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QRE: A PROTOTYPE FOR LOCALIZED UP-TO-DATE ANTIBIOTIC RESISTANCE INFORMATION

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Abstract

Antibiotic resistance is a growing threat for human health. With first reports on it, dating back more than a century, we are now facing a steady increase in infections caused by resistant bacteria. In the clinics, the decision on using a certain antibiotic is usually made by referring to data published in the form of tables, printed on hard paper. We are developing a tool for delivering up-to-date and geographically selected data on antibiotic resistance directly to medical workers. This takes the form of an application for Android smartphones as well as that of a web client.

***Keywords** – antibiotic resistance, clinical decision support, android, e-health, mobile client*

1. Introduction

Antibiotic resistance is an emerging global phenomenon and an increasing threat to public health. In the European Union (EU), there are about 25.000 deaths per year caused by infections with multidrug-resistant bacteria. According to the European Center for Disease Prevention and Control (ECDC), the estimated cost for the healthcare system, plus the loss of productivity generated by these diseases, amounts to at least 1.5 billion Euros per year [8].

The first reports on resistance of microorganisms to antimicrobial matters date back to the early 1900s to the laboratories of Paul Ehrlich [8]. First reports on penicillin-resistant *Staphylococcus aureus* date back to 1945 [10,11], only few years after production of this antibiotic had been taken up at a large scale [4] and even prior to its introduction to the market. Penicillin resistance in isolates of *S. aureus* subsequently increased from 14.1% in 1946 to 59% in 1948 [2].

Nowadays, selection pressure into the direction of antibiotic resistance is not only a result of usage of these drug classes in the human healthcare sector, but also due to their widespread usage in veterinary and agriculture sectors [7].

The latest threat in antibiotic resistance known are strains of bacteria which carry $_{bla}$NDM-1 – a metallo-beta-lactamase which is even able to process carbapenems [12]. Tracing the global spread of $_{bla}$NDM-1 carrying microorganisms – their first occurrences were reported 2008 in India [12] and until today more than 22 countries on 4 continents are affected – we have a distribution marker for new resistances.

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In the future the „war" on antibiotic resistance will have to be fought on multiple battle lines: Basic research; research on old, new and alternatives to antibiotics; education of the public; improvements in public health, hygiene and the quality of life; and control of antibiotic usage [3].

For educational purposes – by the public or professional – the efficient dissemination of information and the quick and adequate promulgation – locally, nationally, regionally and internationally – of information on the current resistance situation for both newly developed and already known resistances including their optimal antibiotic therapy will be a great challenge [3]. The use of new technologies, summarized using the expression "Health 2.0" [6] will be of prime importance for this matter.

Doctors need the information on respective spectra and correct dosing regimens of various antibiotics to efficiently fight against antibiotic resistances. Resistance tables printed on hard-paper to be carried along easily are useful to support the therapeutic decision-making process. The problem here relies in the static nature of printed information while antibiotic resistance is an ongoing dynamic process. Furthermore, the worldwide distribution of these resistance tables is hindered only by language barriers what has a very problematic aspect: Resistance to antibiotics differ widely even between neighboring states, leading to the possibility of mistreatment.

We report of an early development stage of the project "**q**uery **Re**sistances" (qRe). It takes the form of an Android smartphone application as well as that of a web-based client. It aims to supply doctors in all parts of the healthcare-system with relevant and up-to-date resistance information, automatically adapted to their current local and individual needs. The range of the first prototypes is limited to usage in Austria only.

2. Methods

Technical realization is done using a modular and extensible design. With this approach, we want to ease further development of client software for other target platforms.

2. 1. Data collection and processing

Good and reliable data are crucial for success of the project. Our approach is to collect data through a Medical Social Community, with aspects of Crowdsourcing: The collaborative aggregation of resistance-data by the community with the aim to share the filtered and interpreted information to the public. We are working to extend the community to most medical universities, hospitals and laboratories as possible as well as national and international reference centers. We aim towards a close-meshed voluntary surveillance network for reliable resistance information. All members of the network will push data about antibiograms to the server on a regular basis through supplied import filters. Based on the reported resistance information the database is updated weekly.

Minimum information required for reliable operation are the geographic location of the patient as a ZIP-code, the date of the antibiogram, the binomial names of the pathogens isolated, the names of the testing-drugs and the corresponding resistance analyzed – either as an interpreted value (resistant, intermediary, sensitive) or the raw minimum inhibitory concentrations (MIC). Additional information like hospital- vs. community-acquired-infection is optional and will help discriminating between those in qRe later.

To provide a complete set of data to the physicians we import complete resistance-datasets that have been published recently as base-data. Differences between the base-data and our calculated resistance-frequencies in the surrounding area are graphically represented in the user interface.

2. 2. Technical details on the server-side

Mainly written in Java EE, the software of the backend is divided in 3 main parts (Figure 1). Import filters deal with the heterogeneity of software systems that export data to our system. Duplicates elimination, anonymization, and frequency calculations are performed in another module that always uses the same algorithms independent from the data source. For reducing performance prerequisites on the client-side we define various public interfaces using technologies that deliver the data in the best format needed by the clients. With this modular structure we ensure the flexibility needed for consistent data quality.

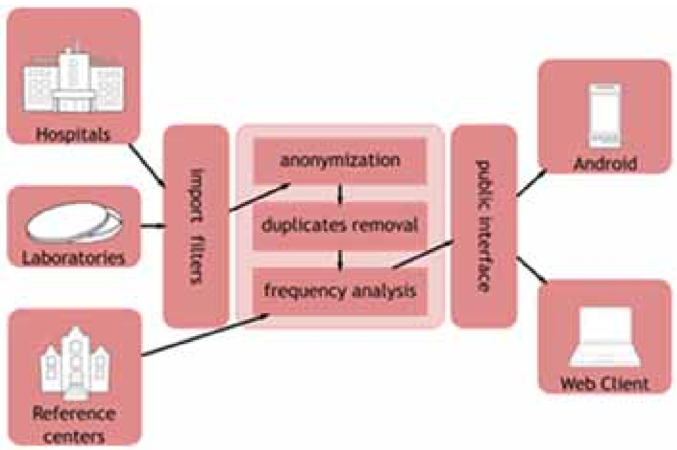

Figure 1: Technical design of the backend and its interfaces to the datasources and the clients.

As an end-result of the calculations, our database contains the calculated frequencies associated with geographic positions.
Encapsulated in the queries by the clients are the date of the last update of the local database and the current position. The server then returns the corresponding datasets or none if there haven't been any changes. Only frequencies of antibiotic-resistance corresponding to the location of the user is being exported to the clients.

Dealing with medical data – although it is only statistical data in the form of calculated frequencies of antibiotic resistance and completely anonymized – security is a big concern. To ensure only authorized clients can access the data, we are implementing a multi-level security system.

2. 3. Technical details of the clients

For prototyping we are building 2 clients at this time. One of them is a web-client, the other one is an application for Android-powered smartphones.

A big advantage of using new smartphone technologies for delivering resistance tables to doctors is the phones' ability to determine their users' location using 3G- or WiFi-connectivity or even built-in GPS modules. This allows for delivery of resistance tables specifically tailored to the region where the doctor is currently working. For users using the web-interface we offer location-detection asking the web-browser for the current position, or using reverse-IP-lookup in cases where it is impossible or access to the location-data is denied by the user. In these cases the user is notified about the estimated position that can be adjusted by entering the correct ZIP-code of his current location. Another advantage comes with the implemented regular synchronization schedule: The user can always be sure that his/her decisions are based on correct and up-to-date information.

Achieving a high usage count is important for the project to help reducing antibiotic resistance development and spread. For this purpose, the user interface should be intuitive and easy to use. Designing such an interface is challenging as the resolution between the different types of Android powered smartphones is varying. In the final version, most phones and tablets are going to be supported. At the moment, minimum requirements are an Android-version equal to or higher than 2.3. We can not give any exact estimations on minimum-resolution, CPU-speed or RAM requirements currently. We aim to support most Android-powered phones and even versions prior to 2.3 in future versions.

Figure 2: Comparison of the table view of the user interface with a hard-paper antibiotics table (taken from: Thalhammer F. Antibiotika & Antiinfektiva. Bayer Austria Healthcare GmbH. 2009).

For providing maximum usability the user will be able to decide between two different designs for data representation. The first one is similar to the classical representation on hard paper (Figure 2): Antibiotics and pathogens are organized in rows respective columns and the resistance values can be read from the intersections. The flow of touch events is illustrated from left to right. As this is a mockup for the design, the represented data is random.

The second user interface will allow the user to select one or more bacteria from a list to receive antibiotics or combinations that cover them best.

The database is synchronized in the background to a local database on the phone so network connectivity has no impact on usability.

The web-client is designed similarly to the Android client. It is dynamically adapting to the screen size of the viewer to display correctly on PCs, tablets as well as smartphones that run different operating systems. One big disadvantage of the web-client is the lack of a local database copy, so every call has to be run on the server directly, which has impact on usability. Prerequisites for the web-client are the same as for Google Web Toolkit, as we will be using this technology for implementation.

3. Discussion

As we are presenting an early prototype there are limited results to be discussed. Updates about the current status of the software can be found at http://www.q-re.org.

The idea of bringing data about antibiotic resistances to mobile clients is new – recent research in Google Play did not reveal projects similar to the presented. Our aim is to support physicians in their decisions, working together into one direction to diminish antibiotic resistance in the future. They have several advantages over the classical data representation on printed hard-paper cards like up-to-dateness of the data, geographic correctness, and fast and easy access to it directly on their mobile phones.

Similarities between our approach and existing antibiotic-resistance surveillance systems (like ARS [1], EARS-net [5]) can be found. These existing systems aim more towards professionals like infectiologists, microbiologists and hygienists than to practicing physicians. We work to broaden our community and attract these existing projects as members and combine forces in the future.

There are limitations to our approach. First of all the scope of the project depends on the size of and contributions by our community. The more data providers and subsequently the more data we can analyze, the more exact is the presented information. Another limitation – today – is the exclusive support for Android as smartphone operating system. After the roll-out for Android we are planning to broaden our support to other platforms like iOS, Blackberry, or Windows Phone.

In the future we are planning to extend the capabilities of the software and to add support for dosing recommendations.

We expect that the impact of our application helps to reduce antibiotic resistance development and spread in the future as well as the financial burden caused by such pathogens.

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