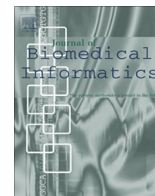




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Model-driven approach to data collection and reporting for quality improvement

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ABSTRACT

Continuous data collection and analysis have been shown essential to achieving improvement in healthcare. However, the data required for local improvement initiatives are often not readily available from hospital Electronic Health Record (EHR) systems or not routinely collected. Furthermore, improvement teams are often restricted in time and funding thus requiring inexpensive and rapid tools to support their work. Hence, the informatics challenge in healthcare local improvement initiatives consists of providing a mechanism for rapid modelling of the local domain by non-informatics experts, including performance metric definitions, and grounded in established improvement techniques. We investigate the feasibility of a model-driven software approach to address this challenge, whereby an improvement model designed by a team is used to automatically generate required electronic data collection instruments and reporting tools. To that goal, we have designed a generic Improvement Data Model (IDM) to capture the data items and quality measures relevant to the project, and constructed Web Improvement Support in Healthcare (WISH), a prototype tool that takes user-generated IDM models and creates a data schema, data collection web interfaces, and a set of live reports, based on Statistical Process Control (SPC) for use by improvement teams. The software has been successfully used in over 50 improvement projects, with more than 700 users. We present in detail the experiences of one of those initiatives, Chronic Obstructive Pulmonary Disease project in Northwest London hospitals. The specific challenges of improvement in healthcare are analysed and the benefits and limitations of the approach are discussed.

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1. Introduction

Rising demand for efficiency and effectiveness in health services with increasingly limited resources puts health systems worldwide under pressure to continuously deliver high quality care [1–4]. More rapid implementation of research into practice has the potential to improve outcomes and value, however it is recognised that implementation in health systems is slow, incomplete, and often not sustainable, with variation in compliance to best practice [5]. This challenge of implementing new approaches into practice has been identified as the second translational gap [6] and research bodies such as Institute for Healthcare Improvement (IHI) in the US, UK's Institute for Innovation and Improvement, and Australian Institute for Health and Welfare, have been set up to

investigate the mechanisms behind effective and sustainable improvement initiatives.

Local improvement initiatives represent an important part of achieving change in a healthcare system, complementing the top-down institutional and national initiatives. Local improvement is also well-suited to implementing clinical research into practice. The proximity of the implementation teams, consisting of, among others, doctors, nurses, administrative staff, pharmacists, patients and members of the public, to front line care delivery ensures relevance and focus of such improvement projects. However such projects face their own set of challenges, including the complex nature of the internal organisational processes, lack of capability and capacity for improvement work in busy staff with diverse responsibilities, and low visibility of the changes being effected.

Data-driven methods are recognised as essential to achieving improvement in healthcare. Boaden's report on quality improvement in healthcare [7], established that appropriate and rigorous use of data, both quantitative and qualitative, is essential to test out interventions during an improvement initiative. Such reliance

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on data improves the chances for success, and for a higher-level evaluation to determine whether the initiative has a significant impact upon quality for patients and carers. Meyer et al. [8] also stresses the need for appropriate selection of metrics to be used in measurement to fit the needs of both end-users and service providers. However, improvement data required by local improvement initiatives are often not available in hospital EHR systems, not at the required level of granularity, not appropriately reported, or not easily accessible to the implementation team members. While national and regional improvement programmes can invest resources in overcoming these problems through adapting their software and information systems, such facilities are rarely available to smaller teams.

To address this need for targeted data to drive local improvement initiatives, we developed an approach based on Improvement Data Model (IDM), a novel computational model of improvement, and a prototype software Web Improvement Support for Healthcare (WISH) to demonstrate its use. Local teams in medical organisations use IDM to specify the metrics to track their performance during the intervention, together with the data points necessary to calculate these metrics. Based on the team's IDM specification, the WISH software automatically generates appropriate data collection pages, and a set of live reports containing the required metrics for team members to access as the improvement project progresses. The standardised reports use Statistical Process Control (SPC) [18,19] as the statistical tool for visual analysis.

The IDM/WISH model-based approach started as the core part of UK's NIHR-funded CLAHRC NW London initiative, where it was used and refined on over 50 projects in Northwest London hospitals between 2007 and 2013. WISH supports multiple concurrent improvement projects inside a single enterprise, with users being parts of several initiatives, potentially with differing administrative privileges, e.g. improvement team members, managers, or administrators.

In order to demonstrate the feasibility of a model-driven approach to improvement data collection and reporting, we describe the usage of IDM and WISH in one CLAHRC NWL improvement project focused on improving care for patients with Chronic Obstructive Pulmonary Disease at discharge from a hospital. The aim of the project was to improve outcomes by ensuring a set of care elements (COPD bundle) is offered to all patients admitted to hospital with a diagnosis of acute exacerbation of COPD. The exemplar IDM model is provided for the project, including the data items captured and metrics defined. The WISH data capture and reporting components generated from the model are presented, together with the user experiences.

2. Background and significance

Performance metrics are increasingly derived from routinely collected data [9,10] to achieve efficiency and effectiveness in health systems. Availability of up-to-date simple measures of performance linked to the improvement aim has been shown to help the understanding of the relationship between actions and outcomes, inform decision making, and drive success [11–13]. For example, if a local improvement team is implementing a change in a particular patient pathway, such as community acquired pneumonia treatment, hospital EHR systems can be used to measure high-level outcome measures (e.g. mortality rates) whilst a change is being implemented, but are poorly suited to providing more finely grained data specific to the local task (e.g. number of anti-smoking leaflets handed out in the ward each week).

Effective data feedback for quality improvement has a number of characteristics: timeliness, specificity to local context, credibility, and sustainability over time [14]. However, routinely collected

data often fails to meet these criteria. Measurement should always reflect the current state, requiring data collection in good time and efficient and fast sharing of results within the team. In a large institution, this is typically a lengthy process since the routinely collected data need to be extracted, curated, and analysed before it can be used for performance analysis and the results sent to the improvement implementation team. Furthermore, the specificity to local context is missing, since the local improvements may require bespoke data that do not reside in an existing EHR system. In order to avoid compromising on measure definitions, by restricting them to data available in the EHR system, such data is often collected in spreadsheets or other local data collection instruments, with no central oversight and no visibility to teams. While potentially useful in the short-term, without a common information model and shared quality standards, this approach fails to produce comparable results that can be used for learning best practices. Finally, analysis techniques used should reflect the needs and skills of the improvement team to achieve credibility and sustainability. Popular Electronic Data Collection (EDC) tools for clinical trials, such as REDCap [25], lack the integrated user-defined analytics that is required for providing understandable and current improvement information to the users. For example, REDCap provides inline frequency counts for individual questions, but any further data analysis is left to specialist researchers using external analytical tools [40].

Quality improvement has been extensively studied in business and manufacturing domains. Continuous data collection, analysis, and feedback form the core of Langley's influential Model for Improvement [15–17]. The Model for Improvement uses Statistical Process Control (SPC) [18,19] as the preferred statistical approach for establishing significant changes in time-series data. Quantitative data in Model for Improvement is enriched by the qualitative Plan-Do-Study-Act (PDSA) cycles [20,21], which provides qualitative description of a change that should result in the improvement, encompassing hypothesis, testing, analysis, and refinement.

The informatics challenge in healthcare local improvement initiatives consists of providing a mechanism for rapid modelling of the local domain by non-informatics experts, including performance metric definitions, and grounded in established improvement techniques. The Improvement Data Model (IDM) provides a flexible information model to local improvement initiatives, similarly to CDISC's ODM standard that provides structure for trial data collection [22]. Such model-based approach encourages sharing of information and data between different departments and/or organisations and overcoming the culture of internal silos to share best practices, compare results, and preserve generated knowledge. Our work goes further than just being based on a model, and is fully *model-driven* in that the system responds dynamically to changes in the model, such as addition of new improvement projects.

3. Materials and methods

A key challenge in model-driven healthcare software [24–26] is the simplification of the model development and the workflow deploying the model to its translation into practice. To address this challenge when using IDM, we have developed the WISH software platform and an associated methodology for developing the IDM models. WISH is a collaborative framework for local improvement teams to specify the quality metrics for their improvement projects, and rapidly deploy the data collection web interfaces for the required data. The basic steps for using WISH are:

1. Define the metrics that will be used to measure the effect of an improvement initiative.

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