



Implementation of a query interface for a generic record server

Tony Austin*, Dipak Kalra, Archana Tapuria,
Nathan Lea, David Ingram

Centre for Health Informatics and Multiprofessional Education (CHIME), UCL, UK

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ABSTRACT

Introduction: This paper presents work to define a representation for clinical research queries that can be used for the design of generic interfaces to electronic healthcare record (EHR) systems. Given the increasing prevalence of EHR systems, with the potential to accumulate life-long health records, opportunities exist to analyse and mine these for new knowledge. This potential is presently limited by many factors, one of which is the challenge of extracting information from them in order to execute a research query.

Method: There is limited pre-existing work on the generic specification of clinical queries. Sets of example queries were obtained from published studies and clinician reference groups. These were re-represented as structured logical expressions, from which a generalisable pattern (information model) was inferred. An iterative design and implementation approach was then pursued to refine the model and evaluate it.

Results: This paper presents a set of requirements for the generic representation of clinical research queries, and an information model to represent any arbitrary such query. A middle-ware component was implemented as an interface to an existing system that holds 20,000 anonymised cancer EHRs in order to validate the model. This component was interfaced in turn to a query design and results presentation tool developed by the Open University, to permit end user demonstrations and feedback as part of the evaluation.

Conclusion: Although it is difficult to separate cleanly the evaluation of a theoretical model from its implementation, the empirical evaluation of the query-execution interface revealed that clinical queries of the kinds studied could all be represented and executed successfully. However, performance was a problem and this paper outlines some of the challenges faced in building generic components to handle specialised data structures on a large scale. The limitations of this work are also discussed. The work complements many years of European research and standardisation on the interoperable communication of electronic health records, by proposing a way in which one or more EHR systems might be queried in a standardised way.

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1. Introduction

1.1. Research objective

The objective of this research has been to develop and evaluate a generic information model that could be implemented

* Corresponding author at: 4th Floor, Holborn Union Building, Highgate Hill, London N19 5LW, UK. Tel.: +44 20 7288 3372.

E-mail address: t.austin@chime.ucl.ac.uk (T. Austin).

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as a query/result interface to a generic and standards-based electronic health record (EHR) system, in order to provide a generalised means of supporting diverse user-driven clinical and bio-science research analyses of EHR data.

1.2. Background/rationale

Given the increasing adoption of EHR systems internationally, some of which are or will be interconnected via regional or national health care networks, there are unprecedented opportunities to knowledge-mine routinely collected EHR data across significant populations for clinical and bio-science research, public health and epidemiology. This potential will be greater as forthcoming interoperability standards become adopted.

Over 15 years of cumulative research has been undertaken to identify the requirements and information architectures needed to support shared longitudinal electronic health records that are clinically and ethically sound [1–6]. This work has so far resulted in two generations of European (CEN) standard [7,8], and a new joint European (CEN) and international (ISO) standard for EHR Communication, parts of which are progressively being published as European Standards during 2007–2008 [9]. These research projects and standards have focussed on supporting the care given to patients by promoting good designs for EHR systems, and standards for the secure communication of part or all of a patient's EHR between authorised systems. However, these EHR-related standards have centred on the communication of parts of the EHR of an individual subject of care, and little work has been done to date on defining a generic means of querying EHR systems, as distributed repositories, in a consistent way. Without such a means the only methods of querying large populations of EHRs are to centralise the data into a new single data warehouse or to transform each required query into multiple formats as supported by each EHR system. It is recognised that not all EHR systems deployed today would be capable of supporting a standards-conformant interface, but there is increasing pressure for them to do so and for many that do, it would be an attractive option to be able to support population queries by extending the same interface.

The research reported in this paper to investigate a generic query interface was conducted as a work plan item within the Clinical E-Science Framework project (CLEF).

1.3. The CLEF project

The Clinical E-Science Framework (CLEF [10]) project, and its follow-on project CLEF-Services, together span five and a half years of research (2002–2007) funded by the UK Medical Research Council as part of the UK national e-Science programme. CLEF aims to develop rigorous generic methods for integrating and analysing clinical information that is captured as part of routine patient care, and to develop tools to facilitate the analysis of EHR data by the clinical and bio-science research communities.

The key goal of CLEF is to provide medically rich information derived from operational health records for the purposes of scientific study and research, in an efficient manner, whilst

ensuring patient confidentiality by developing appropriate safeguards and removing or protecting potentially identifiable information. A separate thread of CLEF research is therefore developing a methodology for deriving large numbers of longitudinal pseudonymised health records, within a managed and monitored authentication and authorisation framework that limits access only to legitimate users [11].

Another thread of research, pertinent to this paper, has been the development of a client tool at the Open University to enable end users to compose clinical research queries in a user-friendly natural language format, and also to present the results in a variety of presentation styles as narrative text, tables and charts [12].

In order to have access to a test-bed of empirical data and systems on which to develop the generic query specification, a pseudonymised EHR system was established at University College London (UCL) during 2004–2005. A sample population of electronic health records (around 20,000 deceased-patient records) was extracted, with ethical approval, from the main computer system at the Royal Marsden Hospital (UK) and subjected to a combination of computerised and manual de-identification on site before being sent via a secure communication to UCL. The generic query interface model reported in this paper, was implemented as an interface to this repository and a test-suite of queries were designed and executed on it using the Open University client.

The final combination of repository and tools, and others developed within the project, are presently being consolidated into a CLEF Workbench, to be published later.

2. Method

The research method adopted was to obtain a diverse set of examples of clinical research questions that could be represented as queries executed on a clinical data repository, in order to infer some generalisable patterns. These were reflected in a set of requirements and an interface information model. The interface was implemented as a Java middleware component communicating with an existing EHR server, also written in Java, at University College London. Using a client component developed by the Open University, a suite of test queries were composed and executed in order to validate the implementation, the utility of the design approach and as a visualisation from which to gain end user feedback. A number of queries were examined in more detail, one of which is described in the next section.

2.1. Investigations

Several complementary approaches were pursued, for which one clinical domain (cancer) was selected as the principal focus in order to make the investigation manageable. Cancer was selected because of particular opportunities for implementation and evaluation using data from the Royal Marsden Hospital (described in Section 1.3).

1. A review of published clinical studies was conducted in order to find papers that investigated the research questions in a formal and rigorous way.

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