



Integrating feedback from a clinical data warehouse into practice organisation

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KEYWORDS

Dashboard;
Data warehouse;
Hospital information
systems;
Feedback;
Quality indicators;
Patient care team

Summary A patient oriented hospital information system (ARIANE) was inaugurated at the Sherbrooke University hospital (CHUS) in 1990 and a clinical data warehouse (CDW) completed 2004. The CDW is updated from ARIANE every 24 h and includes ICD discharge diagnosis data, visit DRG and SNOMED encoding. The data is encrypted on storage. Data is accessed according to institutional approval. To facilitate data access two levels of tool have been made accessible using a web-browser. The first level consists of a 'dashboard' that has a defined design and enables a set of pre-determined dynamic queries about a patient population. This level can be operated with minimal training. The second level uses a convivial database query tool, which requires some prior training. Two prototype dashboards have been designed and evaluated for acceptability. The first for the emergency department enables analysis of patient occupancy. The second for the biochemistry department enables quality assurance evaluation. In most cases worldwide the clinical data warehouse is only beginning to be exploited, often impeded by lack of connection between different enterprise databases. Our CDW is expected rapidly to create a culture change so that clinical practice can be continuously evaluated using compiled data readily available from the electronic health record/hospital information system.

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1. Introduction

It is of some interest that information feedback as an operational control approach is rarely used in the health system. The reason is fairly obvious if the paper patient record is the primary source of

information. Even in the best organised situation it is very time consuming to review a series of patient records. Here is a major opportunity for the indexed electronic record. However, although the potential role that the electronic health record (EHR) should have for improving care quality is frequently discussed in the literature, there are but few reports of the use of EHR data for practice feedback [1]. The EHR should also become an important source of health system performance indicators. Feedback,

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assuming high quality data, is a source of objective information of the process and outcome of patient care. It should enable itemised review by a patient care team, critique with respect to best evidence, be a primary source of information for consensual practice improvement and support education for students and the team.

In 1989, a patient centred hospital information system, named ARIANE, was installed at the Sherbrooke University hospital (CHUS) Centre universitaire de l'Université de Sherbrooke, obtained from Health Data Systems (HDS, California, now Per-sé Technologies, Georgia). Thus a single operational database concerns all transactions of admission, diagnostics, therapeutics and interventions; ICD coding is attributed by the medical records department. There is on average a system terminal for every four beds and about 80% of the patient record is paperless, the main exception being the clinical notes. In 2002, as part of an initiative Infostructure de recherche intégrée en santé (IRIS-Quebec), financially supported by the Canada Foundation for Innovation, a clinical data warehouse (CDW) linked to the ARIANE system was built using the Nucleus database (Sand Technologies, Montreal). The CDW incorporates a first stage automatic encoding to SNOMED and ICD 9 and 10 with tools for professional coding validation, and integration of the MEDECHO data (Système de maintenance et d'exploitation des données pour l'étude de la clientèle hospitalière) required by the Quebec Ministry of Health, that includes the Diagnosis Related Group (DRG) based on the ICD codes of the medical records department. The CDW, incorporated into CIRESSS, is updated from ARIANE every 24 h.

ARIANE is a transaction oriented database consisting of about 1400 tables. CIRESSS CDW is a subject oriented database for analytical processing simplifying to 11 tables according to major dimensions such as patient, location, visits, diagnostics, prescriptions, results and others. The Nucleus database supports 100% data indexing. Major simplification of tables, possible when passing from a transactional to an analytical purpose, along with full data indexing enables fast queries including complex data-mining. Additions to the ARIANE database such as addition of a new diagnostic procedure can be automatically updated into the CDW.

Data is encrypted on transfer to the CDW. Data access requires project approval by the Director of Professional Services supported according to project by the ethics committee review. The medical records department based on the explicit documentation of the project and predetermined procedures manages the attribution of security

level to individual data fields. The levels are total denormalisation, a pseudonym to enable cross-comparison between records, and nominal. At each security level data filtering can be applied.

To assess the current efficiency of the SNOMED coding tool, the specificity of coding and the rate and type of error has been assessed using a series of representative pathology reports in French. 74% of medical concepts and 81% of modifiers were correctly coded. About 30% of the coding was erroneous, mostly due to coding noise of unimportant words, which can be progressively controlled with experience and the remainder mainly due to physician use of language which should be corrected during training use of the tool. The SNOMED coding tool provides easy analysis of the coding by the user, dictionary support and the possibility to modify the coding by creating an updated version, all previous versions remaining accessible. At present this tool is very useful for searching and linking medical concepts and is suited to support integration of coding into clinical practice, for which further studies are ongoing.

In previous work, prior to the installation of the CDW, using requested datasets and help of the ARIANE personnel, we have investigated a methodology for providing feedback to clinical teams. This methodology resulted in the Autocontrol model shown in Fig. 1 and whose development is illustrated by the following study description [2,3]. The study in the intensive care unit at the request of the intensive care physician considered whether there was an excessive use of blood gas measurements. Two teams of physicians and nurses agreed to take part and were asked to consider literature evidence of how tests should be used and also data about test use from the ARIANE system. The physicians and nurses met separately and then together following a structured method of problem and solution analysis. The study illustrated, with reference to the Autocontrol cyclical model, Fig. 1: (A) *Evidence*: the study used diverse sources of evidence for problem solving, including the relevant contribution of practice data which could show the relation of blood gas requests to time and events such as prior surgery, (B) *Critique*: sharing of evidence between professionals sorted out causes and solutions; critique enables adjustment of the mental model or metacognition that the individual has of the situation, (C) *Construction*: the critique led to a constructive plan for change in practice, and (D) *Integration*: team adaptation with adoption of practice change that can subsequently be evaluated by analysis of practice data.

The arrival of the CDW gives the opportunity to put in place different tools and approaches for using

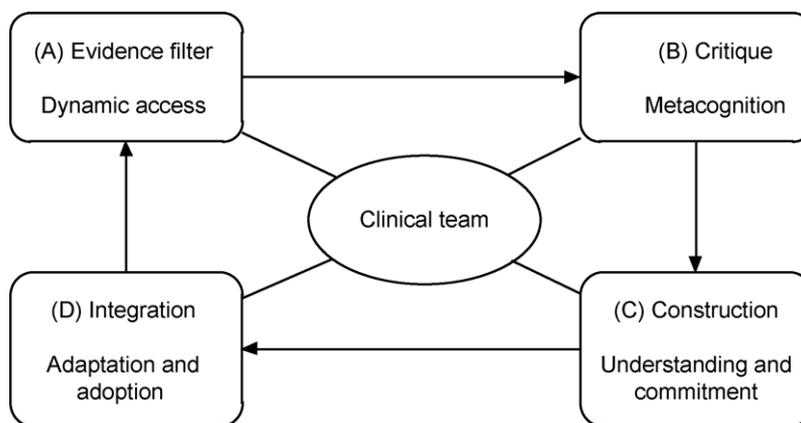


Fig. 1 The Autocontrol practice change methodology.

practice data as feedback for practice change, optimisation and innovation.

A distinction has been made in the literature between methods of data interrogation including drill down and combining data in different displays, sometimes called decision information systems, and systems that use diverse algorithms to explore data sometimes called intelligent systems. The 'dashboard' is a term that has developed a certain currency in relation to enterprise data warehouses, aiming to provide the decision-maker a human computer interface with a set of windows that enable choice of data, ranges and combinations of data to make a query to the database which then returns the selected data that are portrayed as a graph or table or both. Inherent in this approach, as for the decision information system, is the dynamic nature of the enquiry, in contrast to a static administrative report, so that different combinations can be examined, one enquiry leading to another, so that an overall view of a situation can be obtained as part of making a policy decision.

As the CDW is indeed a rich resource for practice evaluation and potentially for knowledge discovery, it is of interest to consider the family of tools that should be associated with the CDW. We consider three levels of complexity. The dashboard level of complexity is characterised by windows that are preprogrammed after user consultation and requires only a small amount of training for use by the patient care team. The next more complex level requires some database expertise and in using more complex tools for data exploration, data mining and statistical analysis; this has been currently partially made available using a Query tool, Brio and with training of specialist users. The most complex level, currently under research, interacts data with models of clinical practice and organisations.

The objective of this paper is to consider how the development of a dashboard approach to feedback from the CIRESSS clinical data warehouse might be incorporated into regular paradigms of practice review with particular consideration of the development of two examples for the emergency unit and for the clinical biochemistry department.

2. Methods

Following on the Autocontrol experience, the CIRESSS team has worked with clinical teams to define the sets of data that are considered likely the most meaningful to provide useful feedback for quality practice adjustment and that can be incorporated into the dashboard design. In principle dashboards relate to a segment of the organisation and are used according to role with impact on policy decision-making and also on education. The dashboard tool is required to be accessible, intuitive and dynamic. The accessibility extends to the clinical team and their students and, as it is not at this stage a tool for direct patient management, it contains no nominal data.

The consultation with the user enables definition of classes of important data in relation to different types of enquiry and in relation to defined scenarios of utilisation. Precision of requirements enables formalisation of screen design. Informatics personnel and users together define the functionality expected of their first prototype dashboard ensuring that data fields have been exactly chosen and carefully named with appropriate expression of individual data, for example, the number of significant figures after the decimal point, and their units. Certain data may need some transformation as part of their visualisation, for example, methods of statistical treatment of outlying data.

Based on the first round of user consultation a prototype version enables revision, for example, of security, accessibility, usability, results representation, correctness of data fields and statistical representations such as minimum and maximum values.

An evaluation approach to the overall process therefore requires understanding the reasons for the scenarios, choice of data, methods of data transformation, clarity and precision of display. Also required are parameters of use in practice such as accessibility, satisfactory speed of dynamic interaction, and general user satisfaction.

Two applications have been developed, for the emergency department and for the clinical biochemistry department. That for the emergency department currently is oriented on understanding patient occupancy of the department and has a primarily administrative aim. The implementation for the clinical biochemistry department is to support assessment of the quality of the service to different clinical units.

3. Results

The description of the development of two different dashboard applications is given including the lessons learnt from this process.

3.1. Emergency department

The dashboard developed for the emergency department has a mainly organisational purpose. The first scenario chosen by these users is in response to the chronic overcrowding of the emergency department, and the main aim is to look at distribution of cases according to origin and time of day. Figs. 2 and 3 respectively show a request and result dashboard screen. In Fig. 2 the left hand query panel enables selection of year, financial period, which hospital, type of clientele (walk-in or by ambulance) and time of day or work shift period. The right hand screen shows a graphical display of previous query results. Comparative data are available since 1990.

3.2. Clinical biochemistry department

Two scenarios were decided in consultation between users and designers, both concerning quality assurance. The first scenario sought to evaluate the turn-around time between request by the clinician and the clinician receiving the test. The second concerned the monitoring of the distribution of test results over time, requiring a descriptive statistical analysis of the distribution. A request dashboard screen for the clinical biochemistry department is shown in Fig. 4. In the left and upper panels can be

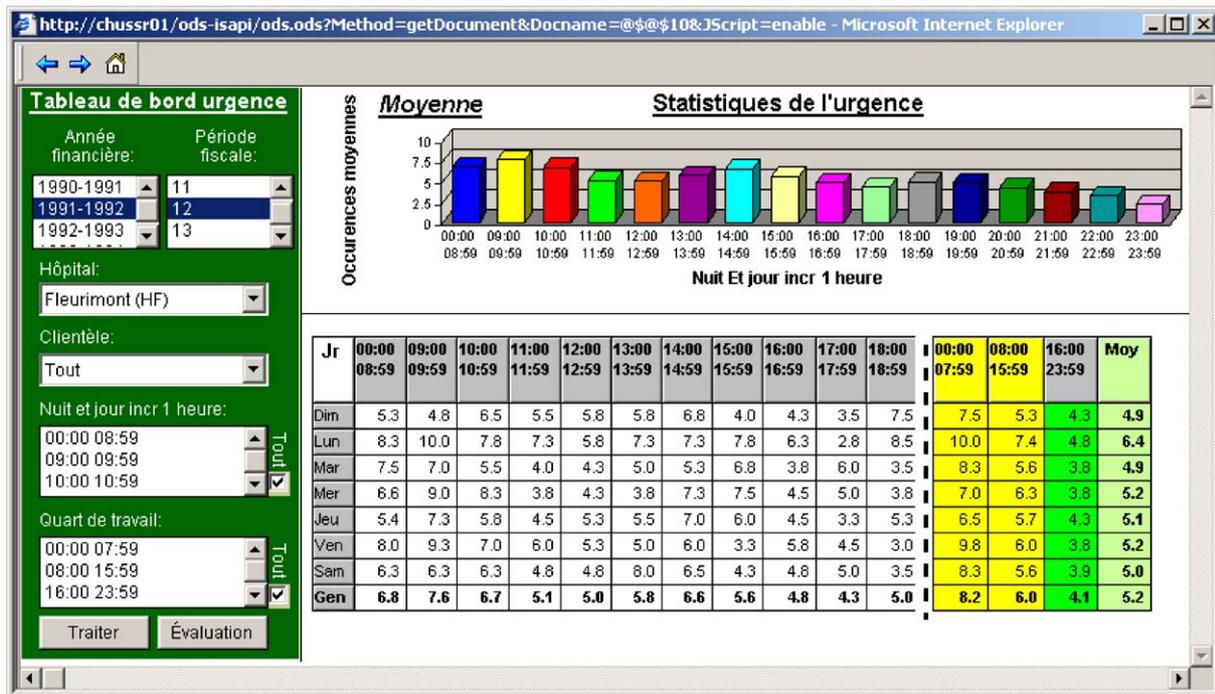


Fig. 2 Request screen to look at emergency department attendance.

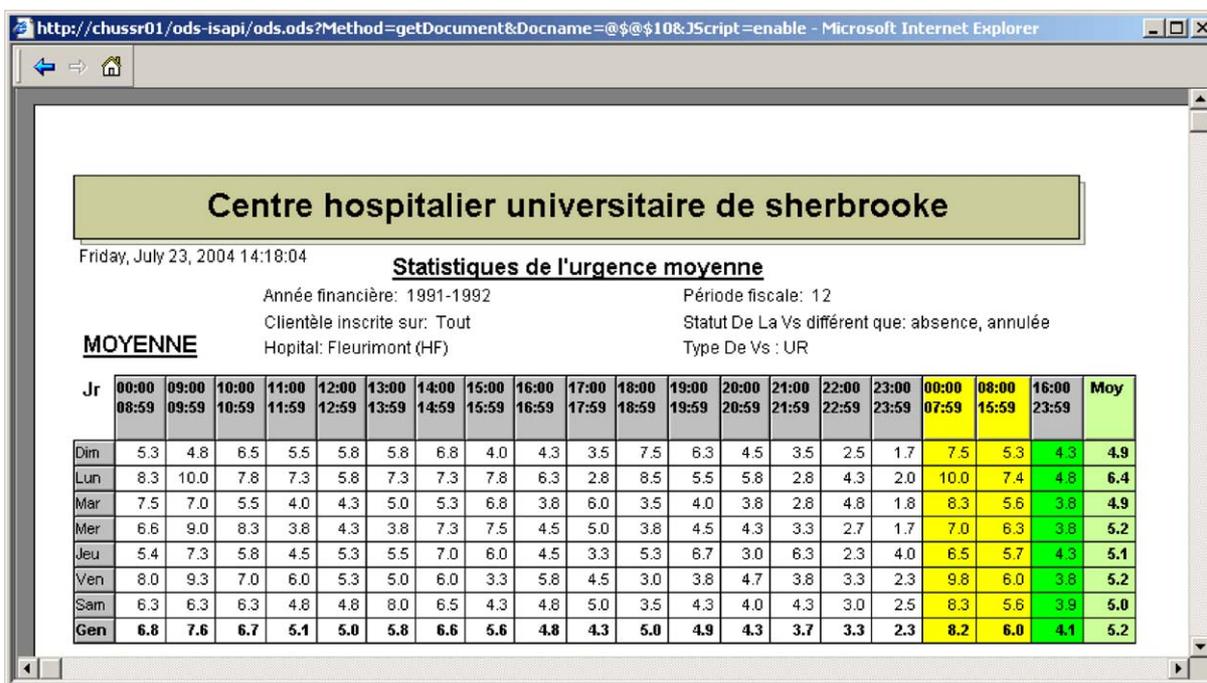


Fig. 3 Result screen, emergency department.

chosen time period, hospital unit or specialty, the type of display of data, a particular laboratory test, the category of patient visit, for example, outpatient, the time of day and the information about the test which might be the result, the time of request of the result or the turn-around time of the test. The right hand lower panel shows a graphical display

of previous results. Other result displays giving fuller graphics and statistical detail are available (Fig. 5).

During validation of the first prototype with the users the dashboard was modified so that the user can choose an appropriate interval of values for graphical display.

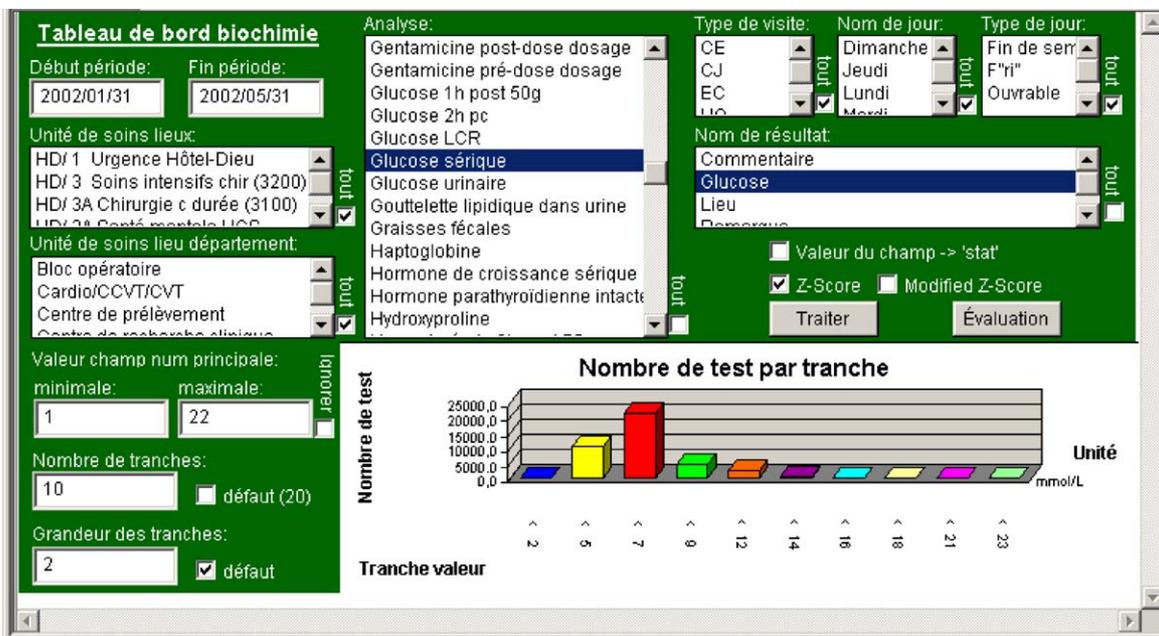


Fig. 4 Clinical biochemistry request screen.

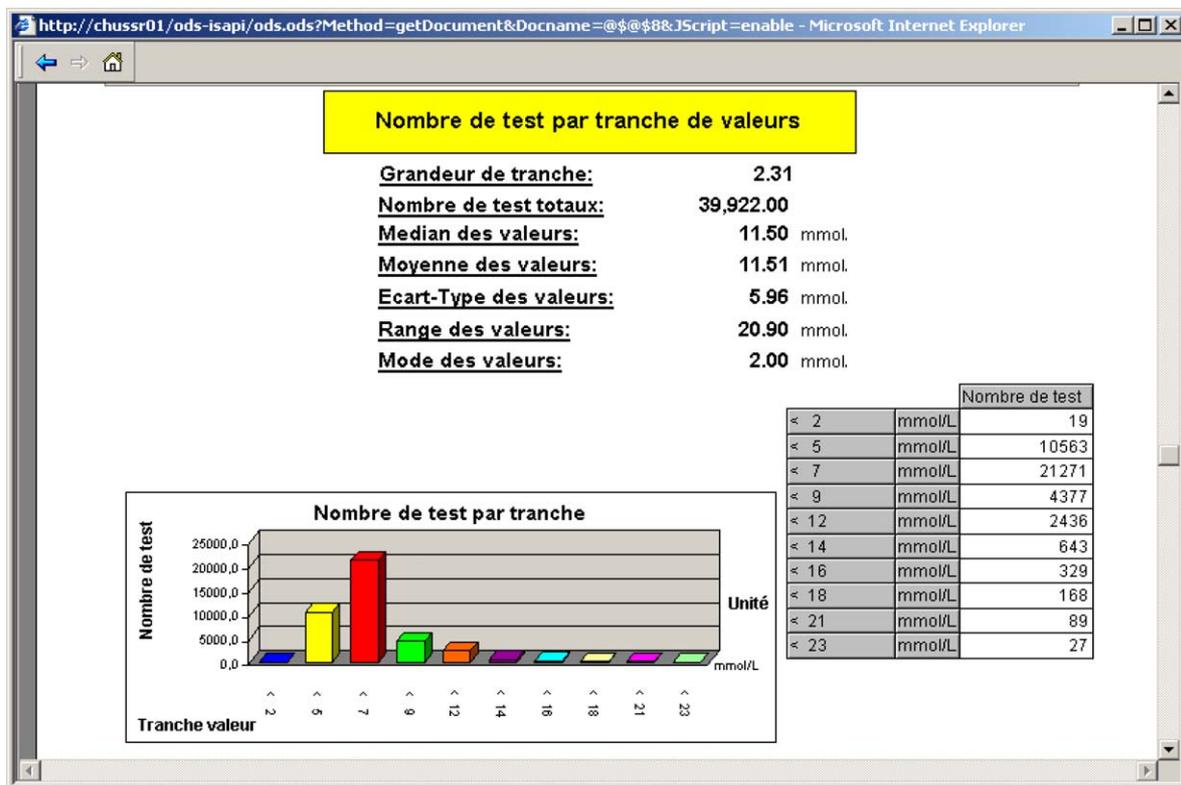


Fig. 5 Clinical biochemistry result screen.

4. Lessons learned

Users and designers have different perspectives of the data. The designer understands the content of data, for example, of a laboratory test that starts with selection from a repertoire by an identified requester, the actual time of taking the specimen, the reception by the laboratory and so forth. The user has a results based understanding and is not used to thinking about all the content of data behind a test request or the constraints that a data screen may impose. Secondly some descriptions in the database may not be exactly those normally employed by the user, which can impede their communication. There is indeed a need for an empirical approach that in the first meetings explains the dashboard and its design characteristics and second meetings where a prototype is conjointly evaluated. The prototype importantly enables validation of data representation and easy visualisation, data correctness including of calculated data and statistics, data completeness with all the required data represented, and correct naming of data and results. In particular the second meetings for the clinical biochemistry dashboard showed that data display should be improved by adding the possibility to choose the intervals for bar chart display

which can be changed according to the individual test results.

5. Discussion

This paper describes an innovative paradigm for the use of data from the electronic health record and health information system. Although there has been much discussion of identifying performance indicators or benchmarks in the health system, the focus has been on identifying a minimal data set that can be a regular static report rather than a dynamic approach of interrogating a clinical data warehouse for timely support to the professionals of the patient care team involved in practice improvement and education.

There is a distinction to be made between an operational health information system whose primary goal is to directly support ongoing patient management and an analytical system that can make use of the acquired data, sometimes called secondary data. The CDW architecture should facilitate the different needs of analysis both of data and of text. To enable the latter in the Sherbrooke CDW all text is coded using SNOMED with a tool that performs automatic SNOMED and ICD coding as well

as supporting professional review and where necessary revision of coding. Secondary data exploitation can mean data being accessed by those who are not directly involved in patient care, for example, research assistants and students, and appropriate safeguards are necessary. All data are encrypted on storage into the database and data access is only sanctioned on a project by project basis by the director of professional services supported with reference as necessary to the institutional ethics committee. Clear definition is required of which data, by whom, when (for what time period), where and why the data will be analysed and how the data will be published.

The role of audit and feedback as part of quality assurance has been well studied in recent years [4]. There is much discussion about factors that result in resistance to practice change and the often temporary effects of feedback before practice returns to its previous pattern. Indeed in 1993 a review of unnecessary use of laboratory tests found that despite many efforts to rationalise use of routine tests there was no clear evidence of success [5].

Work with benchmarks and performance indicators has furthermore highlighted the difficulty of defining performance indicators that can be widely used so as to be neither too detailed or too trivial and yet can be useful despite local variation [6]. Benchmarks remain mainly the realm of administrators with limited penetration into the health care system and with in some cases considerable paranoia that the indicators might be used against rather than with professions.

There are still but few examples worldwide of the existence of clinical data warehouses that provide access to all data about patient care. The Sherbrooke CDW accesses a patient centred hospital information system, that is all operational data that concern a patient, admission, laboratories, nursing, surgical interventions, radiology, medications, etc., are managed by the same information system. Still today there is frequently a heterogeneity of systems located at the same institution that is a barrier to integration and the development of an analytical CDW. Although our CDW currently relates to the major teaching hospitals we look forward to a regional CDW that can support evaluation of the longitudinal care of the population.

The relatively few publications about the CDW have emphasised the multiple roles of the use of secondary data including for quality assurance, but without substantial demonstration of how feedback from a CDW can become an integrated part of the practice of the clinical team [7–9].

The development of the dashboard, which is becoming used in domains other than medicine,

underlines the importance of communication between designer and user. Each dashboard designed is a creative exercise of interest to health informatics researchers demanding reflection on the priority data and how this data will best be useful to decision making. It is also an empirical process as the continuing use of the dashboard will likely influence the refinement of design for each application with both application specific and generic lessons for future implementations.

The chosen data fields generally are indicators of activity and performance that benefit from regular consultation. The dashboard tool enables dynamic access to combinations of data enhancing critiquing and understanding of the data by a clinical team. The dashboard concept is therefore very close to that of performance indicators and benchmarks and is also an opportunity to examine the role of the dashboard as a feedback tool to support practice evaluation and change. The extensive ongoing review in the Cochrane collaboration of the effectiveness of audit and feedback for health practice review makes no mention of the role of the electronic health record or clinical data warehouse [4]. It confirms in 2003 that whereas several factors, including context, the provision of accompanying educational material, duration, and peer support can influence feedback, truly effective methods of feedback have yet to be found. The parallel literature on benchmarks similarly describes the difficulty of creating useful benchmarks [6].

Here, we combine a practice change methodology, Autocontrol, with the use of a dashboard targeted to user requirements. The novel features answer at least in part the reported problems of benchmarks and feedback. Foremost the methodology emphasises the role of the professional team in taking charge of the information. The methodology further underlines the importance of critique in order to nuance interpretation of the findings. The dashboard, specified by the user, is dynamic in that it allows exploration of data that should enable linking of solutions to the problem. The dynamic functionality should improve the problematic of benchmarks, which tend to be static and pre-defined rather than exploratory. The purpose of the dashboard is determined by the clinical team to be relevant to their context. It must be readily accessible and should evolve based on experience. The user involvement and accessibility as well as the dynamic enquiry should improve the opportunity for feedback to be a regular part of practice management. We envisage a growth in the use of dashboards with generic and contextual features that will be an important cultural change. Professionally led review of objective data should enhance

effective care and support the dialogue between the care team and administrator.

Ethical concerns about patient privacy are a key consideration and a current debate in many jurisdictions. The challenge is to ensure privacy and also to enable data from patients to be used for quality improvement, disease surveillance, knowledge discovery, education and epidemiological research. We have described an approach based on encryption and authorised access on a project by project basis using a process of institutional approval and management by the medical records department. These approaches will be constantly under review.

In conclusion we demonstrate the development of two dashboards with an administrative and quality assurance purpose as innovative approaches to exploit a clinical data warehouse to also support better use of quality indicators and integration of feedback into practice. Furthermore they are developed within a cyclical methodology of Autocontrol that values the professional team and the role of critique in evidence uptake essential for appropriate practice change.

Acknowledgements

We wish to acknowledge the ARIANE and Medical Records teams and the constant support of Professor Jean-Marie Moutquin, director of the Clinical

Research Centre of the Centre Hospitalier Universitaire de Sherbrooke.

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