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DebugIT CAB: Publishable Summary Project YEAR #1

Detecting and Eliminating Bacteria
Using Information Technology

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Detecting and Eliminating Bacteria Using Information Technology

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 is developing an IT-framework to allow health care systems to better address these emergent problems and improve their management. In the case of infectious diseases, DebugIT

- detects patient safety related patterns and trends,
- acquires new knowledge through advanced data mining, and
- uses this knowledge for better decision-making on the optimal treatment for infectious diseases,
- thereby improving the quality of healthcare.

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, community-based 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 methicillin-resistant 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 will make 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 is to establish the coherent and systematic exchange of a rich data set, harmonised across the DebugIT sites and their CIS systems. This data set will include information about patients and their illness situations, pathogens and drug treatments.

DebugIT is adopting a multi-stage framework of several distinct steps:

- **Collect Data:** Clinical data is aggregated from across different hospitals, countries, languages and information models, via advanced and commonly agreed data models (minimum data sets), standards and mapping algorithms, organized in a virtualized, 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 will be stored, validated, visualized and aggregated together with pre-existing medical and biological knowledge (guidelines, regulations) in a federated knowledge repository to achieve a consolidated view on the required knowledge.
- **Apply:** Appropriate software tools will be integrated into available clinical and public health information systems. Decision support tools will apply the newly generated knowledge and help the clinician to provide improved clinical care (choice, dose and administration of antibiotics for example). The new knowledge will also be 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.

DebugIT will allow 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 will enable the recording of activities and results and thus make sure the necessary data are generated for a next cycle of learning.
Throughout this process, DebugIT will pay strong attention to privacy concerns, taking into account the various legal and ethical frameworks that must be met across Europe. DebugIT will use a virtual repository of anonymized data without needing direct access to the original clinical data at each site.

Expected outcomes

DebugIT will contribute to achieving world-leading levels of patient safety with fewer medical errors and optimised medical interventions. The learn-predict-prevent approach embodied in the knowledge base and the decision support system of DebugIT will contribute to effective and automated risk prediction. Further expected outcomes are:

- Clinical Information Systems (CIS) of participating European hospitals, industry and their clients are updated with DebugIT knowledge
- New knowledge will be made available at a global level, preferably through a European or global Disease Control Centre/Public Authority, and/or through Open Source services
- New, advanced ICT applications and innovations will be marketed in the following domains: virtualization of Clinical Data Repository information, advanced multimodal data mining techniques on text, image and distributed storage, use of machine reasoning related to real, point of care patient data
- A distributed Medical Knowledge Repository (MKR) integrated with domain knowledge coming from external sources (guidelines and scientific evidence)
- Innovative and user friendly knowledge representation paradigms for both clinicians and IT experts

Feeding DebugIT results into applications

Real world examples of applications benefiting from DebugIT research include

- Computerised Physician Order Entry (CPOE) systems, integrated with, e.g., drug data bases and/or clinical decision support systems,
- Adverse Drug Event (ADE) reporting solutions, and hospital-wide Clinical Information Systems (CIS), Health Database Systems, or Electronic Health Record (EHR) Systems, and
- Integration of knowledge translation and decision support into hospital and GP practice systems.

Above all, the DebugIT project is a good example of how to achieve Translational and Evidence Based Medicine:

- clinical information is used to support medical research and to enhance medical knowledge,
- this new evidence is used to support clinical care.

Although the DebugIT project is focusing on infectious diseases, its translational framework will be suitable for many other clinical problems, providing a solution to increase patient safety and enhance the quality of care.

Achievements in project year one

In a nutshell the global evolution of the project is divided in 4 phases: Year 1: planning, organizing, investigation, proof of concept - Year 2: establishing of the full circle (end to end process) - Year 3: more coverage, more data, deployment - Year 4: framework running and implemented: clinical results, socio-economic and clinical impact assessment.

The DebugIT framework can be seen as a collection of loosely coupled subsystems. Each of the subsystems is taken care of by a specific work package. In addition, a work package deals with semantic interoperability and ontologies.

In order to establish a realistic and phased approach the first year scope focussed on a ‘treatment course’: the portion of a patient care pathway that starts with a culture and contains at least one antibiogram and one treatment. This decision was taken after discussion with clinicians, both internal and external to the project. It resulted in a set of use cases, scenario’s, clearly defined clinical questions and ultimately in a formal description of the year-1 data sub-set.

This data sub-set yields answers to interesting clinical questions:

- Is antibiotic treatment following the antibiogram?
- Is antibiotic treatment adapted after obtaining the antibiogram results?
- What proportions of pathogens are treated with an inappropriate antibiotic?
- What would be the most appropriate antibiotic?
- Can culture alone predict the best antibiotic?

An advantage of this limited data set was its unproblematic scope with regard to privacy issues, as it did not contain any information about the patients themselves. The dataset was analyzed across the different clinical sites and mapped to the clinical terms of SNOMED.

First extractions from the CIS-production databases were data mined, and the extensive interpretation of the results is in progress. Early findings confronted the project teams immediately with some (predicted) challenges:

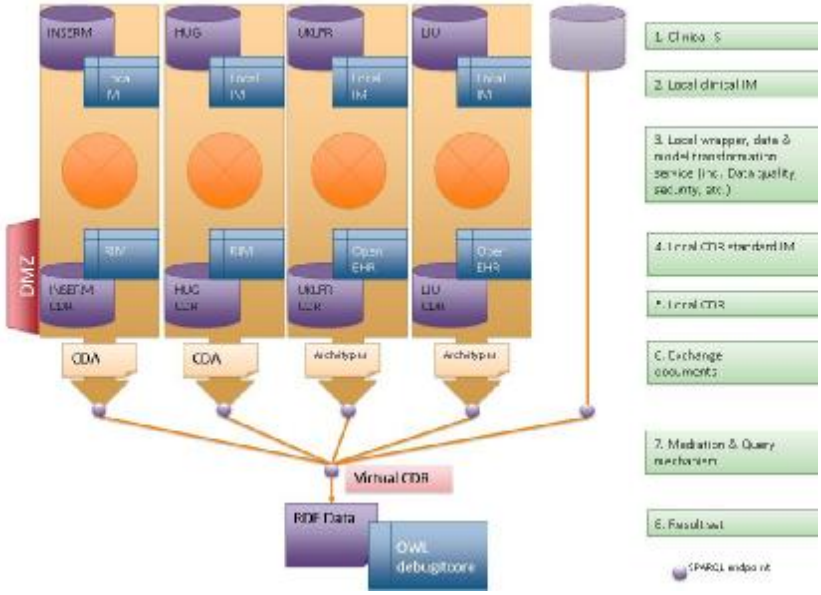
- poor quality and incomplete clinical data
- important clinical information buried in free text
- lack of explicit relationships between data elements.

Stimulating the use of structured data entry as well as free text mining will help to cope with the first two challenges. Looking at temporal relations will help to establish and reconstruct the treatment course.

So far, the data set definition and the resulting extractions were done on an empirical basis. An important goal in the course of the project is the development and use of ontologies to increase the formalization and thereby improve the semantic clarity of the data. Existing ontologies were studied to identify elements that could be reused in a DebugIT core ontology. The project consortium identified a set of upper ontologies, foundational ontologies and specific domain ontologies as building blocks for the DebugIT core ontology. This will be a continuous and iterative refining process until the end of the project.

Another step towards a real deployable framework with a virtual common Clinical Data Repository was the definition of an interoperability platform architecture.

The consortium explores to make a SPARQL endpoint on top of each clinical information system. The clinical questions will be defined as SPARQL queries using the concepts of the DebugIT ontology. Each SPARQL endpoint will translate this into the proper SQL statements tailored to the specific clinical system, and will return the results using the ontology concepts. This will guarantee not only semantic interoperability but also the level of formalization and abstraction needed for the data mining on a global level. Proof of concept of a SPARQL endpoint has been successfully performed. SPARQL mappings will be made towards the ISO 13606 and HL7 RIM information models and in specific cases this mapping will be done directly on the database scheme of the Clinical System.



Another component of the framework is the knowledge repository and authoring tool. The functional and technical requirements were drafted and several knowledge authoring and storage tools evaluated. Already available tools formed the basis of investigations concerning ways to represent knowledge and rules.

The clinical benefits of the DebugIT framework will materialise once it enters actual clinical practice. So far it is too early to integrate decision support or monitoring tools into the clinical systems, but the consortium has worked on the engines needed to support this by experimenting with different machine learning and reasoning approaches (fuzzy cognitive maps, Bayesian belief networks, nearest neighbor etc.) The integration of different reasoning technologies in the same framework is planned.

Based on used cases the DebugIT workpackages have delivered both functional and technical requirement specifications. This has been glued together into an overall architectural blueprint which needles integrates the required subsystems

Ideas and principles of the project have been disseminated in different ways: the consortium has created both a DebugIT website (www.debugit.eu) and a brochure with an overall description of the project. Several papers and poster sessions in conferences have been published, complemented by internal trainings around ontologies and machine learning.

A clinical Advisory Board composed of leading experts has been established to provide feedback on the key assumptions and results and to guide the consortium towards a successful completion of the project. The members of the board are presented in the following overview:

External independent experts:

1	Prof. Dr. Didier Pittet	WHO World Alliance for Patient Safety	Switzerland
2	Dr. Didier Guillemot	CeRBEP, Institut Pasteur	France
3	Prof. Dr. Javier Garau	European Society of Clinical Microbiology & Infectious Diseases (ESCMID)	Spain
4	Prof. Dr. Kendall Ho	University of British Columbia	Canada
5	Dr. Hans Rutberg	Linköping University Hospital	Sweden
6	Dr. Vilma Marešová	Clinic for Infectious Diseases, Prague	Czech Republic
7	Mr. László Balkányi MD, PhD	European Centre for Disease Prevention and Control (ECDC)	Sweden

Experts participating within the project

8	Dr. Håkan Hanberger	Swedish Programme for Rational Use of Antimicrobial and Surveillance of Resistance (STRAMA)	Sweden
9	Dr. Hugo Sax	Les Hôpitaux Universitaires de Genève	Switzerland
10	Prof. Dr. Sten Walther	Swedish Intensive Care Registry	Sweden

Consortium

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- Prof. Christian Lovis, Les Hôpitaux Universitaires de Genève

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- Institut National de la Santé et de la Recherche Médicale, France
- Internetový Pristup Ke Zdravotním Informacím Pacienta (IZIP), Czech Republic
- Linköpings Universitetet, Sweden
- Technologiko Expedeftiko Idrima Lamias, Greece
- University College London, United Kingdom
- Les Hôpitaux Universitaires de Genève, Switzerland
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- Université de Genève, Switzerland

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