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Digital transformation of hospital quality and safety: real-time data for real-time action

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Abstract. The Australian Commission for Safety and Quality in Health Care has created the National Safety and Quality Health Service standards that all hospitals must address in order to remain accredited. This case study details the first known digitisation of the 10 national quality and safety standards mandated in a quaternary integrated digital hospital. A team of clinical informaticians, information technology experts and clinicians was assembled. Data were chosen and the data were then extracted and validated and presented (often in near real time) in an easily consumable dashboard format with appropriate governance to allow clinicians and executives to monitor the quality and safety standards across the hospital. All 10 standards were defined and extracted contemporaneously from the digital hospital for every patient, every time. This is in stark contrast with traditional retrospective point prevalence surveys. This case study details the first known fully digital accreditation in a sophisticated integrated digital hospital. Digitisation of hospital quality and safety to produce real-time data is the future of clinical redesign to improve patient care.

What is known about the topic? Healthcare delivery is complex and the ability of healthcare providers to maintain consistent standards of quality and safety is variable. Traditionally, these standards have been assessed by intermittent retrospective point-prevalence survey activity. Sophisticated digital hospitals provide the opportunity to develop data and analytics that monitor quality and safety standards across every patient, every time in near real time.
What does this paper add? This paper describes a digital hospital which has created streaming analytics to monitor live performance of quality and safety standards. The necessary skills, leadership and governance for this process are outlined and the products described.

What are the implications for practitioners? Shifting from retrospective paper-based point prevalence surveys to a digital platform has several implications. Firstly, it is an imperative to drive digital transformation of Australian hospitals. Secondly, it provides data for intervention to the hospital staff, so that issues can be addressed and improved in real-time, rather than waiting for survey results. Lastly, this new model of maintaining quality and safety also requires the development of new skills in the hospital setting including data literacy, digital clinical governance and clinical informatics.

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Introduction

Delivering health care is complex, and maintaining the quality and safety of care can be challenging. It is estimated over 500 000 hospital-acquired adverse events occur every year in Australia, equivalent to approximately 6.7 events for every 100 hospitalisations.[1] These errors contribute to avoidable morbidity and mortality in patient populations.[1–3]

The Australian Commission for Safety and Quality in Health Care has created the National Safety and Quality Health Service standards that all hospitals must address in order to remain accredited.[4] These standards are endorsed by the Australian Health Minister's Advisory Council and include safety and quality indicators such as pressure injuries, falls and cardiac arrests. Accreditation qualifies the hospital to receive funding. It is performed on a 2-yearly cycle, with accreditors examining performance across the 10 standards and assessing adequacy.[4]

Hospital quality and safety systems use the framework of the 10 standards to assess performance. Manual data collection and point prevalence surveys with retrospective reporting of compliance have been the traditional methodology.[5] This type of activity is expensive and time-consuming. The data are also difficult to action because they are provided retrospectively and do not always reach frontline clinicians.

The index hospital recently underwent a deep digital transformation to roll out an integrated electronic medical record (ieMR).[6] The advent of an integrated medical record that amassed rich clinical data linked across a patient's healthcare journey challenged the organisation to examine traditional quality and safety monitoring and to leverage the sophisticated digital platform to improve patient care.[7]

The team hypothesised that the use of streaming analytics from a sophisticated digital hospital would provide data for hospital accreditation and, perhaps more importantly, provide data to clinical teams in near real time to improve patient care. The aim of this project was to deliver safety and quality data in near real time to the hospital executive and clinicians to facilitate better patient care.

Setting

This work was undertaken in a large academic quaternary hospital that had a Healthcare Information Management Society Electronic Medical Record Adoption Model Level 6 accreditation evidencing a deep and integrated digital transformation.[8] The ieMR included clinical documentation, integrated vital sign monitoring and electrocardiographs, electronic physician order entry, electronic medication management and decision support.

Methods

This project was completed over an intensive 6-month period with dedicated clinical informaticians and information technology (IT) resources, as well as quarantined clinician time. Principles of scalability and sustainability underpinned the development of the analytical solution. The work aimed to be scalable by leveraging data elements that existed within the ieMR or other mandatory collections. These could be applied to multiple geographical sites and patient cohorts. Data collection was automated, where possible, to avoid additional burden to clinicians or workflow processes.

The following steps were undertaken by a team of clinical informaticians with the support of the IT department and hospital executive team.

Current state analysis

A current state analysis was completed for each of the 10 national standards. This included compliance reporting requirements for the national safety standards, mandatory reporting requirements at both state and national levels, evidence-based practice (including literature review and published clinical guidelines), cataloguing individual ieMR data elements and linked systems, current reporting and data sources within the organisation and documentation and workflow practices associated with reporting requirements.

Data item selection

A working group of subject matter experts, clinicians and clinical informaticians identified clinically relevant, evidence-based metrics that were defined, reproducible and comparable across multiple health services organisations. Data item selection was based on the following criteria: high-impact data related to high-volume and high-risk areas of patient care; information that would assist clinicians in mitigating patient risk; information that should assist in future health service planning; evidence-based outcome and process measures; intervention is possible to improve outcomes; clinically relevant and able to be easily consumed by clinical staff; and consistency and reliability of data documentation and capture.

Data extraction

Data extraction was achieved using a 'pair programming' approach of data analyst–clinical informatician and clinician exploring data extracts and defining elements. Data specifications relating to each individual metric were developed, including identification of each data element required and their location and data cell within the ieMR tables or other relevant database. This included identification of the clinician data entry point to match the right data to the right metric.

Once the data elements were defined, the frequency of data refresh was determined and the code written. Data specifications for each metric were translated into technical data extracts using Cerner command language (CCL) and structured query language (SQL). Some data required manual extraction and integration. The data were stored, transformed and linked in an SQL data warehouse, with automated and regular data refresh feeds scheduled.

Data validation

The data extracted were clinically validated by the working group. Clinical validation involved looking for false positives (assessing the accuracy of the data extracted) and false negatives (reviewing the patient's chart to identify whether any omissions are present from the dataset) and 'false negative' sweeps of in-patient wards to ensure data extracts were complete and no patients were omitted. This was an intensive iterative process that continued until no discrepancies or omissions were identified. This process was vital to achieving clinically accurate meaningful and relevant data.

Creation of analytical products

Ten national standard dashboards were developed with data displays designed to be accurate, relevant, accessible and easily consumed by the end-user for application to clinical practice.[9]

Visual displays of the data were built by data analysts in partnership with the clinical owners and end-user clinicians. This partnership model is based on codesign principles.[10] A business intelligence tool was used to visually display data in a clinically meaningful way with logic application to support data analysis.[11]

Governance

Each standard within the organisation had an executive committee responsible for hospital oversight and performance. Governance of each dashboard was given to the corresponding hospital committee. The committee assumed the responsibility for monitoring the data, acting on the insights created and escalating through usual hospital governance structures. The chair of the relevant committee became the clinical owner of the work. Clinical owners were responsible for assigning appropriate access to users and defining distribution pathways for the dashboards.

Operationalising the analytics

The successful integration of clinical analytics into the hospital environment required a combination of technical and transformative support. The technical component involved translating the technical specifications of the data and analytics product, whereas the transformation component consisted of working with clinicians collaboratively to support them through the associated cultural shift, establishment of appropriate governance and transition into executive and clinical workflows.

Each dashboard was formally commissioned with clinical owners being briefed on the need for ongoing data validation, data security and the process of escalation for issues identified using the analytics. Commissioning required an implementation plan with a minimum inclusion of a defined and endorsed workflow. Staff were upskilled in digital literacy through education sessions focused on dashboard functionality. This included demonstrations of how to interrogate data for clinical insights, such as identification of high-priority case reviews.

Results

The hospital used these products in parallel with traditional Australian Council of Healthcare Standards preparations for the accreditation visit in 2017. To our knowledge, this was the first time streaming clinical analytics for the 10 safety and quality standards have been used in an Australian health facility and contributed to the successful reaccreditation of the hospital. An example of the dashboards is shown in Fig. 1.

The national standard dashboards enabled the index hospital to interrogate clinical data in real time in response to surveyor queries, and therefore demonstrate compliance with the standards. Key outcomes from the survey report are summarised below:[12]

> *The accessibility of patient safety data in real time and in safety focussed dashboards allows the clinicians and managers to identify safety and quality indicators and facilitate timely interventions and continuous monitoring and evaluation*. (p. 6)

> *The transparency and timeliness of performance data facilitated by the digital transformation supports clinical decision making and timely interventions and informs committees*. (p. 11)

The analytics are facilitating the development of new and innovative models of practice and are associated with increased compliance with the recommended standards. It is too early to claim large-scale improvement due to the analytics; this is expected to take some time as the insights from the data are acted upon.

Constraints

Live clinical streaming analytics is pioneering technology. We were unable to find literature detailing the process so had to develop our methods *de novo*. This involved investment in resources and effort. With the reworking of the current standards into a new format, some revision of the existing dashboards will be required, but most data elements will remain unchanged.

Significant challenges were encountered during this case study and the lessons learned are summarised in Table 1.

Discussion

Such sophisticated use of near real-time clinical data for accreditation is in stark contrast with traditional reporting presented to accreditors. Table 2 outlines the comparison between the two.

To the best of our knowledge, this is the first live streaming clinical analytics platform facilitating clinicians to improve the quality and efficiency of care across the 10 federally endorsed hospital standards.

The key to success for this project was true clinical ownership. The clinical teams validated their own data and created their data views. They took ownership of the data and were prepared to action the insights that were generated. This project may have failed if these dashboards were simply imposed upon clinicians as a performance management tool by the hospital executive,

Fig. 1. Example of the digital accreditation dashboards. Screenshot used with permission of Metro South Health.

Table 1. Lessons learned during the establishment of live streaming clinical analytics for hospital accreditation
ieMR, integrated electronic medical record

Issue	Detail	Treatment
Technical complexity of ieMR data tables	Considerable effort required to understand and navigate the database tables within the ieMR Knowledge of and ability to interrogate the tables is critical to extracting accurate data; this knowledge is difficult to acquire due to the complexity and labelling of the data tables	Investment in resources to learn tables and knowledge
Technical complexity of data labelling	The data storage architecture is complex; the data item entered into the ieMR is written to tables that may lack accurate labelling and individual cells may contain multiple variants of the same data item (Fig. 2)	Careful exploration of the data tables Analysis and mapping of clinical workflows to data capture and storage Clinical consensus to choose the most clinically appropriate data item and define metadata
Lability of data elements	Data elements can be labile; front-end configuration changes and code upgrades can alter the data element, corrupting the data extracted	Data validation needs to be a continuous process Spot validation should occur at regular intervals and after significant events, such as configuration changes and code upgrades
Cultural challenges	Introducing live clinical streaming analytics can be culturally challenging, because data are exposed and careful governance is required	Cultural preparations are required to prepare clinical owners and consumers of the transparency of the data outputs Clinical owners are required to manage the allocation of data access and risks of data exposure Education and training on clinical redesign
Governance challenges	Existing siloed information technology and clinical governance models were not mature enough to manage the multidisciplinary nature of the teams required to establish clinical analytics	Temporary multidisciplinary virtual teams were established Agile membership to meet varied development demands

Table 2. Comparison of manual auditing versus live streaming clinical analytics

Characteristic	Traditional manual auditing for accreditation	Live streaming clinical analytics for accreditation
Data age	Retrospective data is presented (often months old)	Current data is presented (15 min old)
Data plasticity	Data are presented in flat PDF files that cannot be easily interrogated	Interactive data visualisations that can be interrogated, filtered and manipulated in real time to answer new questions
Data sampling	Point prevalence data snapshots with variable sample size and varied or absent state-wide definitions	Data are collected and presented for every patient during every episode of care Standardised statewide data source and definitions

VITAL	VITAL_TYPE
Diastolic blood pressure	BP
Diastolic Blood Pressure Invasive	BP
Systolic blood pressure	BP
Systolic Blood Pressure Invasive	BP
Mean arterial pressure cuff calc	BP
Mean Arterial Pressure Invasive Calc	BP
Systolic Blood Pressure Supine	BP
Pre-dialysis standing systolic BP	BP
Post dialysis sitting systolic BP	BP
Pre-dialysis standing diastolic BP	BP
Post dialysis standing systolic BP	BP
Diastolic blood pressure sitting	BP
Systolic blood pressure sitting	BP
Post dialysis lying systolic BP	BP
Pre-dialysis lying systolic BP	BP
Systolic blood pressure standing	BP
Post dialysis sitting diastolic BP	BP
Pre-dialysis lying diastolic BP	BP
Post dialysis lying diastolic BP	BP
Diastolic blood pressure standing	BP
Diastolic blood pressure supine	BP
Pre-dialysis sitting systolic BP	BP
Pre-dialysis sitting diastolic BP	BP
Post dialysis standing diastolic BP	BP

Fig. 2. Example of the complexity of data storage in the integrated electronic medical record tables. When querying the tables for blood pressure, the developer is presented with many similar values and clinical judgment is needed to select the correct data item. BP, blood pressure; Calc, calculation.

rather than provided as a quality improvement tool created by clinicians for their own use.

Clinical informaticians with a diverse skill set, including qualifications in clinical data and analytics, project management and health informatics, acted as 'boundary spanners' and translated between the clinicians and healthcare systems and IT.[13] With an understanding of both clinical and technical requirements, this role bridged the health care and technical divide and translated clinical requirements into a format that was able to be converted into technical specifications.

Multiple technical roles within the team underpin a core part of the overall delivery of the project outputs. Developers with a niche understanding of ieMR database design and structure are vital to conducting database analysis and data extraction, integration and transformation. Data analysts with contextual awareness of the healthcare environment play a key liaison role, to understand clinical requirements and specifications, business rules and logic and translate these into the design and build of visual analytic tools. Analysts apply specific skills and effort to ensure the aesthetic design and build of the analytic outputs optimises the consumption and interrogation of the data presented. The clinical governance and effective action on insights from the data are equally challenging and under development.

The true ability to transform practice does not come from the analytic solution itself; instead, transformation occurs when the analytics are integrated into practice and used by the clinical workforce to mitigate and manage patient risk and to improve the quality, safety and efficiency of care. Without this clinical translation, the tool itself has minimal effect.

Future directions include presentation of the data to individual clinicians at the point of care and moving from the current descriptive analytics to predictive and then prescriptive analytics. The aim will be to move quality and safety improvement from the current 'break–fix' model to a 'predict–prevent' model. Improving the quality and safety of care is essential if our system is to remain sustainable, and digital platforms provide a perfect vehicle for significant data-driven improvements at scale to improve outcomes for our patients.

Competing interests

None declared.

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