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The DebugIT Project

Improving the quality of healthcare and patient safety are priority health policy goals globally. Despite half a century of antibiotic use, re-emerging and new infectious diseases, partially caused by the rise of antimicrobial resistance, have become important problems. This increasing prevalence of resistance results in escalating healthcare costs, increased morbidity and mortality and the (re-) emergence of potentially untreatable conditions. The DebugIT project has developed an IT-framework to allow healthcare systems to better address these emergent problems and improve their management. In the context of infectious diseases, DebugIT

- Detects patient safety related patterns and trends;
- Acquires new knowledge through advanced data mining; and
- Uses this knowledge for better decisionmaking on the optimal treatment for nfectious diseases.

The Problem: The Rapid Emergence of Resistance Among Pathogens, the Misuse and Overuse of Antibiotics

Although medical errors are currently under the spotlight, (re-)emerging infectious diseases are also becoming an important challenge. The rapid development of antimicrobial resistance, the spread of nosocomial and other infections are major concerns.

The impact of this phenomenon is most apparent in hospitals. However, communitybased practice is not immune, due to the frequency and rapidity of patient transfers between the two sectors and citizen mobility. Hence, epidemics are a regular occurrence and may spread between continents. Examples of such epidemics are methicillinresistant Staphylococcus aureus and vancomycin- resistant Enterococci or multiresistant tuberculosis. In addition, as a result of the efforts made in harmonising data on infections and antimicrobial resistance across Europe, it has become clear that a wide variability in preventive practices and outcomes across European countries exists, indicating considerable leeway for improvement.

The DebugIT Response

To address the challenges of improving antibiotic therapy and reducing antimicrobial resistance, the DebugIT project makes use of data that are already routinely collected and stored in electronic Clinical Information Systems (CIS) in hospitals and primary care clinics. Today however, this occurs in widely differing systems. The DebugIT challenge was to establish the coherent and systematic exchange of a rich data set, harmonised across the DebugIT sites and their CIS systems. This data set primarily includes information about pathogens and drug treatments.

DebugIT adopts a multi-stage framework of several distinct steps:

Collect Data: Clinical data is aggregated from across different hospitals, countries, languages and information models, organised in a virtualised, decentralised but fully integrated Clinical Data Repository (CDR).

Learn: Advanced data mining techniques on multimodal, multi-source, structured and unstructured data to detect patterns, relevant for patient safety and the better treatment of infectious diseases.

Store Knowledge: This knowledge is stored, validated, visualised and aggregated together with pre-existing medical and biological knowledge (guidelines, regulations) in a knowledge repository to achieve a consolidated view on the required knowledge.

Apply: The new knowledge is applied to the monitoring of ongoing care activities and outcomes, and may help to predict future outcomes to give additional support to treatment decision on individual patients and for populations. To a lesser extent, based on the input of our Clinical Advisory Board, decision support tools apply the newly generated knowledge and help the clinician to provide improved clinical care (choice, dose and administration of antibiotics for example).

DebugIT allows healthcare providers and decision makers to take appropriate actions at various levels in the healthcare system, including policy, point-of-care, service management, and subsequently influence the future development of our health systems. Integration of DebugIT tools into existing CIS enables the recording of activities and results and thus makes sure the necessary data are generated for a next cycle of learning. Throughout this process, DebugIT pays strong attention to privacy concerns, taking into account the various legal and ethical frameworks that must be met across Europe.

Technical Outcomes

We have built and deployed a semantic interoperability platform accessing and aggregating data from 6 clinical sites. After applying data mining and statistical algorithms we store the results in a knowledge repository

This knowledge is visualised in a monitoring dashboard and used for decision support. Above all, the DebugIT project is a good example of how

to achieve Translational and Evidence Based Medicine.

Translational: Clinical information is used to support medical research and to enhance medical knowledge (bed to bench), the outcome of the research - is used to support clinical care (bench to bed).

Evidence based: The evidence, coming from the reseach is used to steer the clinical process. Although the DebugIT project is focusing on infectious diseases, its translational framework is suitable for many other clinical problems, providing a solution to help increasing patient safety and enhancing the quality of care. This is depicted in the figure 2. (pg. 34) where a semantic interoperability platform is shown, giving applications access to different sources of information, as if they were part of one big (virtual) database. It is important to know that clinical data is not centralised (only temporarily cached). In the local site, data is accessed either on the production database, either on a copy of the production database, either on an existing or ad hoc data warehouse.

The value of the sum is more than the sum of the values: Combining multiple sources of clinical data enables application to do more than they could do with the individual sources. Combining data can reveal patterns, otherwise not visible. In the DebugIT project we didn't have to deal with privacy issues, because we only used sample and bacterium related data. At some sites the used data warehouse was already anonymised. Other clinical applications will require the use of an anonymisation or pseudonimisation service in the framework.

Scientific Approach

The whole scientific approach is based on the semantic web technology, which connects different sources of information in a highly formal, computer readable and 'meaning preserving' way. This enables smart applications to act intelligently on clinical data, across the different standards and IT systems. A crucial concept of the semantic web technology is the ontology, which is a formal description of concepts and relationships in a certain domain. The scientific approaches and choices can be summarised as follows:

Ontology engineering: we followed a dual approach. We constructed a DebugIT Core Ontology DCO), capturing the concepts of the medical domain of infectious diseases. The purpose of DCO is to describe the domain in a comprehensive and complete way. Besides DCO we have built a set of operational ontologies. These are ontologies with a domain of discourse more directed to the actual implementation and usage of the system. These ontologies formalise domains such as query building, statistics, analysis, evidence classes, etc…. We reused existing ontologies as much as possible.

The interoperability platform heavily counts on the sparql technology. Sparql stands for 'Semantic protocol and RDF query language' and means on the semantic level what SQL (Structured Query Language) means for querying relational databases. We argue that ultimately semantic interoperability can only be achieved by formalising the clinical data and raising them up to the semantic layer as soon as possible. This is exactly what we do by building sparql endpoints on top of the individual clinical information sources. This also considerably facilitates aggregation of clinical data across clinical sites.

The decision support uses knowledge extracted by the clinical analysis. Different approaches are used (Bayesian belief networks, fuzzy cognitive maps) and part of the work was making a reasoning framework that can cope with different decision support approaches. We use (and contribute to) the open source Euler reasoning engine (http://eulersharp.sourceforge.net/).

Population monitoring is build around an "igoogle"- like parametrisable dashboard, where individual visualisation portlets called gadgets, show the results of sparql queries and can be dragged to the desktop, according to each user's needs and preferences.

Clinical Outcome and Validation

During the project the consortium was advised by a Clinical Advisory Board, chaired by Professor Didier Pitet. At the end of 2011 research and technical development was finished and pilots have been installed. Currently, a clinical validation is ongoing, conducted by the clinical partners in the consortium. Preliminary data indicate that the results are good. Microbiologists at several sites compared the actual resistance percentages as calculated by the DebugIT system with their own calculations, based on manual collection of the data. When (small) differences were found, they could be explained by (correctable) errors in the mappings between the local and central system or by different approaches on double measurements. The DebugIT system counted two antibiograms for the same patient twice, while some manual calculations disgarded them. This is an issue that can easily be resolved and anyway would not influence trends in resistance, given the calculations are done in a consistent way over time.

Current practice in many hospitals is still to painfully collect the data, import it in a spreadsheet and then publish the results. In reality this means that often microbiologists do it only once a year. The consortium also contacted the European Center of Disease Control (ECDC). Apparently the ECDC only publishes resistance figures once a year, based on data that are collected from pilot labs, to which physical sample are sent to be examined. While this will certainly work in some cases, this could be optimised significantly with a DebugIT-like system The DebugIT system allows for a real- or neartime monitoring at 'the press of a button'. It can be used on a local level to monitor resistance patterns and on a hospital wide scale to compare individual departments. Once this is in place it is easy to connect the participating hospitals and monitor patterns on a regional or even bigger scale.

Because the technical framework is very generic, the same system can be extended to also query other types of data to solve problems in many different clinical contexts. For example, the system could be a powerful tool to provide decision makers with clinical and operational evidences to adapt healthcare policies. It can be a useful instrument to find eligible patients for medical research and clinical trials. It can serve as a framework for e-health applications, sharing structured and granular data or it can be used as a source of data for epidemiolocal research, etc.

Consortium

The project is coordinated by Agfa Healthcare N.V., Belgium

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