Towards a next-generation Diagnostic Support System

Vasa CURCIN\textsuperscript{a,1} and Derek CORRIGAN\textsuperscript{b} and Olga KOSTOPOULOU\textsuperscript{a} and Prezmyslaw KAZIENKO\textsuperscript{c} and Mike ROBINSON\textsuperscript{d} and Brendan DELANEY\textsuperscript{a}

\textsuperscript{a}King’s College London, London, United Kingdom
\textsuperscript{b}Royal College of Surgeons in Ireland, Dublin, Ireland
\textsuperscript{c}Wroclaw University of Technology, Wroclaw, Poland
\textsuperscript{d}InPractice Systems (INPS) Ltd, London, United Kingdom

Abstract The EU FP7 TRANSFoRm project will produce a digital infrastructure to support translational research, by facilitating the reuse of routinely collected primary care data in different types of clinical research. Its diagnostic decision support (DDS) component uses the infrastructure to provide diagnostic recommendations at the point of care, based on the knowledge extracted from the data. The DDS prototype has been developed for abdominal pain, chest pain and dyspnea, comprising an evidence base and associated services required by a clinician-facing software tool. The software has been integrated into INPS Vision EHR system in primary care and evaluated with real clinicians using simulated patient encounters. The panel shall discuss clinical, informatics, and commercial issues surrounding the disruptive change brought about by this new approach.

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Introduction of the topic

The widespread adoption of electronic medical records and better understanding of the informatics requirements of both clinical research and transactional knowledge provide an opportunity to accelerate both research and knowledge translation, via a digital infrastructure. This coupling of research infrastructure with infrastructure for the rapid adoption of research findings is termed The Learning Healthcare System (LHS).

The EU FP7 TRANSFoRm project has produced a digital infrastructure to support translational research, by facilitating the reuse of routinely collected primary care data in different types of clinical research and providing mechanisms for reusing data collected during trials in clinical data repositories. Associated with this is the decision support component that uses the infrastructure to provide diagnostic recommendations at the point of care, based on the knowledge extracted from routinely collected data. Thus, TRANSFoRm provides a software platform for the LHS.

TRANSFoRm Diagnostic Decision Support System (DDSS) prototype supports three presenting problems: abdominal pain, chest pain and dyspnea. At its core are an evidence base and associated services required by a clinician-facing software tool integrated into INPS’s Vision3 EHR system in primary care and evaluated with real
clinchs using simulated patient encounters (trained actors). The panel shall discuss clinical, informatics and commercial issues in embedding DDS into EHR systems, addressing the Clinical user interfaces and Digital healthcare strategies topics of MIE.

1. Model-driven diagnostic support systems (Corrigan)

We describe the overall decision support technical architecture showing how TRANSFoRm technologies, such as the provenance model and EHR data integration are implemented as part of a broader decision support solution. The discussion will focus on the development of the Clinical Evidence Model for the representation of diagnostic evidence. The evidence model allows for representation of diagnostic evidence independently of, but supporting, code binding to appropriate clinical terminology bindings used by a target EHR system. Evidence model is deployed inside a clinical evidence web service accessible by third party decision support tools. We show how the evidence service also supports update of clinical evidence generated from data mined sources. We will demonstrate how diagnostic questions can be asked of the evidence service using patient data extracted from an EHR system. We demonstrate how we have effectively deployed this information using a diagnostic decision support interface integrated with a chosen EHR to provide early and late decision support during the clinical consultation.

2. DSS design based on psychology theory and evidence (Kostopoulou)

We conducted two randomised controlled experiments with GPs as participants to investigate the best timing of diagnostic support during the consultation. The experiments took place in the UK (N=297) and Greece (N=150), two countries with entirely different healthcare systems. The experiments tested the principle of early support, where GPs are presented with a list of possible diagnoses to consider at the start of the consultation, before starting testing their own diagnostic hypotheses. This principle is based on psychology evidence about the power of first impressions on subsequent judgements and designed to counteract the ‘first-impressions bias’. In both countries, early support resulted in improved accuracy over an unaided control group.

We subsequently used human factors methods to elicit user decision requirements, on the basis of which we designed an interface for a DSS prototype. The prototype is driven by the Clinical Evidence Model described above and is integrated with the electronic health record. Finally, we conducted a within-participants evaluation of the DSS prototype, where 32 UK GPs consulted with simulated patients (actors), first with their usual EHR system and, on a second occasion, with the DSS integrated into their EHR system. We will present and discuss preliminary findings from this evaluation.

3. Data mining for diagnostic support (Przemyslaw Kazienko)

Clinical Prediction Rules (CPRs) quantify the contribution of the different clinical data to a particular clinical outcome and help clinicians to decide the diagnosis, prognosis or therapeutic conduct for any given patient. The TRANSFoRm DSS is based on an
ontological CPR repository for diagnosis prediction, with clinical evidence expressed using a unified vocabulary. This talk shall explain the proposed methodology for constructing the repository and discuss the heterogeneity of the domain vocabularies, data mining goals, algorithms and quality measures for filtering relevant findings. CPRs mined from heterogeneous data sources, together with the patient and clinical context provide valuable information for diagnostic support. In particular, physicians can filter only CPRs for a given population (restricted by e.g. country, gender or age range), compare them or combine to have wider and more comprehensive look-up.

4. Provenance-based learning from rule usage (Curcin)

The DSS tools developed in TRANSFoRm are provenance-aware, capturing the semantic trail of both evidence base generation, and individual diagnostic advice given. This lays the ground work for enabling the tracing of individual decisions back to originating models, and, in turn, data sets and algorithms used to generate them, enabling unprecedented insight into the produced rules. Based on the DSS evaluation, we have constructed the first collection of provenance data from diagnostic support, and we shall present the pilot analysis techniques that have been developed on that data and discuss how this data can be used to design rule performance models and impact rule adoption in healthcare environments.

5. Vendor perspectives on evolving business models for EHR systems (Robinson)

The LHS is optimizing the knowledge routes in the health system to maximize patient benefit and research throughput, and EHR vendors have a key role to play in this effort. Their contribution is two-fold: firstly, the data routinely stored in the EHRs is used by LHS technologies such as TRANSFoRm, to facilitate data collection and build knowledge bases for DSS systems; secondly, their presence “on the ground” in clinical practices provides a channel for translating that knowledge into deployed diagnostic tools. We foresee that EHR vendors shall increasingly focus on this knowledge reuse, thereby providing more integrated clinical practice/research offering to their customers.

6. Role of DSS in the LHS (Delaney)

The LHS requires an ‘efferent’ arm to distribute and utilize the knowledge gained in the ‘afferent’ or research arm of the cycle. Thus, not only is clinical data required to be structured and semantically organized for research use, but research data must be organized and made computable for use in the appropriate clinical setting. DSS, whether, as in TRANSFoRm’s case, for diagnosis, or for treatment or prognostication, requires a knowledge engine, able to reason with artifacts in the clinical encounter. At the same time knowledge must be created, curated and maintained. TRANSFoRm’s approach with a core Ontology and instances of rules within the ontology being made available as a web-service, is both efficient, in that updates to the ontology affect all DSS nodes instantly, but also separates the structure of knowledge from both its content and its application (within an EHR system).