Frequency Distribution of the Microbial Isolates in Major Nosocomial Infections Groups

Todorova-Christova M*, Vatcheva R², Filipova R², Kamenova T¹, Arnaudov Y¹, Radulova Y¹, Ivanov I¹ and Dobrev E¹

¹National Center of Infectious and Parasitic Diseases, Sofia, Bulgaria
²University Hospital "Queen Yoanna", Sofia, Bulgaria
³Ministry of Health, Sofia, Bulgaria
⁴National Center of Public Health and Analyses, Sofia, Bulgaria

Abstract

This second part presents the results of the survey of the microbial isolates frequency distribution by infection sites (principal NI classification groups) in the country throughout the period 1999-2011. The results refer to the overall percentage distribution of the isolates in major NI classification groups (VAP, LRTIs, SSIs, sepsis, UTIs) on the basis of the official registration data of the Computerized Information System-Nosocomial Infections (CIS-NI).

The objective was to emphasize the tendencies in the isolation rate of the most frequent nosocomial pathogens for the period studied attempting to propose links for binding the surveillance of NI microbiological diagnostic with the special surveillance of patients undergoing risk procedures as well as a link for monitoring of the drug-resistance.

The generalized CIS-NI database for the total country is extrapolated. The predominance of the ten most frequently isolated microbial species is presented in the form of percent from the total number of isolates in the microbiologically confirmed cases for the corresponding infections group (infection site), and for the corresponding year of the period indicated.

The microbial characteristics presented mark out in broad outlines the involvement of the most common microbial agents important for the clinical practice nosocomial infections. The isolates assigned as NI causative agents refer predominantly to strains of S. aureus and E. coli (of substantial importance in SSIs), S. aureus (sepsis), E. coli (UTIs), a number of opportunistic bacteria as Pseudomonas spp., Acinetobacter spp., Klebsiella spp., enterococci, other Enterobacteriaceae as Enterobacter spp. and Serratia spp., Proteus spp. (VAP, LRTIs, sepsis). These species in comparatively constant or in separate years in an increasing percentage are invariably present in the visualized by years microbiological spectrum of the discussed infections groups. The presented microbiologic characteristics emphasizes the necessity of strict implementation of the NI prevention and control measures endorsed, updated guidelines including, in the risk clinical practices as operative/resuscitation procedures and manipulations, installation of vascular devices, urinary catheters, etc., and the care respectively for the patients, undergoing such procedures as preoperative, postoperative care, or attendance in the course of other clinical treatment.

Schemes for assessment of the antibacterial resistance based on NHSN pattern are proposed for approbation as well as adapted from external sources e-files intended for supervision of the observance of the correct hospital practices for care of the patients on mechanical ventilation and/or vascular catheter.

Keywords: Nosocomial infections; Computerized information system-nosocomial infections; Ventilator-associated pneumonia; Lower respiratory tract infections; Pulmonary infections; Surgical site infections; Urinary tract infections; Sepsis; Central line-associated bloodstream infection; Catheter-associated urinary tract infection; Coagulase-negative Staphylococci

Introduction

The microbiological diagnosis, comprising the relevant antimicrobial sensitivity testing of the isolates in nosocomial infections is of basic importance for the proper treatment of the patients, the latter relying in a large number of urgent cases on rapid tests. The microbiological tests are of particular importance in the treatment of infections caused by multi-resistant bacteria. Due to emerging or increasing resistance of hospital strains selected in the hospital environment, the exact microbial diagnosis and the complementary antibiogram are the primary precondition for the treatment of infections caused by drug-resistant bacteria. The information system in the country exerts a continued surveillance of nosocomial infections microbiological characteristics. The indices engage frequency distribution (percentage of isolates) by infection sites, and by infection sites and types of wards. Along the first line we dispose of the overall data for the country about the total percentage of the identified to species and subspecies isolates in each infection site, the data considered indicative of the common isolation level, attributable to nosocomial infections by years.

Objective

This second part presents the results of the survey of the microbial isolates frequency distribution by infection sites (principal NI classification groups) in the country throughout the period 1999-2011. The results refer to the overall percentage distribution of the isolates in major NI classification groups (VAP, LRTIs, SSIs, sepsis, UTIs) on the basis of the official registration data of the Computerized Information System-Nosocomial Infections (CIS-NI).

*Corresponding author: Todorova-Christova M, National Center of Public Health and Analyses, Sofia, Bulgaria, Tel: +359 2 94 46 99; E-mail: maria.christova@gmail.com

Received November 25, 2014; Accepted February 20, 2015; Published February 20, 2015

Citation: Todorova-Christova M, Vatcheva R, Filipova R, Kamenova T, Arnaudov Y, et al. (2015) Frequency Distribution of the Microbial Isolates in Major Nosocomial Infections Groups. J Bacteriol Parasitol 6: 217. doi: 10.4172/2155-9597.1000217

Copyright: © 2015 Todorova-Christova M, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Information System-Nosocomial Infections (CIS-NI). The objective was to emphasize the tendencies in the incidence rates (in the first part of the study) and the isolation rate of the most frequent nosocomial pathogens (second part) for the period studied attempting to propose links for binding the surveillance of NI microbiological diagnostic with the special surveillance of patients undergoing risk procedures as well as a link for monitoring of the drug-resistance.

Materials and Methods

The bacterial etiology is discussed of the principal NI groups, subject to surveillance in the country as VAP, LRTIs (pulmonary infections), SSIs, UTIs, sepsis, in the course of a comparatively long period from 1999 to 2011. The generalized CIS-NI database for the total country is extrapolated. The predominance of the ten most frequently isolated microbial species is presented in the form of percent from the total number of isolates in the microbiologically confirmed cases for the corresponding infections group (infection site), and for the corresponding year of the period indicated. The importance of some subspecies is specifically emphasised. Although the comparisons by years of the most frequent isolates in each of the above-mentioned infection sites utilize only percentages as a statistical criterion, this frequency distribution still gives an idea of the microbial characteristics of important nosocomial infections, analyzing the changes in the thus extrapolated isolation level of the leading causative agents.

Results

Frequency distribution of the microbial isolates by infection sites

Ventilator-associated pneumonia (VAP): Table 1 indicates the ten most frequently isolated microbial species isolated from tracheal aspirate samples of patients registered with Ventilator-Associated Pneumonia (VAP). The data refer only to 2011, the year of VAP introduction as a separate category into the surveillance system. Practically these are the data, originating grow the critical care units in the country, attending for patients on mechanical ventilation, i.e. the units classified, according to the latest update of the wards nomenclature as Anesthesiology & Reanimation (A&R), and Intensive Therapy (IT).

On the basis of our data of greatest importance for pulmonary infection in intubated patients are opportunistic (conditionally pathogenic bacteria) of high potential for survival in the environment at minimum requirements for humidity, and of proved multiple drug resistance of the hospital strains of these species by a number of foreign and our studies [1-5], P. aeruginosa-27%, Acinetobacter baumannii-29%, K. pneumoniae-15%. A comparison with 2006-2007 NHSN data indicates the same species ranking among the most common pathogens, e.g., P. aeruginosa-16%, Acinetobacter baumannii-8%, K. pneumoniae-7% [6]. One of the differences is that S. aureus accounts for the highest percentage of the isolates according to NHSN data (24.4%), in our country it is isolated in 5% of VAP microbiologically confirmed cases. Both systems, however, submit data about the isolation of intestinal flora-facultative anaerobes as: coliforms (sanitary-indicative microorganisms, used for testing of environmental samples for fecal contamination-pneumonia. In our (of 5% each species-CIS-NI data). The two subspecies of the latter-E. aerogenes and E. cloacae have been proved as causative agents of sepsis and VAP-immunocompromized patients and patients on mechanical ventilation [1,4,7], Proteus spp. (3% in our country), Enterococci (2%-CIS-NI, 1,3%-NHSN), of which E. faecalis (1%, NHSN-0,4%), fungi-Candida spp. [2,3,7,9].

LRTIs (Pulmonary infections)

Brief introduction to the problem: Nosocomial bacterial pneumonia is often a complication subsequent to operative procedure. By reason of that NHSN reports it separately as postoperative pneumonia-“post procedure pneumonia”. In our system the International Disease Classification nosologic group of the pulmonary infections is adopted, including pneumonia and borderline conditions as bronchiolitis and bronchitis, no differentiation, however, made strictly for the cases of postoperative pneumonia.

By analogy with VAP cases (patients on prolonged mechanical ventilation), the patients undergoing operative intervention, critically ill patients and immunocompromized due to other reasons, are supposedly especially susceptible to a pulmonary infection. Nosocomial infections may occur as a result of primary and much more rarely secondary bacteremia, the latter occurring mainly following skin infections [8].

The follow up of LRTIs bacterial etiology for the prolonged period studied (1999-2011) demonstrates to a high extent similarity with the indicated for VAP (Table 2). Main causative agents are the above-mentioned opportunistic bacteria, according to 2011 data: P. aeruginosa (19%), Acinetobacter spp. (17%), K. pneumoniae (14%), responsible as a total for a half of all the registered cases of nosocomial pneumonia. S. aureus isolates maintain a comparatively stable percentage in the course of years-between 8 and 13%. Fungi (Candida spp.) and fecal microorganisms (E. coli, Enterobacter spp. and Enterococcus spp.) are isolated as comparatively common pathogens.

The isolated in VAP or postoperative pneumonia strains of conditionally pathogenic flora, normally commensal bacteria of the upper respiratory tract (K. pneumoniae) or the environment (P. aeruginosa, Acinetobacter spp.), are treated as hospital strains. The isolation of such strains, belonging to species known for their multiresistance, may pose serious problems to the treatment of the infections, and implies on the strict compliance with the clinical protocols for operating rooms/resuscitation/surgery as regards the specified NI control measures for the operative/resuscitation procedures.
Table 2: The ten most frequent pathogens of lRTIs (pulmonary infections). 1999-2011 (% of the microbiologically confirmed cases).

| LRTIs (Pulmonary infections) | 1999 | 2000 | 2001 | 2002 | 2003 |
|------------------------------|------|------|------|------|------|
| P. aeruginosa                | 22.0 | 25.0 | 28.8 | 23.2 | 26.3 |
| Acinetobacter spp            | 16.0 | 17.0 | 12.7 | 12.4 | 13.1 |
| S. aureus                    | 13.0 | 11.3 | 12.7 | 11.9 | 10.2 |
| K. pneumoniae                | 9.9  | 10.8 | 11.9 | 11.4 | 8.9  |
| E. coli                      | 5.7  | 6.0  | 6.1  | 9.7  | 9.2  |
| Viruses                      | 5.4  | 3.8  | 4.5  | 5.5  | 5.9  |
| Serratia spp                 | 3.9  | 3.8  | 3.7  | 5.4  | 4.0  |
| Str. pneumoniae              | 3.8  | 3.8  | 3.4  | 2.8  | 3.2  |
| P. mirabilis                 | 3.4  | 3.1  | 3.2  | 2.0  | 2.7  |
| Candida spp                  | 2.9  | 3.0  | 3.1  | 1.8  | 2.2  |

| LRTIs (Pulmonary infections) | 2004 | 2005 | 2006 | 2007 | 2008 |
|------------------------------|------|------|------|------|------|
| P. aeruginosa                | 25.9 | 27.7 | 23.8 | 23.2 | 20.1 |
| Acinetobacter spp            | 19.7 | 21.3 | 19.1 | 18.0 | 19.5 |
| S. aureus                    | 9.85 | 9.3  | 12.4 | 9.6  | 11.8 |
| K. pneumoniae                | 7.98 | 8.9  | 6.4  | 9.1  | 7.5  |
| E. coli                      | 6.68 | 4.1  | 5.5  | 6.1  | 6.7  |
| Viruses                      | 4.64 | 4.1  | 4.6  | 5.6  | 6.3  |
| Enterobacter spp             | 3.42 | 4.0  | 4.1  | 4.0  | 5.5  |
| Str. pneumoniae              | 3.17 | 3.1  | 3.3  | 3.2  | 2.3  |
| Candida spp                  | 3.17 | 2.7  | 2.2  | 1.9  | 2.0  |
| Serratia spp                 | 2.85 | 1.3  | 2.0  | 1.4  | 1.9  |
| Enterococcus spp             | 1.0  | 0.8  | 0.8  | 0.9  | 3.3  |

| LRTIs (Pulmonary infections) | 2009 | 2010 | 2011 |
|------------------------------|------|------|------|
| Acinetobacter spp            | 19.4 | 19.8 | 19.3 |
| P. aeruginosa                | 19.0 | 19.7 | 16.6 |
| K. pneumoniae                | 11.5 | 15.2 | 14.0 |
| S. aureus                    | 9.0  | 8.4  | 9.8  |
| Candida spp                  | 7.2  | 5.7  | 7.0  |
| Enterobacter spp             | 5.4  | 5.3  | 4.9  |
| E. coli                      | 4.2  | 5.0  | 4.7  |
| Str. pneumoniae              | 2.6  | 2.7  | 3.2  |
| Serratia spp                 | 2.2  | 1.8  | 2.1  |
| P. mirabilis                 | 2.0  | 1.7  | 2.0  |
| Streptococcus spp            | 4.9  | 3.2  | 6.6  |
| Enterococcus spp             | 4.0  | 1.3  | 3.2  |
| CoNS                         | 3.2  | 1.4  | 1.2  |

and postoperative care, for example the requirements for reprocessing of reusable resuscitation/anesthesia equipment etc.

**Surgical Site Infections (SSIs)**

**Brief introduction to the problem:** Surgical Site Infections (SSIs) are frequent complications, diminishing the effect of the operative procedure, in certain cases to a fatal outcome from the intervention, at the same time prolonging the hospital stay and increasing the treatment costs because of additional antibiotic coverage. The surveillance of these infections takes into account the impact of the type of the operative procedure, i.e. the routine surgical technique applied, over the incidence and etiology of infections. For the present our system reports the overall incidence rates and etiology (percent of the causative agents) by infection site and hospital wards. A more precise surveillance system submits the NHSN, former NNISS component respectively. The SSIs module takes into account risk factors as surgical wound class, duration of operation and ASA score, the latter evaluating patients’ physical status prior to the surgical intervention in five subcategories.

Another criterion, for the present interpreted only clinically, is the anatomical localization of the infection and the classification of SSIs accordingly to incisional, including superficial and deep incisional, and organ/space or organ/cavity type. An eventual categorization according
to this definition should engage precised criteria applying to the special surgery interventions, e.g. comments proposed for the elective colon surgery by DE Fry [9].

All above-mentioned factors (type of procedure, incision respectively) influence not only the morbidity (the incidence of infections), but their etiology as well. On the one hand, the normal skin flora (resident flora), ensuring a natural defence against pathogenic microorganisms should be considered, i.e. Gram positive cocci: Micrococcus, S. saprophyticus, S. epidermidis; Gram positive bacilli: Corynebacterium, Propionibacterium. On the other hand, there should be taken into account the most frequent contaminants of the digestive tract, the multiplication of which in case of impaired integrity of the tissues and certain conditions (presence of blood, pus), is able to lead to infection development, i.e.: Gram (+) cocci as Streptococci, Enterococci, Staphylococci; Gram (-) bacilli as enteric bacteria: E. coli, Klebsiella spp., Enterobacter spp.; non-fermentative Gram negative bacilli as Pseudomonas spp., Acinetobacter spp.; anaerobes including cocci: Streptococci, Peptostreptococci, and Bacilli: Bacteroides, Clostridium, Fusobacterium. The complex interpretation of SSIs microbiological results requires considerable experience in the testing, e.g., in some cases coagulase-negative Staphylococci (CoNS) isolates, normally commensal skin bacteria, may be considered etiologic agents.

In general, SSIs etiologic structure is determined by bacteria, widely distributed and easily multiplying in the environment. At the conditions of the human organism they colonize the skin, the respiratory, gastrointestinal, genitourinary tract with special affinity to damaged and/or immunocompromised (of weakened immunity) tissues. In a number of SSIs hospital isolates, especially opportunistic bacteria, is found high-level resistance pattern. The therapeutic practices should dispose of international institutions’ consultative manuals (Guidelines and User Manuals) on antibiotics usage as the yearly updated CLSI (NCCLS)* standards for antibiotic sensitivity, and recommendations for clinical approach to the initial choice of antimicrobial therapy, for e.g., Sanford Guide [10,11]. A special accent in the preventive measures against SSIs is put on the antibiotic prophylaxis [12]. Improvements as regards the choice of the correct moment for initial/single dose application, appropriate antibiotic and application scheme of short duration prescribed, defined more distinctly the value of this technique for postoperative wound infections rates reduction (Nichols RL) [13].

**Clinical and Laboratory Standards Institute (CLSI), till 2005 known as National Committee on Clinical Laboratory Standards (NCCLS)**

The basic etiological role of S. aureus is admitted by the studies on SSIs etiology, e.g. the 2006-2007 NHSN data-30% of the cases [6]. The pathogen is identified in our country approximately ¼ of the cases its 21-26%, in another ¼ of the cases (20-23%). E. coli is isolated, the latter supposedly due to contamination during the operative procedure or in the process of wound care afterwards (Table 3).

The next by order isolates are P. aeruginosa strains (our data 8-12%, NHSN-6%) and enterococci [6]. Acinetobacter spp. are isolated in 6-8%, Klebsiella spp. in increasing percentage from 4-5% in the beginning of the period 1999-2011 to 8% for the last year of the period. Among the most frequent isolates in SSIs are also other bacteria of intestinal flora as Enterobacter spp.-2-4%, P. mirabilis in a decreasing percentage from 7 to 4%, in separate years of the period-Serratia spp. in 2-1%. In the last two years a total number of five cases of anaerobic infection have been registered -2 cases of Cl. perfringens, 2-Clostridium non-specified in 2010, and 1-Cl. difficile in 2011. Candida spp. isolation level ranges between 1 and 2%. For the last two years of the studied period coagulase-negative staphylococci are implicated as causative agents in 6-7%, as of 2006-2007 NHSN data indicate a double percentage-14% [6].

**Sepsis**

**Brief introduction to the problem:** Under the nosologic category "sepsis" our system reports a total number of the cases with clinical evidence of bacteremia in hospitalized patients, acquired postoperatively including and/or related to procedures of mechanical ventilation, vascular catheterization, etc. A lot of studies on nosocomial septic complications, including trials on biofilms have demonstrated the underlying role of the catheter contamination. The foreign surveillance systems operate with effective criteria for calculating the incidence rates per 1000 patient-days with a device, as regards, particularly, the vascular catheters-per 1000 patient-days with a central line [14,15,17-19]. The infections associated with a peripheral catheter for the present are exempt from calculation of this specific rate. The Central Line-Associated Bloodstream Infection (CLABIs) are subject to special supervision at the basis of considering the complex catheterization technique with penetration into large vessels, associated with high risk for bacteremia. A calculation per 1000 patient-days permits the comparison of the results for the so formed cohorts of patients with a central line.

In view of the severity of the infection, and the possibility of fatal outcome, the treatment of the nosocomial septicemia presents a serious problem. The prevention and control strategy envisages special supervision over the observance of the requirements for procedures of insertion, maintenance and removal of a vascular catheter.

The etiology of these infections is determined by the same, the so called "nosocomial pathogens", of concern in the foreign studies. The cases of staphylococcal sepsis comprise the greatest part of the reported cases of sepsis in the country. It refers particularly to S. aureus, isolated in 12-26% yearly in the course of the studied period, as well as coagulase-negative Staphylococci (CoNS), of which predominantly S. epidermidis isolates (23-27% in the course of the years), the other CoNS of rising percentage recently. Studies have demonstrated that CoNS invade the vascular endotol at the catheter insertion site, forming biofilms and multiplying in the blood stream to the extent of clinically manifested sepsis. Their role in the etiology of vascular device-associated sepsis was confirmed by transmissible electron microscopy of the biofilm along the catheter surface [16]. The 2006-2007 NHSN data indicate CoNS as the most common causative agent of CLABSI-34% [6].

According to CIS-NI data for 1999-2011 the percentage of K. pneumoniae isolates has increased two-fold-from 6 to 15-14% for the last two years. The isolates in CLABSI-NHSN are about 5% [6]. Taking into account that K. pneumoniae colonizes predominantly the respiratory tract, septic complications in pulmonary infections are possible. Acinetobacter spp. and Pseudomonas spp. determine 6-14% of the cases. Studies of nosocomial infections and outbreaks in our country in neonatal wards, surgeries, cases of sepsis including, have confirmed the multiresistance of A. baumannii and P. aeruginosa hospital strains [20-23]. These subspecies have been isolated in septicemia of nosocomial origin in the country in 4-6% of the isolates from notified cases of sepsis, in CLABSI (NHSN) in 2-3%. According to K. Todar [24] data Pseudomonas spp. is responsible for about 25% of all acquired Gram negative bacteremias in the hospital.

Recently the Enterococci, and especially multiresistant strains or vancomycin resistant enterococci emerge as one of the causative agents of bacteremias in surgical patients and intravascular catheter related
bacteremias [25-27]. As NHSN data indicate, these species are isolated in the second place in CLABSI incidence ranking: *E. faecalis* -5%, *E. faecium* 8%, non-differentiated-2%, i.e. a total of 15% of the cases; according to CIS-NI data correspondingly: *E. faecalis* 2-3%, *Enterococci* as a total-5-6% [6]. Other isolates of intestinal flora - *E. cloacae* 8%, non-differentiated-2%, i.e. a total of 15% of the cases; *S. marcescens* and *S. faecalis* strains from blood comprise 3-6% of the isolates. The *Candida* spp. strains from blood cultures of hospitalized patients account for 2-5% in our country, in CLABSI 11, 8% of the isolates (NHSH data), Streptococcal sepsis was confirmed in 2% of the cases in 2010, 2011 respectively, 1 case of anaerobic sepsis (*Clostridium* perfringens) was registered in 2010 (Table 4).

**Urinary tract infections (UTIs)**

**Brief introduction to the problem:** References data indicate that the urinary tract infections amount to 40-50% of all NI [28,29]. Underlying the role of catheterization procedures (an indwelling or an intermittent urinary catheter) and/or interventions (diagnostic procedures, eg., cystoscopies, operative interventions) over the urinary tract. Considering the particular risk related to the indwelling catheter, urosepsis respectively, NHSN was the first to introduce the exact index of calculating the incidence rate per 1000 urinary catheter-days. The prevention of the acute infections and the chronic course is of proved etiological role in NI outbreaks in the country, comprising 3-6% of the isolates. The *Candida* spp. strains from blood cultures of hospitalized patients account for 2-5% in our country, in CLABSI 11, 8% of the isolates (NHSH data). Streptococcal sepsis was confirmed in 2% of the cases in 2010, 2011 respectively, 1 case of anaerobic sepsis (*Clostridium* perfringens) was registered in 2010 (Table 4).

**Table 3: The ten most frequent pathogens of ssis. 1999-2011 (% of the microbiologically confirmed cases).**
### Table 4: The ten most frequent pathogens of sepsis. 1999-2011 (% of the microbiologically confirmed cases)

| Pathogen          | 1999 | 2000 | 2001 | 2002 | 2003 |
|-------------------|------|------|------|------|------|
| S. aureus         | 21.6 | 22.7 | 21.9 | 25.7 | 21.9 |
| S. epidermidis    | 12.1 | 14.5 | 12.4 | 8.8  | 11.2 |
| Serratia spp      | 8.8  | 13.1 | 12.0 | 8.8  | 10.2 |
| E. coli           | 8.1  | 10.7 | 9.6  | 8.8  | 9.7  |
| P. aeruginosa     | 6.6  | 7.0  | 9.2  | 7.4  | 9.7  |
| Acinetobacter spp| 6.2  | 6.1  | 8.1  | 7.1  | 8.1  |
| Klebsiella spp    | 6.2  | 5.1  | 6.2  | 5.0  | 4.2  |
| Enterobacter spp  | 4.2  | 4.7  | 3.4  | 4.3  | 3.9  |
| Enterococcus spp  | 3.8  | 1.9  | 2.1  | 2.4  | 1.8  |
| S. epidermidis    | 14.8 | 15.1 | 16.4 | 16.8 | 17.4 |
| S. aureus         | 13.1 | 13.3 | 14.7 | 16.5 | 14.8 |
| Acinetobacter spp| 13.9 | 12.3 | 12.0 | 12.2 | 9.9  |
| E. coli           | 8.9  | 10.9 | 11.3 | 7.6  | 9.2  |
| Klebsiella spp    | 8.3  | 9.5  | 9.4  | 7.5  | 7.5  |
| Enterobacter spp  | 7.0  | 8.3  | 8.1  | 7.3  | 7.5  |
| P. aeruginosa     | 6.5  | 7.5  | 6.4  | 6.1  | 6.6  |
| Enterococcus spp  | 4.8  | 6.0  | 6.0  | 5.8  | 6.4  |
| Candida spp       | 4.8  | 4.6  | 3.6  | 3.3  | 4.0  |
| Serratia spp      | 3.9  | 3.8  | 3.2  | 3.7  | 4.0  |
| S. epidermidis    | 14.2 | 15.5 | 15.1 | 13.7 | 12.2 |
| S. aureus         | 10.0 | 14.6 | 11.0 | 8.9  | 5.9  |
| Acinetobacter spp| 7.7  | 7.3  | 7.3  | 6.0  | 6.5  |
| Other CoNS        | 5.0  | 7.0  | 3.7  | 5.9  | 6.5  |
| Enterococcus spp  | 3.8  | 3.6  | 3.7  | 5.2  | 3.2  |
| S. marcescens     | 3.2  | 2.1  | 2.1  | 5.7  | 5.7  |
| E. coli           | 10.0 | 14.6 | 11.0 | 8.9  | 5.9  |
| E. faecalis       | 3.3  | 3.3  | 3.2  | 5.3  | 5.3  |
| E. faecium        | 1.3  | 1.3  | 1.3  | 5.7  | 5.7  |
| Enterobacter spp  | 2.2  | 2.2  | 2.2  | 1.6  | 1.6  |
| Enterococcus spp  | 2.7  | 2.7  | 2.7  | 3.6  | 3.6  |
| C. albicans       | 0.7  | 0.7  | 0.7  | 1.5  | 1.5  |
| Serratia spp      | 2.5  | 2.5  | 2.5  | 2.0  | 2.0  |
| S. marcescens     | 2.4  | 2.4  | 2.4  | 2.4  | 2.4  |
| Streptococcus spp | 2.2  | 2.2  | 2.2  | 2.2  | 2.2  |

*C. albicans* is included.

### Table 5: The predominance of bacterial pathogens in UTIs isolates. 1999-2011 (% of the microbiologically confirmed cases).

| Pathogen          | 2004 | 2005 | 2006 | 2007 | 2008 |
|-------------------|------|------|------|------|------|
| S. epidermidis    | 14.8 | 15.1 | 16.4 | 16.8 | 17.4 |
| S. aureus         | 13.1 | 13.3 | 14.7 | 16.5 | 14.8 |
| Acinetobacter spp| 13.9 | 12.3 | 12.0 | 12.2 | 9.9  |
| E. coli           | 8.9  | 10.9 | 11.3 | 7.6  | 9.2  |
| Klebsiella spp    | 8.3  | 9.5  | 9.4  | 7.5  | 7.5  |
| Enterobacter spp  | 7.0  | 8.3  | 8.1  | 7.3  | 7.5  |
| P. aeruginosa     | 6.5  | 7.5  | 6.4  | 6.1  | 6.6  |
| Enterococcus spp  | 4.8  | 6.0  | 6.0  | 5.8  | 6.4  |
| Candida spp       | 4.8  | 4.6  | 3.6  | 5.3  | 4.0  |
| Serratia spp      | 3.9  | 3.8  | 3.2  | 3.7  | 4.0  |

S. faecalis is a predominant serotype 7-11% (2010-2011). Klebsiella spp. percentage has raised two-fold-from 8% to 15%, predominantly K.
The ten most frequent pathogens of UTIs. 1999-2011 (% of the microbiologically confirmed cases).

### Table 5

| Year | E. coli | Klebsiella spp | Enterococcus spp | Candida spp | P. aeruginosa | P. mirabilis | Enterobacter spp | S. aureus | Citrobacter spp | Acinetobacter spp | Enterococcus spp | CoNS |
|------|---------|----------------|------------------|------------|---------------|-------------|-----------------|-----------|----------------|----------------|-----------------|-----|
| 1999 | 31.9    | 15.0           | 12.3             | 8.5        | 23.7          | 7.8         | 6.3             | 2.8       | 3.7            | 2.6            | 1.1              |     |
| 2000 | 32.7    | 15.3           | 12.3             | 12.3       | 21.0          | 10.3        | 6.4             | 3.6       | 3.5            | 5.6            | 1.3              |     |
| 2001 | 30.4    | 15.3           | 12.3             | 11.8       | 21.9          | 11.8        | 5.6             | 3.6       | 4.8            | 5.6            | 1.3              |     |
| 2002 | 32.5    | 15.3           | 12.3             | 11.8       | 19.6          | 11.4        | 6.5             | 4.0       | 3.5            | 5.7            | 1.3              |     |
| 2003 | 33.6    | 15.3           | 12.3             | 11.7       | 19.6          | 11.4        | 6.5             | 4.0       | 3.5            | 5.7            | 1.3              |     |

**UTIs**

- **E. coli**: For the last two years, in the second place by isolation rate. 
- **P. aeruginosa**: For the last two years, in the second place by isolation rate. 
- **Klebsiella spp**: For the last two years, in the second place by isolation rate. 
- **Enterococcus spp**: For the last two years, in the second place by isolation rate. 
- **Candida spp**: For the last two years, in the second place by isolation rate. 
- **P. mirabilis**: For the last two years, in the second place by isolation rate. 
- **Enterobacter spp**: For the last two years, in the second place by isolation rate. 
- **S. aureus**: For the last two years, in the second place by isolation rate. 
- **Citrobacter spp**: For the last two years, in the second place by isolation rate. 
- **Acinetobacter spp**: For the last two years, in the second place by isolation rate. 
- **Pseudomonas spp**: For the last two years, in the second place by isolation rate. 
- **Serratia spp**: For the last two years, in the second place by isolation rate. 
- **Proteus spp**: For the last two years, in the second place by isolation rate. 
- **P. mirabilis**: For the last two years, in the second place by isolation rate. 
- **Enterobacter spp**: For the last two years, in the second place by isolation rate. 
- **E. cloaca**: For the last two years, in the second place by isolation rate. 
- **S. aureus**: For the last two years, in the second place by isolation rate. 
- **Acinetobacter spp**: For the last two years, in the second place by isolation rate. 
- **S. marcescens**: For the last two years, in the second place by isolation rate. 
- **CoNS**: For the last two years, in the second place by isolation rate.

**Note**: CoNS-S. epidermidis. included

As a matter of comparison according to the cited NHSN data [6], *K. pneumoniae* isolates rank fifth in UTIs (7.7%). *K. oxytoca* isolates are less important as NI pathogens in our country; NHSN report the subtype among the ten most frequent isolates in NI, ranking tenth in UTIs [6]. In the last years there has been an increase in the fungal infections to the extent of ranking fourth by isolation rate, NHSH-in a second place, an inadequate antibitic treatment presumed as a reason of concern.

*Pseudomonas spp* is among the main isolates in the nosocomial UTIs. However, there has been a decrease in *P. aeruginosa* percentage from 19-24% in the beginning of the studied period to 8% in 2010-2011 years. On the account of other species, which gain a higher place in the rank order of isolates, the NHSN data report a similar percent (10% of CAUTI isolates [6].
In the course of the period 1999-2011 Proteus. A comparison with 2006-2007 NHSN* data (7-8%) and other belonging to the normal gastrointestinal microflora bacteria [Enterobacter spp. (4%), Serratia spp. (2%)] have been yearly isolated. The P. mirabilis serotype has been isolated in 6-7%, S. marcescens-in 1% (2010, 2011). Both serotypes are of proved clinical significance for complicated infections of the upper urinary tract and outbreaks [27,28]. Acinetobacter spp. isolates account for 3%, of which A. baumannii strains-2%, NHSN indicates a similar percent 1.2% [6].

Discussion

The frequency distribution of the most common isolates in the principal NI groups, analyzed in the study attempts to present the problematic microorganisms for each infection site within a follow up of a 13-year period. These results may be considered comprehensive for the country with respect to the current requirements of reporting of the isolates in infections, clinically confirmed as nosocomial ones. CIS-NI provides a possibility for separate studies of the frequency distribution of the isolates by infection sites and wards, using the same statistical criterion as percent distribution. The exact determination of an isolation level of a microbial species in terms of statistical evaluation would require the forming of special cohorts of patients, and consideration, depending on the objective of the study, of certain specific microbiological criteria, e.g., Colony-Forming Unit (CFU), specific limits of antimicrobial sensitivity variation etc.

At a next stage of updating of our reporting system should be considered a sub categorization of the patients in the critical care units on the basis of installed device, providing the possibility for introduction of incidence rates and level of the microbial isolates for the device-associated infections (VAP, CAUTIs, UTIs) per 1000 patient days.

The microbial characteristics presented marks out in broad outlines the involvement of the most common microbial agents in important for the clinical practice nosocomial infections, namely VAP, LRTIs, SSIs, sepsis, UTIs. The results are to a high extent consistent with the reference studies on the distribution of the nosocomial pathogens for each of these infection sites. The isolates assigned as NI causative agents refer predominantly to strains of S. aureus and E. coli (of substantial importance in SSIs), S. aureus (sepsis), E. coli (UTIs), a number of opportunistic bacteria as Pseudomonas spp., Acinetobacter spp., Klebsiella spp., Enterococci, other Enterobacteriaceae as Enterobacter spp. and Serratia spp., Proteus spp. (VAR LRTIs, sepsis). These species in comparatively constant or in separate years in an increasing percentage are invariably present in the visualized by years microbiological spectrum of the discussed infections groups. The presented microbiologic characteristics emphasizes the necessity of strict implementation of the NI prevention and control measures endorsed, updated guidelines including, in the risk clinical practices as operative/resuscitation procedures and manipulations, installation of vascular devices, urinary catheters, etc., and the care respectively for the patients, undergoing such procedures as preoperative, postoperative care, or attendance in the course of other clinical treatment. Some hospital strains of these microbial species may manifest resistance of different level to the ordinarily used antibacterials, or multi-drug resistance, as a number of studies, in the country including, have stated. It is considered that feed-back information to the wards about the resistance of their isolates would contribute to précising the antibiotics prescriptions. Several specific programs for monitoring of the antibacterial resistance of the hospital isolates have been functioning in intervals in a few of our university hospitals, of questionable benefit, however, for the clinical practice. The assessment of the antibacterial resistance should respond to the following tasks:

- Promotion of the provision of additional extended tests for hospital strains identification and antibiotic sensitivity testing;
- Workout of periodic analyses of the antimicrobial resistance intended for the specific wards as a guide in the choice of antimicrobials.

On the basis of NHSN patterns could be reported:

The antimicrobial resistance rates of a given microbial species by types of infections and wards (number, percent of the resistant strains and rates per 1000 patients treated), the antimicrobial resistance to specific antibiotics being accepted as a standard for resistance in the form of combinations of pathogen/antimicrobial agent (relevant class, group) accepted as a standard for resistance—

Table 6: Antimicrobial resistance to specific antibiotics accepted as a standard for resistance Combination of pathogen and antimicrobial agent (relevant class, group) (Table 6) [29].

For each antimicrobial agent/pathogen combination the resistance rates are calculated as:

| Resistance | Number of resistant isolates x 100 | Number of isolates tested | Number of resistant isolates x 1000 | Patients treated |
|------------|-----------------------------------|---------------------------|-----------------------------------|-----------------|

Conclusion

In view of adopting criteria for evaluation of NI supervision of high-risk patients on mechanical ventilation and/or vascular catheter, two types of electronic version file-cards are proposed for approbation in the hospital settings. The files allow the calculation of the indices on the basis of patient-days with a device, i.e. ventilator-days, central line/peripheral catheter-days; they visualize, thus documenting the observance of the correct hospital practices for care of these patients [30,31].

References

1. Malacarne P, Boccalatte D, Acquarolo A, Agostini F, Anghileri A, et al. (2010) Epidemiology of nosocomial infection in 125 Italian intensive care units.
2. Regnier B (1994) Maîtrise de la diffusion des germes hospitaliers multi-résistants. In: Blech MF, Arnette SA (eds.) Guide pour la prévention des infections nosocomiales en réanimation. Microbes 1: 173-183.
3. von Eiff C, Jansen B, Kohnen W, Becker K (2005) Infections Associated with medical Devices. Pathogenesis, Management and Prophylaxis. Drugs 65: 179-214.
4. Moreillon P (2007) Antibiotic Mechanisms of Resistance.
5. Christova E, Georgieva R, Kantardjiev T, Hadjieva N, Todorova M, et al. (2004) A study on the microbiological characteristics of Acinetobacter baumannii isolates in pneumonia of infants in a neonatal intensive care unit. Seventh National Congress on Hygiene, Sofia.
6. Hidron AI, Edwards JR, Patel J, Sievert DM, et al. (2008) NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. Infect Control Hosp Epidemiol 29: 996-1011.
7. Salfar N, Cniuch C, Maki D (2005) The Pathogenesis of Ventilator-Associated Pneumonia: Its Relevance to Developing Effective Strategies for Prevention. Respir Care 50: 725-739.
8. Husni RN, Goldstein LS, Arroliga AC, Hall GS, Fatica C, et al. (1999) Risk Factors for an Outbreak of Multi-Drug-Resistant Acinetobacter Nosocomial Pneumonia among Intubated Patients. Chest 115: 1376-1382.
9. Fry DE (2013) The Prevention of Surgical Site Infection in Elective Colon Surgery. Scientifica 2013.
10. Tenover FC (2006) Implementation of NCCLS Antimicrobial Susceptibility Testing standards: 1-20.
11. Sanford Guide.
12. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR, et al. (1999) Guideline for Prevention of Surgical Site Infection 1999. Infection Control and Hospital Epidemiology 20: 251-252.
13. Nichols RL (2001) Preventing Surgical Site Infections: A Surgeon’s Perspective. Emerging Inf Dis 7: 220-224.
14. (2004) National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. Am J Infect Control 32: 470-485.
15. Dudeck MA, Horan TC, Peterson KD, Alten-Bridson, Morrell G, et al. (2011) NHSN Annual Report: data summary for 2010. AJIC 39: 798-816.
16. Donlan RM, Costerton JW (2002) Biofilms: Survival Mechanisms of Clinically Relevant Microorganisms. Clin Microbiol Rev 15: 167–193.
17. Desplanches L, Mahieu G, Gottot S (1996) Infections nosocomiales en réanimation pédiatrique: expérience du réseau RECPED. In: F. Beaufils, Y. Aujard, E. Bingen (eds.) Les infections nosocomiales en pédiatrie. Arnette Blackwell S.A. Paris: 19-28.
18. Mariani-Kurkdjian P, Bingen E (1996) Épidémiologie des septicémies nosocomiales en pédiatrie. In: F. Beaufils, Y. Aujard, E. Bingen (eds.) Les infections nosocomiales en pédiatrie. Arnette Blackwell S.A. Paris: 29-38.
19. (1992) Méthodes de calcul des taux d’infection. In: 100 recommandations pour la surveillance et la prévention des infections nosocomiales, Conseil Supérieur d’Hygiène Publique de France, Section “prophylaxie des maladies”, Groupe de travail “Infections nosocomiales”, Mai:25-27.
20. Christova E, Petrov M, Christova M, Hadjieva N, Genova V (2009) Fréquence et importance clinique des infections nosocomiales néonatales: Expérience d’une unité de soins intensifs néonatale. Archives of the Balkan Medical Union 44: 279-284.
21. Christova E, Georgieva R, Christova M (2000) Bakterialni nozokomialni infektsii v neonatologiyata: diagnosisi i terapeutichni aspekti. In: D. Damyanov, Medart –SUB (eds.) Vratetelnichni infektsii. Sofia: 91-103.
22. Christova E, Georgieva R, Todorova M (2000) Clinical aspects of Acinetobacter baumannii infection in a neonatal intensive care unit. National Interdisciplinary Conference on Nosocomial Infections, Ribaritza, Teteven.
23. Todar K (2012) Opportunistic Infections Caused by Pseudomonas aeruginosa.
24. Dougherty SH (1984) Role of enterococcus in intraabdominal sepsis. Am J Surg 148: 308-312.
25. Fraser SL, Lim J, Donskey CJ, Salata RA (2014) Enterococcal Infections.
26. Sandoe JA, Witherden IR, Au-Yeung HK, Kite P, Kerr KG (2002) Enterococcal intravascular catheter-related bloodstream infection: management and outcome of 61 consecutive cases. J Antimicrob Chemother 50: 577-582.
27. Kalsi J, Arya M, Wilson P, Mundy A (2003) Hospital-acquired urinary tract infection. Int J Clin Pract 57: 388-391.
28. http://www.phagetherapycenter.com/pj/PatientServlet?command=static_uti.
29. (2001) National Nosocomial Infections Surveillance (NNIS) System Report, Data Summary from January 1992-June 2001, Issued August 2001. AJIC 29: 404-421.
30. Tablan, OC, Anderson LJ, Besser R, Bridges C, Hajjeh R (2003) Guidelines for Preventing Health-care-associated Pneumonia, 2003. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. Division of Healthcare Quality Promotion (DHQP): 179.
31. Guidelines for Preventing Intravascular Catheter-related Infection. Published by the Infection Control Nurses Association in collaboration with 3M Health Care Ltd. 2001:14.