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ORIGINAL PAPER

Infectious disease services: a survey from four university hospitals in Germany

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Abstract

Purpose Involvement of infectious disease (ID) specialists in the care of hospitalized patients with infections through consultation services improves the quality of care and the outcome of patients. This survey aimed to describe activities and utilization of ID consultations at four German tertiary care hospitals.

Methods A 1-month (March 2016) retrospective cross-sectional study at four university hospitals (Freiburg, Jena, Cologne and Regensburg) was performed. Only ID consultations with written documentation and bedside patient evaluation were included. Consultations were analyzed with regard to requesting departments, infections, case severity, and diagnostic and therapeutic recommendations.

Results In the study period, 638 ID consultations were performed in 479 patients—corresponding to 3–4 consultations per 100 inpatient cases. Patients were characterized by a high disease complexity—the mean case mix index in patients with consultation was 10.1 compared to 1.6 for all patients. ID consultations were requested by many different specialties, with approximately half of the requests coming from surgical disciplines. ID consultations resulted in revised diagnoses in 34% of the cases, provided recommendations for additional diagnostic procedures in 66%, and for modifications of antimicrobial regimens in 70% of the cases.

Conclusions Infectious disease consultations were requested for patients with severe and complicated diseases and resulted in recommendations that highly impacted the diagnostic work-up and therapeutic management of patients. The results of this survey may help to estimate requirements for establishment of such services in Germany.

Keywords Infectious disease consultation · Quality of care · Quality indicators · Patient management · Difficult-to-treat infections · Survival

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Introduction

Two current challenges are eminent in the management of infectious diseases: the increasing rates of antimicrobial resistance especially in Gram-negative pathogens and the rising numbers of patients at risk for severe infections, either due to immunosuppressive regimens or to complex procedures including implantation of prosthetic joints, intracardiac devices, vascular grafts, and others [1].

A number of studies have demonstrated that ID consultation services can improve quality of care in patients with severe infections. This can translate to better adherence to diagnostic and therapeutic quality indicators, and even to better survival [1]. These effects have best been demonstrated in bloodstream infections with *Staphylococcus aureus* and with *Candida* spp. [2–5]. When performed in

the early phase of hospitalization, ID consultations reduce the length of stay [6]. Moreover, ID consultations result in higher rates of targeted and narrow spectrum antibiotic therapies, leading to lower rates of antimicrobial resistance development [7–9].

To deliver optimal care for patients with complex infections, adequate staffing of infectious diseases services is mandatory especially in tertiary care hospitals [10].

In contrast to other European countries, specialized infectious disease consultation services are established only in few centers in Germany, mostly university or tertiary care centers. The centers contributing to this survey were established initially with funds of the Federal Ministry of Education and Research (BMBF). Experiences made in these centers may serve as a template for the development of new and further centers with specialized ID consultation services in secondary or tertiary care centers in Germany. The aim of the current survey was to describe utilization and activities of ID consultation services at four German tertiary care hospitals. In particular, we were interested in patient characteristics, reasons for consultations (including type of infection and causative pathogen), requesting disciplines, and the type of recommendations made by ID consultants.

Methods

Study design and setting

In this retrospective cross-sectional survey, we analyzed the inpatient infectious disease (ID) consultations at four University Hospitals over 1 month (March 2016).

The four study sites were the University Hospitals of Cologne, Freiburg, Regensburg and Jena. These hospitals have a large number of inpatients (range 32,000–69,000 admissions per year). The ID divisions at the participating hospitals additionally have ID outpatient clinics with further special services, e.g. for HIV-infected patients, patients with tuberculosis, with multi-resistant pathogens, immunocompromised patients, travel clinic and others, and some run inpatient ID wards. ID consultation services were established for more than 5 years in each of the centers. In addition to the formal bedside consultations with written reports, the ID consultants participate in further activities in the care of patients with suspected or proven infectious diseases. These consist of telephone consultations without patient contact (5–10/day per consultant), written consultations for outpatients, interdisciplinary boards (e.g. osteomyelitis, endocarditis) and intensive care unit rounds. Each hospital employs at least three physicians for these functions.

Definitions

Only formal bedside ID consultations fulfilling the following criteria were included in the analysis: (i) the consultation was requested or triggered by local rules ('self-initiated'/mandatory, e.g. *S. aureus* bloodstream infection) for inpatients, (ii) the consultation included the critical review of all medical reports, recent interventions and therapies, a detailed medical history and a thorough patient evaluation at the bedside, and (iii) the resulting recommendations concerning diagnostic procedures and therapy were discussed with the responsible physician and recorded in written form. Both first and follow-up consultations were included. Telephone or curbside consultations, written consultations without patient contact, out-patient consultation, interdisciplinary boards and ward rounds were excluded.

Statistics and ethics

Data analyzed were the numbers of ID consultations (including the time trend over years) and the characteristics of the hospitals [number of inpatient beds and admissions, case mix index (CMI), inpatient length of stay]. Data for the characterization of the hospitals were retrieved from the local central data collections. All other data were extracted from the written consultation forms and entered anonymously in an online questionnaire registered in Clinicalsurveys.net, a web-based portal and documentation system. The questionnaire was developed by the four centers. Data analysis was performed using Microsoft Excel Version 2010 and GraphPad5 software.

We followed the ethical standards set by the Helsinki Declaration of 1975, as revised in 2004, and the research guidelines of the Universities of Freiburg, Cologne, Regensburg and Jena. No patient attributable or identifying data were used in this retrospective study. Thus, neither formal ethics committee approval nor informed consent was necessary for this study.

Results

All centers had started with at least 400 formal ID consultations within the first year of implementation and had a continuous increase to over 1500 formal ID consultations after 5 years (see Fig. 1). In 2016, the ID consultations of the four centers added up from 2.9 to 4.2 consultations per 100 inpatients and from 3.6 to 5.0 consultations per 1000 occupied bed days, respectively. During the survey period,

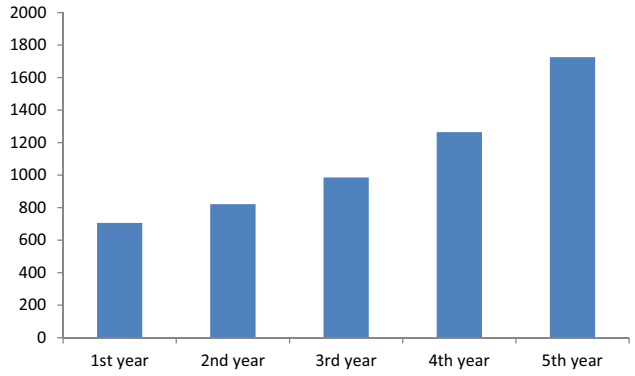

Fig. 1 Trend in numbers of ID consultations over the first 5 years after implementation of the ID services. Data are presented as the mean value of the four hospitals

a total of 638 formal ID consultations for 479 patients were performed at the four centers.

Patients with formal ID consultations suffered from more severe or complex diseases compared to all inpatients, which is reflected in higher case severity indices [with ID consultation: mean case mix index (CMI) 10.1 (range 7.7–14.8); without ID consultation: 1.6 (range 1.4–1.9)] and longer length of stay in the hospital [with ID consultation: mean 32 days (range 28–38 days)]; without ID consultation: 6.8 days (range 6.0–7.9 days) (see Table 1).

The median age was 65 years, 64% were male and 25% were treated in intensive care units (Table 2). The conditions leading to hospital admission were often other conditions than infections (42%), with cardiovascular diseases representing the main entities (12%). 83% of the consultations were performed on request; about half of the self-initiated consultations were performed to optimize the management of *S. aureus* bloodstream infections (8% of total). 62% of the 638 consultations were first, 21% second and 17% third or later follow-up consultations.

Requests from surgical and non-surgical departments for ID consultations were nearly identical in frequency (Table 3). Of all internal medicine departments, cardiology requested the highest number of ID consultations ($n=97$; 15%), whereas within the surgical departments, cardiac and thoracic surgery were the leading specialties ($n=91$; 14%).

Patients without antimicrobial therapy before ID consultation represented only a small fraction (12%) (Table 4). Most requests were related to diagnostic management (76%) and/or antimicrobial treatment modification (33%). Accordingly, 66% of the recommendations included diagnostic tests or procedures. In addition, other specific requests (16%) included questions regarding vaccinations, risk evaluation before continuation of antineoplastic chemotherapy, relevance of isolated pathogens, prophylaxis (perioperative and post-exposure), optimal time of re-implantation of prosthetic devices, infection control procedures or alternative therapy in case of allergy. Non-specific requests (4%) were related to additional thorough ID evaluation of patients with complex diseases.

Infections presumed by the primarily treating physicians were not confirmed by the ID consultant in 11%, and new infections could be diagnosed in 7% (Table 4). Non-infectious conditions were diagnosed by ID consultation in 2%. In 70%, the ID consultants recommended modification of current antimicrobial therapy—either of the drug used, the dose or the route of application.

The ID consultants identified a new focus of infection in 314 patients (65%) and relevant pathogens in 389 patients (81%) (Supplementary table S1). The four most common foci of infection (respiratory tract, bone/joint, cardiovascular, skin and soft tissue) together accounted for 79% of identified foci. In the majority of the consulted patients with proven pathogens, infections were caused by bacteria (80%) followed by fungi (12%) and viruses (8%). Among bacterial pathogens, Gram-positive species were more frequently isolated (68%), with *S. aureus* being the most commonly confirmed pathogen (28%; $n=88$), more than twice as frequent as the next most common pathogen (*Enterococci* spp. $n=41$; *Streptococci* spp. $n=39$). *E. coli*

Table 1 Characteristics of hospital capacities, case mix index and length of stay

	Hospital A	Hospital B	Hospital C	Hospital D
Number of inpatient beds	1615	1413	1435	833
Number of inpatients (2016)	68.814	62.260	53.635	34.549
Case mix index of all inpatients (2016)	1.4 (2.9)	1.7 (3.5)	1.5 (n.a.)	1.9 (3.9)
Case mix index of patients with ID consultation (March 2016)	7.7 (15.0)	11.0 (16.6)	8.3 (9.6)	14.8 (28.2)
Inpatient length of stay of all patients (days) (2016)	6.0 (8.7)	6.6 (10.4)	7.0 (n.a.)	7.6 (10.7)
Inpatient length of stay of patients with ID consultation (days) (March 2016)	28.2 (32.4)	38.1 (36.8)	32.5 (26.3)	30.2 (20.7)

Data are presented as the mean level with the standard deviation given in parenthesis, unless indicated otherwise

n.a. not available

Table 2 Characteristics of ID consultations and corresponding patients

Parameters	Number (%)
Consultations	638
Patients	479
Age [median (IQR)]	65 (49–74)
Male	411 (64)
Treatment at	
General ward	452 (71)
Intermediate care unit	24 (4)
Intensive care unit	162 (25)
Specification of discipline/ward	
Surgical	318 (50)
Non-surgical	320 (50)
Diagnosis at admission	
Infection	279 (58)
Non-infectious disease	200 (42)
Cardiovascular	56 (12)
Malignant	45 (9)
Autoimmune	13(< 1)
Other	86 (18)
Initiation of ID consultation	
On-demand	533 (83)
Self-initiated/mandatory	105 (16)
S. aureus bloodstream infection	51 (8)
Candidemia	11 (2)
Other indications	43 (7)
Duration from admission until ID consultation (median of days, IQR)	
Current ID consultation (in the observation period)	12 (5–26)
First ID consultation	6 (2–15)
First and follow-up ID consultations	
First	395 (62)
Second	134 (21)
Third	58 (9)
Forth	26 (4)
Fifth or more	25 (4)

Data are numbers with percentages given in parenthesis, unless indicated otherwise

was the leading Gram-negative bacterium (7%; $n = 23$), and *Candida* spp. ($n = 29$), the most frequently isolated fungal pathogen.

Discussion

The results of our study can be summarized in five statements: (i) cases evaluated by the ID consultation service were highly complex. (ii) ID consultations were requested in nearly equal proportions from surgical vs. non-surgical disciplines. (iii) In 70% of ID consultations, modifications of antimicrobial treatment regimens were recommended. (iv) 20% of ID consultations led to a new or altered diagnosis. (v) The number of ID consultation requests increased substantially over a period of 5 years.

The observed high complexity of patients is documented by the high case severity indices, which are substantially higher than the average CMIs of participating hospitals. Differences in length of stay and the proportion of patients being evaluated more than once point to the same direction. Thus, our investigation demonstrates that ID consultants are requested especially in complicated diseases and difficult-to-treat scenarios. A prerequisite in this context is a profound and multifaceted education and training: In the participating centers, each ID physician (attending and resident) completed an internal medicine residency. Half of requests were derived from surgical disciplines. This high rate may be related to the appreciation of the diagnostic and therapeutic expertise of involved consultants and indicates that internal medicine skills may be highly complementary and synergistic to the surgeon's competencies in the care of surgical patients.

The high complexity of cases demands adequate staffing of the ID consultation service, both in quantity and quality. The current survey shows that the number of consultations and the staffing were similar in the four centers—to deliver > 100 consultations per month or 3–4 per 100 admissions two to three physicians who primarily served as consultants were active in the services. However, according to other studies a consultation density of 3–4 per 100 inpatient cases is not sufficient to meet the overall demand. Thus, to secure an optimal coverage the number of consultations would need to be adjusted [11, 12]. Of note, within the current system of reimbursement (DRG based) in Germany, a separate fee for such a service is not provided. To foster further ID services in additional hospitals in Germany, new models for reimbursement need to be developed.

The broad spectrum of departments requesting consultations together with the observed diversity of infectious foci and pathogens underlines that difficult-to-treat infections and challenging differential diagnoses are encountered in almost all clinical disciplines [13–15]. A growing number of studies substantiates that ID consultations are considered as critical in different clinical contexts such as surgical, medical or neurological intensive care units [16–18], hematology-oncology and transplantation wards [19], and in orthopedic/trauma surgery or cardiothoracic units [20]. This is reflected in current guidelines, which recommend regular ID consultations in infective endocarditis [21, 22], orthopedic device-associated infections [23] and vertebral osteomyelitis [24]. In addition, involvement of ID consultants is recommended in patients with invasive aspergillosis [25], candidemia [26], or sepsis/septic shock [27].

Table 3 Departments requesting ID consultations

Department	Number (%)
Non-surgical	298 (47)
Internal medicine with subspeciality*	231 (36)
Cardiology	97 (15)
Gastroenterology	45 (7)
Hemato-oncology	40 (6)
Nephrology and rheumatology	37 (6)
Pneumology	7 (1)
Geriatrics	5 (< 1)
Other (pediatrics, psychiatry, neurology, radiotherapy, dermatology, palliative care medicine)	67
Surgical	340 (53)
Surgical speciality	233 (37)
Cardiac surgery/thoracic surgery	91 (14)
Orthopedics/trauma surgery (including hand and reconstructive surgery)	61 (10)
Neurosurgery (including stereotaxis)	41 (6)
Abdominal surgery	22 (3)
Vascular surgery	18 (3)
Oral and maxillofacial surgery	3 (< 1)
Other (surgical/anaesthesiological intensive care, otolaryngology, ophthalmology, gynecology, urology)	107 (17)
Sum	638

*Including intensive care (internal medicine)

In two-thirds of patients, additional diagnostic procedures were suggested and in 70% of cases a modification of antimicrobial therapy was recommended. The outcome of these recommendations could not be evaluated in terms of patient safety and outcome. However, it can be presumed that these suggestions had an impact on patient management in many instances. This is exemplified by the fact that 60% of ID consultant-recommended surgical interventions such as debridement or focus eradication were subsequently performed. In a time of growing (sub)specialization and continuous shortening of length of stay, diagnostic and therapeutic advice of experienced ID clinicians is highly welcomed, particularly by less-experienced physicians. These observations give an estimate on how highly-qualified ID consultation services implemented regularly in secondary and tertiary care centers would positively impact treatment quality, patient safety, and potentially economic burden of infectious diseases.

We could not investigate the impact of ID consultations with respect to duration of antibiotic treatment, time until clinical improvement or cure, length of stay and mortality. Given the heterogeneity of the patient population and their respective infections, this is difficult to accomplish even with large numbers of consultations. However, according to results of other studies, positive effects may be expected [1]. Our survey focused on recommendations of ID consultants. Evaluation of adherence to these recommendations and correlation to discharge diagnoses are worthwhile to study in the future, yet the retrospective nature of the current survey does not allow a sound analysis of these aspects. Another limitation of our survey is its non-generalisability to general hospitals, as it was performed at four tertiary care/university hospitals. However, we sought to deliver key figures that may serve as templates for establishing ID consultation services in other settings including non-academic hospitals in Germany.

Conclusion

This survey summarizes activities of ID consultation services, the disciplines requesting these services, the spectrum of infections and key figures of staffing which may serve as template for establishing additional ID consultation services at other tertiary care hospitals.

The current challenges in infectious diseases with rising number of patients at risk for severe or complicated infections and the rapid emergence of antibiotic resistance can only be met by an appropriate number of well-trained clinical ID specialists. Stepping up education programs in infectious diseases and setting up integrative and interdisciplinary ID consultation services are essential to ensure optimal care and therapeutic outcomes of patients.

Table 4 Requests to and advice of ID specialists

	Number (%)
Patients without antiinfective therapy before ID consultation	79 (12)
Antiinfective treatment* before ID consultation	
Antibacterial	527 (83)
Antifungal	82 (13)
Antiviral	36 (6)
Antiparasitic	3 (< 1)
Requests for ID consultation related to*	
Diagnostic management	484 (76)
Optimizing treatment	212 (33)
Other specific questions	99 (16)
Unspecific questions	28 (4)
ID diagnosis before ID consultation	
Nosocomial infection	262 (41)
Community-acquired infection	311 (49)
ID diagnosis after ID consultation*	
Nosocomial infection	281 (44)
Community-acquired infection	300 (47)
Colonization or contamination (without evidence for infection)	30 (5)
Other diseases (without evidence for infection)	24 (4)
Diagnosis before and after ID consultation*	
Infection/diagnosis confirmed	423 (66)
Infection/diagnosis not confirmed	71 (11)
New infections	44 (7)
New diseases (not infectious)	12 (2)
Advice regarding diagnostic management	
Yes	419 (66)
No	219 (34)
Advice regarding antiinfective treatment*	
Continue current antimicrobial therapy	189 (30)
Modification of current antimicrobial therapy	449 (70)
Drug	153 (24)
Dose	34 (5)
Additional drug	72 (11)
Stop single but not all drugs	86 (14)
Stop all drugs	50 (8)
Change to oral route with same drug	7 (1)
Change to oral route with different drug	18 (3)
Other interventions (e.g. surgical intervention)	10 (2)
Recommended surgery performed[†]	6/10 (60)

*Multiple answers possible

[†]In one case the patient did not consent to the planned surgery

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Compliance with ethical standards

Conflict of interest None to declare.

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