Clin Microbiol Rev* 30:381–407
5. Pulcini C (2017) Antibiotic stewardship: a European perspective. *FEMS Microbiol Lett* 15:364
6. Perez KK, Olsen RJ, Musick WL, Cernoch PL, Davis JR, Land GA et al (2013) Integrating rapid pathogen identification and antimicrobial stewardship significantly decreases hospital costs. *Arch Pathol Lab Med* 137:1247–1254
7. Box MJ, Sullivan EL, Ortwine KN, Parmenter MA, Quigley MM, Aguilar-Higgins LM et al (2015) Outcomes of rapid identification for gram-positive bacteremia in combination with antibiotic stewardship at a community-based hospital system. *Pharmacotherapy* 35:269–276
8. Timbrook TT, Morton JB, McConeghy KW, Caffrey AR, Mylonakis E, LaPlante KL (2017) The effect of molecular rapid diagnostic testing on clinical outcomes in bloodstream infections: a systematic review and meta-analysis. *Clin Infect Dis* 64(1):15–23
9. Bauer KA, Perez KK, Forrest GN, Goff DA (2014) Review of rapid diagnostic tests used by antimicrobial stewardship programs. *Clin Infect Dis* 59(Suppl 3):S134–S145
10. MacKenzie FM, Gould IM, Bruce J, Mollison J, Monnet DL, Krcmery V et al (2007) The role of microbiology and pharmacy departments in the stewardship of antibiotic prescribing in European hospitals. *J Hosp Infect* 65(Suppl 2):73–81

11. Bailey C, Tully M, Cooke J (2015) Perspectives of clinical microbiologists on antimicrobial stewardship programmes within NHS trusts in England. *Antimicrob Resist Infect Control* 4:47
12. Décret n° 2013–841 du 20 septembre 2013 modifiant les dispositions relatives à la commission médicale d'établissement et aux transformations des établissements publics de santé et à la politique du médicament dans les établissements de santé [Internet]. Légifrance; 2013. doi: <https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000027979376&dateTexte=&categorieLien=id>. Accessed 28 July 2019
13. Instruction DGS/RI1/DGOS/PF2/DGCS no 2015–212 du 19 juin 2015 relative à la mise en œuvre de la lutte contre l'antibiorésistance sous la responsabilité des agences régionales de santé [Internet]. Ministère des affaires sociales, de la santé et des droits des femmes; 2015. doi: https://solidarites-sante.gouv.fr/IMG/pdf/instruction_19062015.pdf. Accessed 28 July 2019
14. Fiche descriptive 2018. Thème infections Associées aux Soins (IAS) ICATB.2 [internet]. Haute Autorité de Santé (HAS); 2018. doi: https://www.has-sante.fr/portail/upload/docs/application/pdf/2016-04/2016_has_fiche_descriptive_icatb_2.pdf. Accessed 28 July 2019
15. Annuaire [Internet]. Fédération Hospitalière de France; doi: <https://etablisements.fhf.fr/annuaire/recherche-hopital.php>. Accessed 28 July 2019
16. Kallen MC, Ten Oever J, Prins JM, Kullberg BJ, Schouten JA, Hulscher MEJL (2018) A survey on antimicrobial stewardship prerequisites, objectives and improvement strategies: systematic development and nationwide assessment in Dutch acute care hospitals. *J Antimicrob Chemother* 73:3496–3504
17. Sinha M, Jupe J, Mack H, Coleman TP, Lawrence SM, Fraley SI. Emerging Technologies for Molecular Diagnosis of sepsis. *Clin Microbiol Rev* 2018;31. doi: <https://doi.org/10.1128/CMR.00089-17>
18. Perozziello A, Routelous C, Charani E, Truel A, Birgand G, Yazdanpanah Y et al (2018) Experiences and perspectives of implementing antimicrobial stewardship in five French hospitals: a qualitative study. *Int J Antimicrob Agents* 51:829–835
19. Diallo K, Thilly N, Luc A, Beraud G, Ergonul Ö, Giannella M et al (2018) Management of bloodstream infections by infection specialists: an international ESCMID cross-sectional survey. *Int J Antimicrob Agents* 51:794–798
20. Eveillard M, Lemarié C, Cottin J, Hitoto H, Mahaza C, Kempf M et al (2010) Assessment of the usefulness of performing bacterial identification and antimicrobial susceptibility testing 24 h a day in a clinical microbiology laboratory. *Clin Microbiol Infect* 16:1084–1089
21. Skodvin B, Aase K, Brekken AL, Charani E, Lindemann PC, Smith I (2017) Addressing the key communication barriers between microbiology laboratories and clinical units: a qualitative study. *J Antimicrob Chemother* 72:2666–2672. <https://doi.org/10.1093/jac/dkx163>
22. Coupat C, Pradier C, Degand N, Hofliger P, Pulcini C (2013) Selective reporting of antibiotic susceptibility data improves the appropriateness of intended antibiotic prescriptions in urinary tract infections: a case-vignette randomised study. *Eur J Clin Microbiol Infect Dis* 32:627–636
23. Pulcini C, Tebano G, Muters NT, Tacconelli E, Cambau E, Kahlmeter G et al (2017) Selective reporting of antibiotic susceptibility test results in European countries: an ESCMID cross-sectional survey. *Int J Antimicrob Agents* 49:162–166
24. Comité de l'antibiogramme de la Société Française de Microbiologie [Internet]. European committee on antibiogram susceptibility testing (EUCAST); 2019. doi: https://www.sfm-microbiologie.org/wp-content/uploads/2019/01/CASFM2019_VI.0.pdf. Accessed 04 Aug 2019

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.