Analysis of results and optimization of a WEB-based program used for the antibiotic resistance surveillance in a Romanian universitary hospital

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Abstract: - Antimicrobial resistance is an increasing issue of our days attracting the attention of medical community due to its evolution from a controllable phenomenon into a serious public health problem. The emergence and spread of the bacterial resistance to antibiotics are negative consequences of the excessively use of these substances in human or veterinary medicine and agriculture. Worldwide, hospitals represent the component in which this phenomenon has become critical.

The aim of the study was to analyze the results of the implementation of a WEB-based program for the surveillance of the resistance to antibiotics in the Clinical County Emergency Hospital of Brașov, Romania, and the optimization of this application.

The program allows the generation of analysis reports regarding the distribution of circulating germs in the hospital departments and the patterns of resistance to antibiotics related to the type of pathology.

In implementing the solution we had to address the issue of making the Web-program available to a large category of users (epidemiologists, specialist doctors, managers), providing a user-friendly interface and selecting the software and technology that offer the minimal development and maintenance costs.

The application represents a low cost solution, easy available to the personnel and may be applied in any hospital. Implementing this solution as a web application brings all the advantages offered by this technology which consist in interoperability, easy to access and to integrate, reusability. The proposed implementation takes advantages of using the top open source standards and platforms.

The application can be a powerful support toll of decision in clinical practice, regarding the antibiotic prescription and control. It may be also very useful in surveillance and management of nosocomial infections.

The proposed optimization will lead to the extension of the application functionality in order to obtain additional information for the monitoring of germs with high resistance (ESBL, MRSA, HLRE) and of the bacterial strains implicated in the etiology of nosocomial infections.

Keywords: - WEB-based surveillance program, germ distribution, high resistance germs

1 Introduction
Antimicrobial resistance is an increasing issue of our days attracting the attention of medical community due to its evolution from a controllable phenomenon into a serious public health problem. [18]

The emergence and the spread of the bacterial resistance to antibiotics are negative consequences of the excessively use of these substances in human or veterinary medicine and agriculture. [20]

The antimicrobial resistance is today an under-appreciated threat around the globe. The increasing prevalence of resistance among pathogen germs is no longer counter-balanced by the discovery and the implementation of new antibiotics. The research on the antibiotics resistance patterns should be a priority for each country. [20]

Worldwide, hospitals represent the component in which this phenomenon has become critical because the hospitalization combines the presence of patients with increased susceptibility with an intensive and prolonged use of antibiotics. [19] In these patients, with a weakened immune system, receiving all kinds of treatment, germs being generally considered harmless may cause severe infections. [3]

The therapy of infectious diseases is difficult because the selection of antibiotic resistant bacterial strains. [5]

The antimicrobial resistance is associated with significant morbidity, longer hospitalization, high costs and increased mortality imposing an urgent need to improve the ways bacterial infections are diagnosed and treated. [16]
In the last four decades, the selection pressure due by an excessive and inadequate use of antibiotics, lead to the emergence and the spread of multiresistant bacterial strains like MRSA (Methicillin Resistant Staphylococcus aureus), VRSA (Vancomycin Resistant Staphylococcus aureus), ESBL (Extended Spectrum β-lactamases), HLRE (High Level Resistant Enterococci), and other. [6,13]

In this context, each specialist needs to be constantly informed regarding the pattern of the resistance to antibiotics for the pathogen germs isolated from his department and his hospital. Such, the analysis of the collected microbiological data during different period of times is considered to be one of the most important activities to restrain the spreading of resistant strains and avoid the negative consequences of the antibiotic resistance. [12]

It has been widely recognized that the evaluation of germ prevalence in hospitalized patients needs to be monitored and updated permanently. Nowadays, the internet provides the access of the specialist doctors to surveillance information that can be kept up to date by a continuous updating process. Several solutions are available for the clinicians to help in a proper selection of antimicrobial agents in the case of severe infections, especially those caused by antibiotic resistant bacteria. [10,17]

Several studies have been conducted in order to assist physicians in the selection of the proper antibiotic therapy and computer applications are now available to query large data sets and can be used as decision support tools in the antibiotic therapy process. [15]

Many surveillance systems are now available to monitor the results of microbiological analysis, discovering validation rules and perform real-time alarming. [6, 9]

It was also demonstrated that the implementation of such Web-based applications is highly effective for supporting the clinical doctors in selecting the appropriate and most efficient antibiotic and will lead to a better communication between departments, a higher antibiotic prescription accuracy, significant cost savings, improvement of clinical care and patient outcomes. [1, 2, 14, 15]

In implementing the solution we had to address the issue of making the Web-program available to a large category of users (epidemiologists, specialist doctors, managers), providing a user-friendly interface and selecting the software and technology that offer the minimal development and maintenance costs.

The MySQL database [11] and the Java Web-program [7] running on a JBoss application server [8] have been selected in this respect, of benefiting from the leader open source IT technologies with minimal costs.

2 Problem formulation

The aims of this study were to evaluate the results of the implementation of a WEB-based program for surveillance of the resistance to antibiotics of germs implicated in infections of patients hospitalized in the Clinical County Emergency Hospital of Brașov, Romania, and to optimize this application.

The program allows the generation of analysis reports regarding the distribution of circulating germs in the hospital departments and patterns of resistance to antimicrobial substances, related to the type of pathology.

The modules of the used client-server Web application written in Java are presented in Figure 1 below.

The data collected from the patients hospitalized during 2008 in the medical and surgical departments of this medical unit have been stored in a database, in order to be processed and analyzed.

The data entry process is very simple and does not require any advanced training. It was performed in the Department of Bacteriology of the Clinical Laboratory from the mentioned hospital, based on the medical forms for biological samples and laboratory data regarding the identification of the strains and the results of the antibiograms.

The personal data form is the same in all cases containing all the available information regarding the patient, department of hospitalization, pathological products and isolated germs, while the results of the antibiograms are filled in using specialized forms.
The antibiotics tested for each bacterial species were selected according to the recommendations of CLSI (Clinical and Laboratory Standards Institute) from 2008. [4]

As shown in Figure 2, the application data entry user will have to fill in the data regarding the patient and hospital department, pathological product and the species of isolated germ. This form will be filled in for each isolated bacterial strain because there are clinical situations when from the same biological sample there can be isolated multiple germs.

Based on the germ selected in the previous form, the program offers a list of the antibacterial substances and the possibility to select the appropriate type of sensitivity to antimicrobials (S – susceptible, IS – intermediate susceptible, R - resistant), as shown in Figure 3.

Another component of the application consists in the reporting module. This allows the generation of following types of reports, by selecting the desired timeframe:
- circulating germs in all the departments of the hospital;
- circulating germs in a specific department;
- susceptibility of a specific germ based on a pathological product;
- susceptibility of a specific germ based on a pathological product in a specific medical department.

The reports can be presented as a user interface screen or as a PDF document and can be generated at any time of the year, reflecting partial or full year statistics.

The program allows also the automatic generation of scheduled reports that are made available to all the departments interested in the results.

3 Results

In Figure 4 is presented the report regarding the microorganisms implicated in the etiology of infections in the patients hospitalized in all departments of the hospital. This type of report offers data regarding the number of isolated strains for each bacterial genre as well as their provenience (the pathological product from which they were isolated and the department in which the patient was hospitalized).

![Figure 2 – Personal data form](image1)

![Figure 3 – Antibiogram results form](image2)

![Figure 4](image3)
In Figure 5 is presented the report regarding the germs etiologically implicated in the infections of the patients hospitalized in a specific department.

As example, it is presented the report obtained for the Plastic surgery department of the hospital, for the year 2008.

It can be observed that this type of report can provide information regarding the species or bacterial genre, number of isolated strains and the pathological products from which they were obtained.

In Figure 6 is presented the report regarding the susceptibility to antibiotics of a specific germ isolated from a patient hospitalized in a specific department of the hospital.

As example, it is presented the report obtained for the Ortopedy department of the hospital, for the year 2008. The tested antibiotics were those recommended by CLSI 2008 for the species Staphylococcus aureus.

It can be observed that this type of report can provide information regarding the species or bacterial genre, number of isolated strains and the behavior to antibiotics related to the pathological products and the department from which they were obtained. This type of report allows also monitoring the number of sensitive, intermediate sensitive and resistant bacterial strains to the tested antibiotics.
- the generation of computer alerts and reports regarding the discovered patterns;
- the generation of computer alerts regarding high levels of resistance to a specific antibiotic.

Also, we consider as necessary the extension of the program in the direction of generating some chart reports like those presented in the next figures.

Figure 7 shows the number of MRSA (Methicillin Resistant Staphylococcus aureus) from the total number of Staphylococcus aureus strains that were found on monthly bases in a hospital department during 2008. Similar charts can be generated with the graphical representation of the distribution of MRSA strains based on the department of hospitalization or pathological product from which they were isolated.

In our days, the importance of the surveillance of these germs in widely recognized, staphylococci being frequently implicated in human pathology, especially in hospitals. The infections caused by MRSA strains raise important issues of therapy due to the resistance to several antibacterial substances. In the case of detection of these strains in vitro, it is considered that beta-lactams, antimicrobial combinations with beta-lactamases inhibitors and even carbapenems will not have any clinical efficiency despite the apparent susceptibility in vitro.

The bacterial strains producing ESBL represent another category of multiresistant germs that need to be continuously monitored.

Figure 8 shows how many HLRE strains (High Level Resistant Enterococci), of the total number of isolated Enterococcus species strains, were detected in each department of the hospital.

Similar charts can be rendered, including the graphical representation with the distribution of the detected HLRE strains in each month for a specific department or in relation to the pathological products from which they were isolated.

Another important document that would be of great support is a special type of report regarding the nosocomial infections. For this purpose, the data entry form can be extended by adding some input fields regarding the information contained in the nosocomial infection documents, completed above by the specialist doctors.
4 Conclusion

The application represents a low cost solution, easy available to the personnel and may be applied in any hospital.

Implementing this solution as a web application brings all the advantages offered by this technology which consist in interoperability, easy to access and to integrate, reusability.

The proposed implementation takes advantages of the top open source standards and platforms and allows the generation of a wide range of reports regarding etiological spectrum of human infections, distribution of microorganism in hospital departments, resistance to antimicrobial of germs and nosocomial infections.

The application can be a powerful support toll of decision in clinical practice, regarding the antibiotic prescription and control. It may be also very useful in surveillance and management of nosocomial infections.

The proposed optimization will lead to the extension of the application functionality in order to obtain additional information for the monitoring of germs with high resistance (ESBL, MRSA, HLRE) and of the bacterial strains implicated in the etiology of nosocomial infections.

References: