Caspian J Intern Med 2019; 10(2):132-141
DOI: 10.22088/cjim.10.2.132

Original Article

Awareness and perception of multidrug-resistant organisms and antimicrobial therapy among internists vs. surgeons of different specialties: Results from the German MR2 Survey

Philipp J. Spachmann (MD) [1]
Matthias May (MD) [2*]
Malte W. Vetterlein (MD) [3]
Hans-Martin Fritsche (MD) [1]
Steffen Lebentrau (MD) [4]
Martin Schostak (MD) [4]
Florian M. Wagenlehner (MD) [5]
Maximilian Burger (MD) [1]
Karsten-Henrich Weylandt (MD) [6]
Bernd Salzberger (MD) [7]
Sabine D. Brookman-May (MD) [8]
Christian Gilfrich (MD) [2]
MR2 study group

1. Department of Urology; University of Regensburg, Caritas St. Josef Medical Center, 93053 Regensburg, Landshuter St.65, Germany.
2. Department of Urology; St. Elisabeth Hospital; 94315 Straubing, St.-Elisabeth-Str. 23, Germany.
3. Department of Urology; University Medical Center Hamburg-Eppendorf; 20246 Hamburg, Martinistr. 52, Germany
4. Department of Urology and Pediatric Urology; Ruppiner Kliniken GmbH, Brandenburg Medical School; 16816 Neuruppin, Fehrbelliner Str. 38, Germany.
5. Department of Urology, Pediatric Urology and Andrology; Justus-Liebig University; 35392 Gießen, Rudolf-Buchheim-Str. 7, Germany.
6. Department of Internal Medicine B, Ruppiner Kliniken GmbH, Brandenburg Medical School; 16816 Neuruppin, Fehrbelliner Str. 38, Germany.
7. Department of Internal Medicine I, University Hospital Regensburg, 93053, Regensburg, Franz-Josef-Strauß-Allee 11, Germany.
8. Department of Urology; LMU Munich, Großhadern; 81377 München, Marchioninistraße 15, Germany.

*** Correspondence:**
Matthias May, Department of Urology; St. Elisabeth Hospital; 94315 Straubing, St.-Elisabeth-Str. 23, Germany

E-mail: matthias.may@klinikum-straubing.de
Tel: 0049 9421 7101701

Received: 9 July 2018
Revised: 17 Nov 2018
Accepted: 17 Dec 2018

Abstract

Background: Recently, antibiotic resistance rates have risen substantially and care for patients infected with multidrug-resistant organisms (MDRO) has become a common problem in most in – and outpatient settings. The objectives of the study were to compare the awareness, perception, and knowledge of MDRO and rational antibiotic use between physicians from different medical specialties in German hospitals.

Methods: A 35-item questionnaire was sent to specialists in internal medicine (internists), gynecologists, urologists, and general surgeons (non-internists) in 18 German hospitals. Likert-scales were used to evaluate awareness and perception of personal performance regarding care for patients infected with MDRO and rational use of antibiotics. Additionally, two items assessing specific knowledge in antibiotic therapy were included. The impact of medical specialty on four predetermined endpoints was assessed by multivariate logistic regression.

Results: 43.0% (456/1061) of recipients responded. Both internists and non-internists had low rates of training in antibiotic stewardship. 50.8% of internists and 58.6% of non-internists had attended special training in rational antibiotic use or care for patients infected with MDRO in the 12 months prior to the study. Internists deemed themselves more confidently to choose the indications for screening patients for colonization with methicillin-resistant *Staphylococcus aureus* (P=0.004) and to initiate adequate infection control measures (P=0.002) than other specialties. However, there was no significant difference between internists and other specialists regarding the two items assessing specific knowledge in antibiotic therapy and infection control.

Conclusion: Among the study participants, a considerable need for advanced training in the study subjects was seen, regardless of the medical specialty.

Keywords: Antibiotic Resistance; Antibiotic Policy; Antibiotic prescription; Multidrug Resistance; Urinary Tract Infection; Survey Study

Citation:
Spachmann PJ, May M, Vetterlein MW, Fritsche HM, Lebentrau S, Schostak.M. Awareness and perception of multidrug-resistant organisms and antimicrobial therapy among internists vs. surgeons of different specialties: Results from the German MR2 Survey. Caspian J Intern Med 2019; 10(2): 132-141.

The increasing rate of multidrug-resistant organisms (MDRO) worldwide poses a number of challenges in infection control and clinical management. The European Center for Disease Prevention and Control estimates that MDRO cause up to 25,000 deaths, costs of more than 1.5 billion Euro, and prolonged hospitalizations of more than 2.5 million days annually (1). To prevent further spread or transmission of these organisms, a number of infection control measures have been proposed by national bodies.

These measures include adequate screening of patients at risk to be colonized with these organisms, personal preventive measures (use of gloves and gowns in personal contact, contact isolation) and strict adherence to hand hygiene measures.

Given that the inadequate prescription of broad-spectrum antibiotics fuel development and spread of antibiotic resistance, simultaneous strategies for a rational use of antibiotics are necessary (2). To maintain the efficacy of antibiotics and to reduce the development of resistance, knowledge regarding the targeted use of antibiotics is necessary (3, 4).

However, several studies have shown high rates of inadequate prescription of antibiotics in a number of clinical situations (5-7). In a recent study, Hansen et al. estimated that approximately 40,000 evaluable patients in 132 German hospitals, around 40% were inadequately treated with antibiotic substances (7).

Multiple national and international programs, such as the German Antimicrobial Resistance Strategy (DART 2020) by the German Federal Ministry of Health, were initiated to address this problem and facilitate training and research in this field (3). Antibiotic stewardship (ABS) programs have been developed to address these challenges. The Centers of Disease Control in the US has recommended that these programs should be initiated in every hospital for acute cases.

A recent meta-analysis by the Cochrane collaboration demonstrated that the implementation of ABS programs is effective in reducing the use of inadequate antibiotic use and stated the potential of ABS programs to lower rates of MDRO and hospital-acquired infection (HAI) (4).

In many countries, infectious diseases are a dedicated subspecialty of internal medicine. However, also general internists commonly prescribe antibiotics in a wide variety of clinical settings. Internists should therefore be particularly trained in the proper use of antibiotics to prevent inadequate use of antibiotics (8).

To date, there are no studies that have evaluated the self-reported perception of competence regarding MDRO and rational use of antibiotics in different clinical specialties. The aim of this study was to compare self-reported knowledge and awareness of MDRO or rather ABS between internists and surgical specialists using a questionnaire addressing different aspects of rational antibiotic use and multidrug resistant organisms.

Methods

Setting, participants, and survey instrument: The study group for developing and carrying out a self-administered questionnaire to evaluate the knowledge of different clinical specialties regarding MDRO and strategies of rational use of antibiotics (Multi-institutional Reconnaissance of practice with Multi-Resistant bacteria – a survey focusing on German hospitals: MR2) was founded in May 2015 and subsequently developed a questionnaire, which was tested and further refined in a pilot study with 15 clinicians representing all included medical specialties, as described previously (9, 10). MR2 survey study was approved by the Institutional Review Board of St.

Elisabeth Hospital Straubing, which served as the central research coordinating facility. The questionnaire was addressed to internists, general surgeons, gynecologists, and urologists employed in German hospitals.

To characterize the respondents, four items were used (hospital, specialty, hospital hierarchy, the frequency of antibiotic prescriptions within the preceding seven workdays). Overall, 35 substantive items were included into the questionnaire and categorized as depicted in table 1.

The questionnaire is used to determine the self-reported confidence in antibiotic prescribing (A, n=4, 4-point Likert-scale: 1=very unsure, 2=unsure, 3=sure, 4=very sure), self-reported individual confidence of knowledge on multidrug resistance and rational use of antibiotics (B, n=13, 4-point Likert-scale: 1=no knowledge, 2= poor to moderate knowledge, 3=average knowledge, 4=knowledge above average), perception of relevance of potential reasons for increasing multidrug resistance (C, n=13, 4-point Likert-scale: 1=no impact, 2=low impact, 3=moderate impact, 4=high impact), the personal rationale for a calculated antibiotic treatment (D, n=1), participation in training on multidrug resistance and rational antibiotic use within the last twelve months (E, n=1), frequency of explicit recording of multidrug resistant bacteria and potentially needed further treatment in medical reports (F, n=1), self-estimated prevalence of ciprofloxacin-resistant *Escherichia coli* at the own hospital (G, n=1, specified by <5%, 5-20%, 21-40%, 41-60%, >60%) and the specific treatment of a 61-year-old woman with a heavily symptomatic acute cystitis (H, n=1, 5 possible answers). In addition to administering the questionnaires, the actual ciprofloxacin-resistance of *Escherichia coli* in the participating hospitals was requested from the participating centers.

Survey administration: 18 German facilities (six university medical centers and 12 non-academic tertiary care centers) were considered for participation in MR2 after coordination with the hospital management boards. Of note, not all hospitals provided survey participants from all specialties. After hospital recruitment, the heads of departments were informed about the study`s aims and were asked to participate with their teams.

Questionnaires were sent out to the participating hospitals in August 2015. Survey response was anonymized, and questionnaires were only sent once. Using a high-performance scanner, all questionnaires returned until October 1, 2015, were digitalized, and the resulting data were separately checked for plausibility by three independent collaborators (O.M., H.S. and T.K.).

These collaborators corrected erroneously the scanned data if they were unequivocally verifiable based on the original questionnaire.

These corrections were based on a consensus decision by all three collaborators. Datasets were truncated, and respective items were treated as missing whenever errors within the data could not be excluded. Furthermore, the local ciprofloxacin-resistance rates in *Escherichia coli* were requested from the microbiological labs in all participating hospitals.

To characterize the interviewees, 4 items focusing on the educational level preceded the survey; further 35 items evaluated the following aspects: Individual certainty concerning antibiotic prescription, self-assessment of knowledge about MDRO and antibiotic prescription, classification of MDRO associated issues, individual basis for decision-making concerning calculated antibiotic prescription, frequency of participation in specific educational activities and practical knowledge about ABS measures.

Thus, a total of 39 items were available (4 + 35). Questionnaires returned with ≥92% data completeness (≥36 / 39 items) were accepted for evaluation.

Statistical analysis: The results of nominally scaled items were described using frequencies and proportions, means and standard deviations were used for items reported by the Likert scale. Specialization was dichotomized into ‘internists’ vs. ‘non-internists’ (urologists, general surgeons, and gynecologists). The distribution of items among these groups was assessed by chi-square tests for categorical variables and by the Kruskal-Wallis test for continuous variables. In addition, four multivariate logistic regression-models (MLRM) were developed to assess the independent influence of the group variable on following dichotomized endpoints:

(1) attendance to theoretical advanced training within the last 12 months (≥1 advanced training courses vs. no training), (2) self-reported quality of discharge letters regarding documentation of MDRO and further clinical management (always vs. not always), (3) knowledge of local ciprofloxacin-resistance rates in *E. coli* (correct category vs. wrong category according to the predefined 5 categories), and (4) guideline-adhering antibiotic therapy in the case study (narrow-spectrum antibiotic with/without antibiogram or symptomatic treatment *vs.* other option). If reasonable, several possible answers in MLRM were condensed. Adjustment of the group variable in MLRM was performed according to following criteria: (1) university medical center vs. non-academic tertiary care center, (2) hospital hierarchy, (3) frequency of antibiotic prescriptions within the preceeding seven workdays.

If useful for improving quality of the model, for each endpoint the MLRM was adjusted to the respective other predetermined endpoints. The latter was assessed by the likelihood-function and Nagelkerke’s R^2. Odds ratios (OR) and 95% confidence intervals (CI) were used to report the influence of different variables on these endpoints. Bootstrap-corrected p-values with 1,000 resamples was used to test the internal validity.

Data analysis was performed by the use of SPSS (Version 23.0, IBM Corp., Armonk, NY, USA). Two-sided statistical significance was defined as a $p<0.05$.

Results

The response rates in the departments of internal medicine, urology, gynecology, and general surgery were 132/454 (29.1%), 135/176 (76.7%), 33/101 (32.7%) and 156/330 (47.3%), respectively. Overall, 41.4% of the surveyed participants were heads of departments or senior physicians, 30.3% consultants, and 28.3% residents. In this context, survey responders were heads or senior physicians of their departments in 43.9% and 40.4% in the groups of internists and non-internists, respectively (P=0.530). Internists and non-internists worked in 44.7% and 40.1%, respectively, at a university hospital (P=0.402). Within seven workdays prior to filling out the questionnaire, internists

prescribed antibiotics to >5 patients less often than non-internists (20.6% vs. 36.9%; P=0.001). The local ciprofloxacin-resistance of *Escherichia coli* in the year 2014 was median 24% (interquartile range 20-30%) for the participating hospitals (n=18).

There were no significant differences between the two groups in the rates of factors influencing antibiotic prescriptions, like national/international or hospital guidelines and in the frequency of advanced training in MDR, but there was a non-significant trend towards a lower rate of internists attending advanced training in comparison to non-internists (50.8 vs. 58.6%, P=0.137; fig. 1). Both groups demonstrated a low perception pf knowledge in respect to ABS (2.00 vs. 1.98, P=0.698) and the concept of DART 2020 (1.95 vs. 2.09, P=0.152).

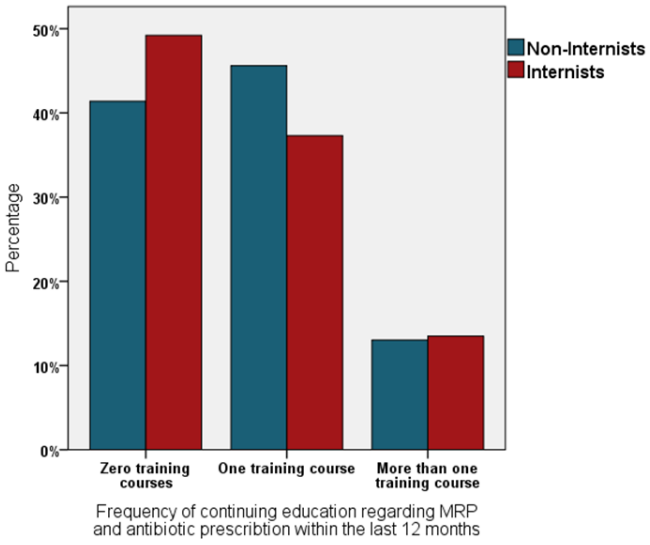

Figure 1. Frequency of continuing medical education regarding multi-resistant pathogens (MRP) and antibiotic prescription within the last 12 months, stratified according to internists vs. non-internists.

Self-reported confidence regarding dosage, frequency, duration, administration, and indication was similar between internists and non-internists , as was perception of causes of relevance for increasing rates of multidrug resistance (MDR): Both groups suspected the overuse of broad-spectrum antibiotics in human medicine (3.50 vs. 3.52, P=0.987) to be a critical factor for increasing rates of MDRO.

There were moderate higher rates in the self-reported confidence levels in internists compared to non-internists in (1) choosing indications for screening patients suspected for colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) (3.43 vs. 3.22; P=0.004), (2) initiating correct patient specific control measures (3.33 vs. 3.15; P=0.002), and (3) in identifying the responsibility to report notifiable infectious diseases (2.74 vs. 2.59; P=0.030). Furthermore, internists suspected the foreign bodies such as Foley catheters significantly more often as risk factors for infections (2.96 vs. 2.79; P=0.011).

However, these small differences did not translate to better performance in the management of our test case: similar proportions of physicians in both groups (25% vs. 33.3%, P=0.090) chose a broad-spectrum antibiotic in this situation.

Detailed documentation regarding MDRO and potential further outpatient management in hospital discharge letters, and knowledge of ciprofloxacin-resistant *Escherichia coli* prevalence in their hospital were also not significantly different between these groups (table 1). Heads of departments and senior physician internists (OR 3.42, p<0.001) and colleagues with more frequent prescription of antibiotics (OR 1.91, P=0.005) significantly attended more often advanced training courses within the 12-month period before the questionnaire was administered. Colleagues who underwent advanced training estimated the quality of discharge letters of their department by 97% (P=0.010) more accurate than their colleagues without advanced training during this time period.

They also had better knowledge of the correct *Escherichia coli* resistance rates to ciprofloxacin in their hospital. (OR 1.67, P=0.025). However, a higher attendance rate of advanced training did not translate into better decision-making in the test case. None of these end points were significantly influenced by the group variable (internist vs. non-internist) based on multivariate analyses (table 2). All results of MLRM were internally valid.

Table 1. Differences between internists and non-internists in responding to select items from the MR2 study.

Item	Overall cohort (n=456)	Internists (n=132)	Non-Internists (n=324)	p value
A: Self-reported individual confidence in:				
… the correct choice of dosage, frequency, and duration of antibiotics	3.13 (±0.57)	3.12 (±0.64)	3.13 (±0.53)	.846
… the correct decision regarding the indication of intravenous or oral application of antibiotics	3.21 (±0.58)	3.24 (±0.62)	3.20 (±0.52)	.405
… the correct interpretation of microbiological reports	3.17 (±0.56)	3.11 (±0.60)	3.20 (±0.55)	.128
… the indication of an antibiotic combination therapy	2.72 (±0.65)	2.73 (±0.67)	2.71 (±0.64)	.829
B: Self-reported level of knowledge of:				
… measures of Antibiotic Stewardships (ABS)	1.99 (±0.92)	2.00 (±0.88)	1.98 (±0.93)	.698
… local resistance patterns	2.47 (±0.78)	2.43 (±0.77)	2.49 (±0.78)	.412
… amount of local antibiotic prescribing	2.32 (±0.86)	2.35 (±0.85)	2.30 (±0.86)	.514
… indications of MRSA-screening	3.28 (±0.65)	3.43 (±0.58)	3.22 (±0.67)	.004
… indications of MDRGN-screening	2.89 (±0.80)	2.91 (±0.81)	2.88 (±0.79)	.735
… patient cohorts with need of isolation	3.20 (±0.62)	3.33 (±0.62)	3.15 (±0.61)	.002
… the definitions of 3- and 4-MDRGN	3.25 (±0.77)	3.27 (±0.77)	3.25 (±0.77)	.706
… hygiene measures and hygiene standards in the hospital	3.22 (±0.67)	3.25 (±0.70)	3.21 (±0.66)	.470
… the current rules for hand disinfection.	3.70 (±0.48)	3.67 (±0.52)	3.72 (±0.45)	.410
… the possibilities of success monitoring of sufficient hygiene measures and hygiene standards	2.71 (±0.87)	2.73 (±0.89)	2.71 (±0.86)	.619
… DART 2020, the German Antimicrobial Resistance Strategy by the Federal Ministry of Health	2.05 (±0.88)	1.95 (±0.84)	2.09 (±0.90)	.152
… the responsibility in identifying notifiable infectious diseases	2.63 (±0.78)	2.74 (±0.77)	2.59 (±0.78)	.030
… mixing and cycling of antibiotic treatment regimes	2.14 (±0.82)	2.19 (±0.79)	2.12 (±0.82)	.368
C: Perception of the relevance of increasing MDR:				
Inadequate and excessive use of antibiotics in animal husbandry	3.36 (±0.69)	3.38 (±0.66)	3.35 (±0.70)	.752
Overuse of antibiotics in human medicine	3.54 (±0.58)	3.49 (±0.64)	3.56 (±0.55)	.437
Overuse of broad-spectrum antibiotics in human medicine	3.51 (±0.59)	3.50 (±0.62)	3.52 (±0.57)	.987
Shortened or extended administration of antibiotics in human medicine	3.24 (±0.65)	3.19 (±0.63)	3.26 (±0.65)	.278
Insufficient hand disinfection and hygiene standards amongst medical staff	3.10 (±0.78)	3.07 (±0.74)	3.11 (±0.79)	.489
Insufficient knowledge and guideline-adherence regarding the rational use of antibiotics	3.15 (±0.63)	3.14 (±0.58)	3.16 (±0.66)	.769
Insufficient surveillance measures on the rational use of antibiotics	2.85 (±0.71)	2.86 (±0.70)	2.84 (±0.71)	.851
Insufficient advanced training and no mandatory advanced training amongst medical staff	2.87 (±0.73)	2.93 (±0.74)	2.84 (±0.72)	.179
Too much influence by pharmaceutical companies	2.27 (±0.79)	2.29 (±0.80)	2.26 (±0.78)	.866
Insufficient research activity by pharmaceutical companies on novel, potent antibiotics	2.33 (±0.84)	2.43 (±0.85)	2.29 (±0.84)	.148
Lack of international and global strategies in fighting	2.95 (±0.76)	2.87 (±0.80)	2.99 (±0.74)	.168

increasing antimicrobial resistances				
Overuse or extended use of foreign bodies (eg. Foley catheters), potentially favoring infections	2.84 (±0.70)	2.96 (±0.68)	2.79 (±0.70)	.011
Lack of trained staff in hospitals and private practices	2.64 (±0.76)	2.70 (±0.73)	2.61 (±0.76)	.282
D: Factors influencing antibiotic prescribing (without antibiogram):				
Official National/International Guidelines	53 (11.6%)	24 (18.2%)	29 (9.0%)	.836*
		30 (22.7%)		
Internal Hospital Guidelines and Hospital Standards	118 (25.9%)		88 (27.2%)	
Colleague advice	49 (10.7%)	15 (11.4%)		
Microbiologist Advice	27 (5.9%)	4 (3.0%)	34 (10.5%)	
No device	209 (45.8%)	59 (44.7%)	23 (7.1%)	
			150 (46.3%)	
E: Frequency of advanced training regarding MDRO and antibiotic prescribing in the last 12 months (n=433; n=23 without response):				
0 advanced training courses	189 (43.6%)	62 (49.2%)	127 (41.4%)	.137**
	187 (43.2%)		1	
1 advanced training course	57 (13.2%)	47 (37.3%)	40 (45.6%)	
>1 advanced training courses		17 (13.5%)	40 (13.0%)	
F: Frequency of detailed documentation regarding MDRO and potential further outpatient arrangements in discharge letters:				
Never	6 (1.3%)	2 (1.5%)	4 (1.2%)	.812
1-49%	68 (14.9%)	21 (15.9%)	47 (14.5%)	
50-99%	245 (53.7%)	66 (50.0%)	179 (55.2%)	
	104 (22.8%)			
100%	33 (7.2%)	31 (23.5%)	73 (22.5%)	
Do not know the correct answer		12 (9.1%)	21 (6.5%)	
G: Rates of ciprofloxacin-resistant E. coli strains in the hospital in 2014 (calculated from five categories and matched with the actual resistance rates):				
… underestimated	242 (53.1%)	62 (47.0%)	180 (55.6%)	.322***
	65 (14.3%)			
… overestimated	149 (32.7%)	22 (16.7%)	43 (13.3%)	
… correctly estimated		48 (36.4%)	101 (31.2%)	
H: Individually chosen clinical pathway in a 61-year old, highly symptomatic female patient with an uncomplicated urinary tract infection (n=443)				
Narrow-spectrum antibiotic without antibiogram	73 (16.5%)	21 (16.4%)	52 (16.5%)	.214
Narrow-spectrum antibiotic with antibiogram	185 (41.8%)	56 (43.8%)	129 (41.0%)	
	49 (11.1%)			
Broad-spectrum antibiotic without antibiogram	88 (19.9%)	9 (7.0%)	40 (12.7%)	
Broad-spectrum antibiotic with antibiogram	48 (10.8%)	23 (18.0%)	65 (20.6%)	
Symptomatic therapy without antibiotic		19 (14.8%)	29 (9.2%)	

E. coli: Escherichia coli MDRGN: multidrug-resistant gram-negative organisms MRSA: methicillin-resistant staphylococcus aureus

* 2x2 comparison between 'one option' and '<no option (no device)'.

** 2x2 comparison between '0 advanced training courses' and '≥1 advanced training courses'.

*** 2x2 comparison between 'incorrect answer' and 'correct answer'.

Table 2. Results of four multivariate logistic regression models evaluating the independent influence of several study criteria on predetermined endpoints: (1) attendance of theoretical advanced training courses in the last 12 months (≥1 advanced training courses vs. no training courses), (2) self-reported quality of discharge letters regarding the documentation of MDRO and further outpatient arrangements (always vs. not always), (3) awareness of local ciprofloxacin-resistance rates in E. coli strains (correct category vs. wrong category), and (4) guideline-adhering treatment course in the case study (narrow-spectrum antibiotic with/without antibiogram vs. other option). [Respective endpoints are underlined]

Criteria	OR (95% CI)	p value	Bootstrap-corrected p value
Endpoint 1 – Attendance of theoretical advanced training courses in the last 12 months			
Internists vs. Non-Internists	0.73 (0.46-1.14)	.169	.196
University Medical Center vs. Other Option	0.89 (0.59-1.34)	.576	.562
Head of the department and senior physician vs. Other Option	3.42 (2.24-5.23)	<.001	.001
>5 Patients vs. Other Option (Antibiotic prescribing in the last seven days)	1.91 (1.22-3.00)	.005	.004
Endpoint 2 – Self-reported quality of discharge letters			
Internists vs. Non-Internists	1.20 (0.72-2.00)	.490	.512
University Medical Center vs. Other Option	0.87 (0.54-1.39)	.549	.556
Head of the department and senior physician vs. Other Option	1.41 (0.87-2.28)	.167	.192
>5 Patients vs. Other Option (Antibiotic prescribing in the last seven days)	1.33 (0.82-2.18)	.253	.275
≥1 vs. no advanced training in the last 12 months	1.97 (1.18-3.31)	.010	.011
Correct vs. Wrong Category (LECR-Ci)	1.06 (0.65-1.73)	.818	.835
Endpoint 3 – Awareness of local ciprofloxacin-resistance rates in E. coli strains			
Internists vs. Non-Internists	1.42 (0.90-2.22)	.132	.127
University Medical Center vs. Other Option	1.32 (0.87-2.01)	.190	.186
Head of the department and senior physician vs. Other Option	1.49 (0.97-2.29)	.070	.082
>5 Patients vs. Other Option (Antibiotic prescribing in the last seven days)	1.15 (0.73-1.80)	.551	.545
≥1 vs. no advanced training in the last 12 months	1.67 (1.07-2.61)	.025	.017
Endpoint 4 – Guideline-adhering treatment course in the case study			
Internists vs. Non-Internists	1.17 (0.75-1.82)	.492	.481
University Medical Center vs. Other Option	0.80 (0.54-1.20)	.285	.298
Head of the department and senior physician vs. Other Option	0.99 (0.65-1.52)	.978	.975
>5 Patients vs. Other Option (Antibiotic prescribing in the last seven days)	1.05 (0.68-1.63)	.830	.825
≥1 vs. no advanced training in the last 12 months	1.37 (0.90-2.09)	.141	.126
Correct vs. Wrong Category (LECR-Ci)	1.38 (0.89-2.12)	.147	.122

CI: confidence interval; LECR-CI: local ciprofloxacin-resistance rates in E. coli strains; MDRO: multidrug-resistant organisms; OR: odds ratio

Discussion

The aim of this study was to determine self-assessment of competence regarding rational antibiotic use and MDRO and to compare these between internists and non-internist from various surgical disciplines. Overall, attendance to training courses regarding MDRO and antibiotic prescribing was generally low). Knowledge of local ciprofloxacin-resistance rates in *Escherichia coli* strains was significantly higher for physicians, who had taken part in training courses within the 12 months prior to the survey, which points to a benefit of training courses, irrespective of the medical discipline. However, the attendance of training did not lead to a

significantly better performance in the assessment of the test case addressed in the MR2-questionnaire.

Self-reported knowledge of indications for MRSA screening, and indications for specific infection control measures for patients colonized with MDRO were slightly but significantly higher in internists, compared to their surgical counterparts. Although, approximately half of the participants in both groups (47.0% of internists as compared to 55.6% of non-internists, p=0.099) underestimated the rate of *Escherichia coli* ciprofloxacin-resistance in their hospital. This underlines the necessity to improve knowledge of local resistance rates.

Present treatment efforts – and structured ABS training – aim at prudent use of broad-spectrum-antibiotics (2). However, a large number of physicians in both groups (25% vs. 33.6%, P=0.090) would treat the case study patient with broad-spectrum antibiotics, where according to current guidelines narrow-spectrum antibiotics or even only symptomatic therapy would be appropriate (11). While a single case study question is probably not sufficient to thoroughly compare knowledge of guidelines of antibiotic therapy between different specialties, these findings nonetheless underline the current deficits in knowledge and training, irrespective of specialty (12). This expertise is particularly important and warranted for internists as infectious diseases is an integral part of internal medicine and thus internists should have a broad and current knowledge of management of common infectious diseases or complications. Furthermore, internists are often consulted by colleagues in other specialties for drug therapy in infectious diseases (13, 140. Thus, the time has come for all specialties and especially for internists to intensify training in the management of infectious diseases, especially in the light of the current challenge of rapidly rising rates of antibiotic resistance. ABS programs should be initiated by hospital managers and led by clinicians, and particularly internists, as they offer a possibility to shape rules and regulations from the physician's point of view in this important field. Future survey studies should probably include additional test case scenarios. These could be based on the "global priority list of antibiotic-resistant bacteria to guide research, discovery, and development of new antibiotics" published by the World Health Organization (WHO) (15). Specific MDRO, such as *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacteriaceae* should be given particular priority because of their emerging resistance to last resort antibiotics, such as carbapenems. Our study has several limitations which must be considered when interpreting our findings. The response rate of 43% is relatively low and the non-response-bias might influence our results. Nevertheless, the response rate is comparable to other survey studies and the evaluated cohorts of hospitals providing all medical specialties were homogenous, regardless of differences in response rates (5, 6). It might also be possible that respondents gave false statements aiming to fulfill certain expectations. To mitigate this response bias, questionnaires were anonymized. Furthermore, the fact that 44% of the respondents did not attend advanced training in the last 12 months and that only 23% confirmed that all details regarding MDRO and further outpatient arrangements are provided in the discharge-letters of their department indicates honest self-critical and reliable feedback. The differences between internists and non-internists were significant, but the differences on the Likert scale were rather small. The performance rates in the test case and in determining the right rate of ciprofloxacin resistance were slightly but not significantly higher in internists. Thus it cannot be excluded that we did not find better performance in the internists although it may have been present, possibly due to the small sample size but also due to the size of the effect. This study targeted German tertiary care hospitals and academic hospitals, and thus might not be generalizable to other regions or hospital types. In regard to hospital type, the facility type was accounted for in multivariate models to mitigate hospital-level biases. Finally, the chosen questionnaire items have not yet been validated. Yet, the questions were chosen from other surveys and after consultation with experts in the field of infectious diseases and a pilot study demonstrated the applicability and comprehensibility of the survey.

In conclusion, the data from the MR2-questionnaire study presented here indicate that internists do not differ in their perception and assessment of issues regarding MDRO and antibiotic prescribing as compared to their surgical colleagues. This is despite their role as primary caregivers for many patients with infectious diseases in an in-patient setting. Given the identified deficits in knowledge regarding MDRO the data thus underline the need for additional advanced MDRO/ABS training for physicians, irrespective of their specialty. Mandatory implementation of ABS programs in German hospitals could support this training in all specialties and raise physician's awareness and

proficiency in antimicrobial treatment. Furthermore, the data gained from the MR2-questionnaire study offer the possibility to optimize and expand questionnaire design: thereby, more detailed evaluation of MDRO and ABS knowledge as well as longitudinal assessments prior to and after implementation of ABS-based trainings could be performed and incorporated into a routine hospital setting.

Acknowledgments

We would like to thank our colleagues from the following hospitals for participating in the MR2 study: Barmherzige Brüder Hospitals Munich, Regensburg and Straubing, Biberach Hospital, Carl-Thiem Klinikum Cottbus, Clinic Dortmund, Frankfurt/Oder Hospital, Garmisch-Partenkirchen Hospital, University Clinic Gießen, Hameln Hospital, University Medical Center Magdeburg, University Medical Center of the Technical University Munich, Nauen Hospital, Ruppiner Kliniken and Brandenburg Medical School, Pegnitz Hospital, Caritas St. Josef Medical Center Regensburg, Kliniken Nordoberpfalz, Weiden.

Compliance with ethical standards and conflicts of interest

Compliance with ethical standards: We affirm that all authors have complied with the principles of the Caspian Journal of Internal Medicine regarding ethical responsibilities of authors and compliance with ethical standards.

Research involving Human Participants and/or Animals: not applicable

Funding: not applicable

Conflicts of interest: F Wagenlehner has served as a paid consultant for Achaogen, Astellas, AstraZeneca, Bionorica, Cubist, Galenus, GSK, Janssen, Leo-Pharma, Merlion, MSD, OM-Pharma, Pierre Fabre, Rosen Pharma, and Zambon, has received payment for presenting at continuing medical education events from Astellas, AstraZeneca, Bionorica Cubist, Galenus, Leo-Pharma, Merlion, MSD, OM-Pharma, Pierre Fabre, Rosen Pharma, Pfizer and Zambon, has also received payment for carrying out clinical trials on behalf of Achaogen, Astellas, AstraZeneca, Bionorica, Calixa, Cerexa, Cubist, The German Research Foundation (Deutsche Forschungsgemeinschaft), the European Association of Urology, Galenus, The Hessen State Ministry of Higher Education, Research and the Arts, Merlion, OM-Pharma, Rosen Pharma, and Zambon.

The other authors have no conflicts to report. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. European Centre for Disease Prevention and Control. The bacterial challenge: time to react. Stockholm: ECDC; 2009. Available at: http://www.ecdc.europa.eu/en/publications/Publications/0909_TER_The_Bacterial_Challenge_Time_to_React.pdf
2. Pletz MW, Eckmann C, Hagel S, et al. Current strategies against multi-drug resistant organisms. Dtsch Med Wochenschr 2015; 140: 975-81.
3. German Federal Ministry of Health. DART 2020 – Fighting antibiotic resistance for the good of both humans and animals. Available at: https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/A/Antibiotika-Resistenz-Strategie/BMG_DART_2020_Bericht_en.pdf Accessed January 23, 2018.
4. Davey P, Marwick CA, Scott CL, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database Syst Rev 2017; 2: CD003543.
5. Remesh A, Gayathri AM, Singh R, Retnavally KG. The knowledge, attitude and the perception of prescribers on the rational use of antibiotics and the need for an antibiotic policy-a cross sectional survey in a tertiary care hospital. J Clin Diagn Res 2013; 7: 675-9.
6. Jump RL, Heath B, Crnich CJ, et al. Knowledge, beliefs, and confidence regarding infections and antimicrobial stewardship: a survey of Veterans Affairs providers who care for older adults. Am J Infect Control 2015; 43: 298-300.
7. Hansen S, Sohr D, Piening B, et al. Antibiotic usage in German hospitals: results of the second national prevalence study. J Antimicrob Chemother 2013; 68: 2934-9.
8. Laxminarayan R, Duse A, Wattal C, et al. Antibiotic resistance-the need for global solutions. Lancet Infect Dis 2013; 13: 1057-98.

9. Lebentrau S, Vetterlein MW, May M. The Urologist's Role in Antibiotic Stewardship: Results from the MR2 Study. Eur Urol 2017; 71: 995-6.
10. Lebentrau S, Gilfrich C, Vetterlein MW, et al. Impact of the medical specialty on knowledge regarding multidrug-resistant organisms and strategies toward antimicrobial stewardship. Int Urol Nephrol 2017; 49: 1311-18.
11. Grabe M, Bartoletti R, Bjerklund Johansen TE, et al. EAU-Guidelines on Urological Infections. Limited Update March 2015. Available at: https://uroweb.org/wp-content/uploads/19-Urological-infections_LR2.pdf [Accessed January 17, 2018]
12. Esparcia A, Artero A, Eiros JM, et al. Influence of inadequate antimicrobial therapy on prognosis in elderly patients with severe urinary tract infections. Eur J Intern Med 2014; 25: 523-7.
13. Tanriover MD, Rigby S, van Hulsteijn LH, et al. What is the role of general internists in the tertiary or academic setting? Eur J Intern Med 2015; 26: 9-11.
14. Rossio R, Franchi C, Ardoino I, et al. Adherence to antibiotic treatment guidelines and outcomes in the hospitalized elderly with different types of pneumonia. Eur J Intern Med 2015; 26: 330-7.
15. Tacconelli E, Magrini N, et al. Global priority list of antibiotic-resistant bacteria to guide research, discovery, and development of new antibiotics. WHO; 2017. Available at: http://www.who.int/medicines/publications/global-priority-list-antibiotic-resistant-bacteria/en [Accessed January 17, 2018]