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Abstract
Today most countries are implementing or planning to implement some type of e-health solution. This in turn leads to an exponential increase to the amount of data created, captured and stored. In order to maximise such a valuable data asset as well as create reliable and trustworthy e-health solutions, it is paramount to have a systematic strategy and robust organising framework which will in turn ensure that superior healthcare delivery can then ensue. The following proffers the Intelligent Performance Management (IPM) framework as such an Internet based model. Thus, this paper examines the technical & conceptual layers of the IPM framework and also defines some of the associated knowledge driven healthcare services which are supported by the IPM model in order to facilitate superior healthcare delivery.

Keywords: Intelligent Performance Management, E-services, E-healthcare, Business Intelligence, Knowledge Management.

1 Introduction

A confluence of several significant forces is impacting healthcare delivery today (Moghimi & Wickramasinghe, 2012). These include, technology advances such as web 2.0 as well as a variety of intelligence capabilities, increasing populations and especially for OECD countries an increase in aging populations and increasing financial pressures as all OECD countries face exponentially increasing cost burdens with regard to healthcare delivery (ibid). These forces have then served as the catalyst for all OECD countries to focus on designing, developing and implementing various e-health solutions (Wickramasinghe et al. 2012).

Such a macro impact on healthcare delivery in turn translates to heightened pressures for all healthcare organisations. In particular, healthcare organizations today are increasingly under pressure to make performance management a part of their culture (Adler et al., 2003). The popularity of the web has made it a prime vehicle for disseminating information (Vaughan, 2001) while the relevance of increasing performance management in the healthcare area using intelligent tools and web based services has led to a significant body of research addressing key issues related to performance management efficiency (Spil, et al., 2002). Central to improving performance is the maximising of critical data assets and then applying lean principles (Wickramasinghe, et al. 2012).) Hence in this paper, we proffer the Intelligence Performance Management(IPM) framework as an appropriate model to facilitate superior, reliable and trustworthy healthcare delivery by enabling healthcare organisations to be able to meet the challenges with which they must contend by applying the tools , techniques and tactics of today's knowledge economy Specifically, we focus on identifying the role for business intelligence to enhance online and real time performance management efficiency; however, we envisage that in future it will also be possible to augment this and incorporate other services or tools to improve performance management.

Currently, when healthcare organizations investigate opportunities to make investments to improve patient care, they tend to look at funding staff or equipment-an MRI machine for example-rather than IT (Cognos, 2008). In contrast, performance management solutions include activities to ensure that goals are consistently being met in an effective and efficient manner. Performance management can focus on performance of the organization, a department, and/or a procedure to build a process or service and facilitate employees. Hence; the central research question answered in this paper then is how can e-performance management be incorporated into e-health delivery?

2 Background

Performance management applications can be found in widely divergent functional areas. However, in e-health contexts because of the importance of real time outcomes and the multi-spectral nature of care teams (Wickramasinghe, et al., 2012), the following key features become most essential:

- Intelligent timing
- Multidimensional views of data
- Calculation-intensive capabilities

This in turn makes an on-line intelligent performance management framework the preferred choice.

2.1. Healthcare Information Treatment

The proliferation of databases in every quadrant of healthcare is evident in the large number of claims databases, registries, electronic medical record data warehouses, disease surveillance systems and ad hoc research database systems (Wickramasinghe, Bali, & Schaffer, 2008b). Pattern-identification tasks such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilisation, or discovering new models of disease in populations of individuals is rapidly becoming

daunting even for the most experienced healthcare researcher or manager(Holmes et al., 2002).

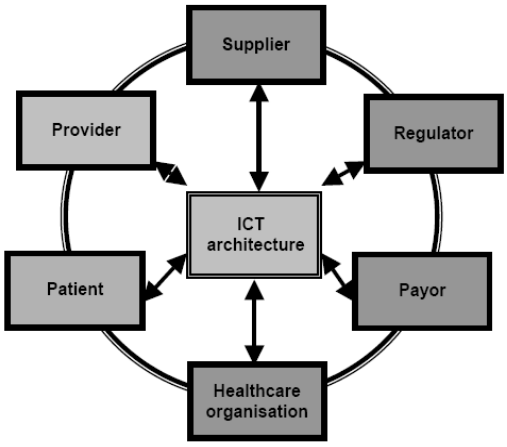

Figure 1: The web of primary healthcare information flows. Source: (Wickramasinghe, et al., 2008a)

Figure 1 presents the central role of the ICT architecture as well as the far-reaching implications of the data and information flows throughout this web and thus the importance of such data and information for the various key players. Maximizing these data and information assets then becomes a key need for healthcare organizations in order to realize their value proposition (Wickramasinghe, et al., 2012). This then is also why the techniques of knowledge management, data mining and business intelligence become strategic necessities for healthcare(Wickramasinghe, et al., 2008a).

2.2. Business Intelligence

Perhaps the biggest single evolutionary driver in the expansion of modern data warehouse management is the democratization of Business Intelligence(BI) (Kalakota & Robinson, 2001; Fayyad, et al. 2008). For the purposes of this research, we use the term BI as an umbrella term that encompasses the processes, tools, and technologies required to turn data into information, and information into knowledge and plans that drive effective business activity (Eckerson, Howson, 2007). In this context, BI also encompasses data warehousing, data integration, reporting, analysis and data mining technologies and processes of the back end, and involves supporting activities such as query, reporting, analysis, and information delivery and processes on the front end(ibid). The key BI tools which are relevant in our research include the following six main categories (TDWI, 2010):

- OLAP(on-line analytic processing)
- Production reporting
- Dashboards/scorecards
- Query & reporting tools
- Data mining tools
- Planning/modeling tools

It is important to note that true real-time, or instantaneous, data availability is oftentimes more an ideal driven by perceived competitive pressures, than a necessary or even a desirable goal (Scheduling, 2010). However, based on an in depth literature review, we believe the best solution to increase the efficiency of Web services involves a comprehensive business intelligence solution that spans both back end and front end processes.

2.3. Web based service management systems

Given the high rate of growth in the volume of data available on the World Wide Web(WWW), locating information of interest in such an anarchic setting becomes a more difficult process every day (Sanjay & Wee, 2004). Thus, there is the recognition of the immediate need for effective and efficient tools for information consumers, who must be able to easily locate disparate information on the web, ranging from unstructured documents and pictures to structured, record-oriented data (Bhowmick, Madria, & Keong, 2004).

Web services are at a higher level of abstraction with respect to conventional middleware services, and therefore directly impact business-level metrics and need to be guided by them (Alonso, Casati, Kuno, & Machiraju, 2003). Management of Web services can be classified based on its scope; it is distinguished between infrastructure-level, application-level, and business-level (or business-oriented) management. Infrastructure-level management focuses on the Web services platform (Casati, Shan, Dayal, & Shan, 2003). Thus, to analyse Web services from an Infrastructure-level management in a business perspective it is important to define and correlate metrics through interfaces, conversations, and compositions (Sanjay & Wee, 2004). The other important aspect is that simplicity and flexibility in managing are crucial. In fact, metrics and reports are not "static," and there is the frequent need to modify them to perfect the analysis and cope with changes (Casati, et al., 2003).

2.4. Healthcare Performance Management

There are similarities and differences across many countries in performance management institutions, using "performance management" in a broad sense (Hurst & Hughes, 2001). All countries rely heavily on professional licensure, self-regulation and peer review for controlling the quality of medical and nursing care. This is not surprising in view of the asymmetry of knowledge. In addition, the institutions of 'external' performance management differ widely between countries (Hurst & Hughes, 2001; Spil et al., 2002).

The optimal role for external scrutiny is not yet well defined (Hurst & Hughes, 2001). Questions remain about who should be the recipients of performance indicators and what incentives there should be to act upon them (Hurst & Hughes, 2001; Cognos, 2008). Figure 2 depicts these key aspects.

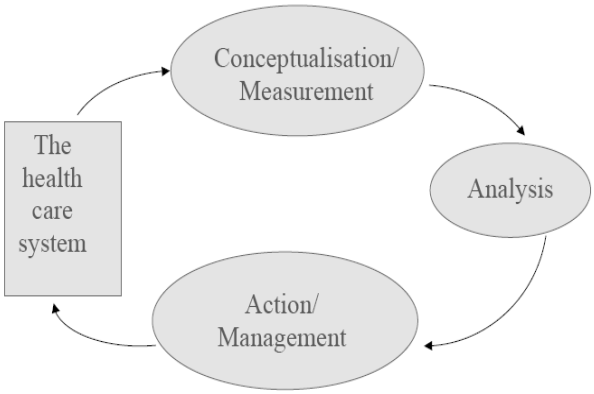

Figure 2: The performance measurement and management. Adapted from Nutley and Smith (Nutley & Smith, 1998)

2.5 Challenges currently facing performance management in the healthcare area

Based on an extensive literature review, several limitations and challenges with on line and real time access relating to applying performance management in the healthcare domain are identified including a) performance indicators/measures, b) controllable and uncontrollable variations, aggregation of indicators and d) the setting of standards or benchmarking. For completeness, we present these in table 1 below.

Key Issues	Description
Performance indicators/measures	A selective review of the performance indicators/measures being developed by WHO, OECD and each of the four OECD Member countries, suggests that the development of indicators is proceeding at different speeds, in different areas of performance measurement (Hurst & Hughes, 2001). Relatively slow progress is being made in the area of e-health outcomes (Hurst & Hughes, 2001). Moreover, such measures as do exist at a population level are usually proxies. Faster progress is being made with the development of indicators of the responsiveness of health services to consumers (Hurst & Hughes, 2001). There is slow progress with the development of equity indicators (Cognos, 2008). There is also slow progress with the compilation of overall measures of the efficiency of health systems of a kind that command widespread confidence (Cognos, 2008). The asymmetry of knowledge between healthcare professionals, on the one hand, and healthcare consumers and lay managers, on the other, is likely to stay for some time to come. Nevertheless, given the effort now being put into collecting performance indicators in many OECD member countries, there seems to be good prospects for improving coverage of such indicators in OECD Health Data within the next few years (Hurst & Hughes, 2001). However, there may be a need for international harmonization of measures if comparative work is to proceed at an international level (Hurst & Hughes, 2001).
Controllable and uncontrollable variations	A key issue is how to discriminate between controllable and uncontrollable variations in performance (Hurst & Hughes, 2001). As we have seen, that arises particularly in the area of health outcome measures, when health status measures are used as proxies for health outcomes (Gold, Stevenson, & Fryback, 2002). There is likely to be less of a problem with process 'measures' of outcomes or with measures of responsiveness. However, even here it may require investigation and analysis to identify what levers must be pulled to improve performance (Gold, et al., 2002). For example, poor quality in the service provided by a department in a globally budgeted public hospital may be due to inefficient working practices (which are the responsibility of local management), shortages of resources (which are the responsibility of the relevant funding body) or inappropriate national wage scales (which are likely to be the responsibility of central government) (Gold, et al., 2002).
Setting standards or benchmarks for	The other issue is how to set standards or benchmarks for performance. One possibility – adopted recently by the UK - is to adopt certain ambitious but achievable targets for key

Key Issues	Description
performance	areas of care, combined with a 'traffic light' system (Hurst & Hughes, 2001). The national standards will be included targets for key conditions and diseases, waiting times, the quality of care and efficiency (Hurst & Hughes, 2001). All NHS organizations will be classified as 'green', 'yellow' or 'red' on the basis of their performance. Red organization will be those failing to meet a number of the core national targets. 'Yellow' organizations will be those meeting all or most national core targets but would not be in the top 25% of performance (Hurst & Hughes, 2001). Green organization will be those meeting all targets and scoring in the top 25% of organizations on performance, taking account of 'value added'. The benchmarks will be reviewed periodically (Hurst & Hughes, 2001).

Table 1: Key issues currently facing performance management in the healthcare area

3 Business intelligence as a Solution

There are three critical concepts of performance management: monitoring, analytics, and planning. With BI all three are brought together to help give everyone in the healthcare organization the information they need to make informed decisions. Table 2 serves to summarize these critical concepts:

Key Concepts	**Description**
Monitoring	Quickly and easily enables the creation of dashboards and scorecards with its functional software, so that everyone can align with departmental and organizational goals. In addition, other aspects include: enabling automating the supporting processes, displaying process metrics and KPIs in Office Performance Point Server business intelligence software, and managing the workflow with Office SharePoint Server. Office SharePoint Server also lets the hospital share reports and analysis, and collaborates with colleagues.
Reporting and analysis	This involves equipping the people with reporting and analysis tools and technologies that will help capture the structured and unstructured information they use to make decisions. In addition easy creation of reports and perform analysis with BI Reporting Services I supported. Moreover, a pivot functionality and slice and dice technique enables hospitals to look at data in different ways and drill down to explore trends (Spil, et al., 2002). Of course, users can always count on Office Excel to manipulate data and create reports. However, BI reporting services are more functional.
Data warehouse	Features within the data warehouse support the obtaining of insights into the data needed through an integrated, centrally managed, and trusted data source. Many healthcare organizations are using data warehouses for data and records management, and so are already familiar with how easy it is to manage data in such a setting. In addition it is possible to combine data from multiple sources into one location and provide access to information, and even create an integrated data base.

Table 2: Key concepts of BI as a solution to improve performance management in healthcare contexts

3.1. Proposed an intelligent e-performance management framework

Today we are seeing the emergence of a powerful distributed computing paradigm, broadly called web services(Vaughan, 2001). In the e-health domain, using web services will play a key role in dynamic performance management and hence forms the foundation for our proposed framework.

3.2. Technical aspects of an intelligent e-performance management framework

The intelligent e-performance management framework (figure 3), technically, has three main components; namely:

- Information System Infrastructure
- A service based framework
- On-line data Access

Further, a Data staging area, a Data presentation area, Web based protocols and e-services form four different layers of the second component. Through the intelligence e-performance application, data will be sent electronically from each GP's(general practitioner's) local systems to the data warehouse. This data will be integrated with information from both the administrative and clinical sides, and arranged using online analytical processing cubes for rapid analysis. The results are then presented as a series of scorecards and key performance indicators on the authority's intranet by using dashboards, SharePoint or office performance points.

In the web based layer, we use gateways to control the amount of server resources allocated to each traffic class. By dynamically changing the amount of resources it is possible to control the response time experienced by each traffic class (Pacifici, Spreitzer, Tantawi, & Youssef, 2003).

In such an environment, a web service provider may provide multiple web services, each in multiple grades, and each of those to multiple customers. The provider will thus have multiple classes of web service traffic, each with its own characteristics and requirements.

3.3. A set of e-services recommended by the proposed framework

There are many ways BI can help clinical organizations manage their performance. Whether via early detection of illness trends, understanding lab turnaround times, or meeting compliance and accreditation standards, having easy access to real-time information can help the organization take reliable and trustworthy progress to the next level. As presented in Table3, some specific examples are described regarding how healthcare organizations can use BI to better manage their organization's performance. (These services are recommended based on BI capabilities justified by Microsoft business intelligence group).

BI proposed capabilities	Description
Service line analysis and reporting	Healthcare organizations can use BI tools to conduct service line analysis and reporting. Analyzing and reporting on service lines allows the organization to accurately-and in real time-understand service inefficiencies, and improve the coordination of services, patient satisfaction, and the quality of care. Health organizations typically track and analyze performance metrics for health and wellness service lines (for example: weight management and nutrition), women and infant services, traditional lines of service (for example: musculoskeletal, orthopedic, and emergency), and chronic disease lines (for example: cancer, heart, and diabetes).By using BI, organizations can analyze and report on service lines to help improve the quality and efficiency of medical service delivery,

	align with organizational goals, reduce costs, and improve margins.
Health and wellness service line management	BI can help healthcare organizations manage performance at all levels of operation, including the health and wellness service line. This service line includes wide-ranging programs such as those that build awareness about disease prevention and healthy lifestyles or that help individuals cope with specific health and well-being issues. Within the health and wellness service line, organizations look to improve disease prevention testing and adherence, analyze demographic information and trends to align service offerings, analyze recurring episodes of illness, and track immunization rates and disease outbreaks. Effective tracking and analysis of these indicators can help healthcare organizations reduce episodes of illness, improve outcomes, reduce costs, and improve patient satisfaction. BI can help organizations better understand and track trends in health issues and health programs with easy access to real-time information. Healthcare professionals can drill down into the data to explore details behind the trends, allowing them to quickly respond and to adjust efforts.
Balanced scorecard	BI tools help healthcare organizations use the Balanced Scorecard as a strategic management system to track organizational performance across financial, clinical, business process, and learning and growth measures. Once performance metrics are set, organizations identify the key drivers, or desired outcomes, and then define indicators to gauge progress. By using BI to manage to key indicators, healthcare organizations can achieve consistent strategy execution and monitor performance. By tracking patient satisfaction, quality of care, financial performance, and enhanced learning and growth metrics, the Balanced Scorecard can provide a complete view of the organization. BI enables organizations to link together all the key elements of the Balanced Scorecard with easy-to-use templates and a single interface for viewing KPIs. Decision makers can track operational performance drivers and analyze financial, operational, and clinical KPIs across the organization with customizable scorecards for groups and individuals.
On -Line Analytical Processing (OLAP)	Typical manufacturing OLAP applications as a part of a Business Intelligence solution include production planning and defect analysis. Important to all of the mentioned tasks is the ability to provide managers with the information they need to make effective decisions about an organization's strategic directions (Howson, 2007). The key indicator of a successful OLAP application is its ability to provide information as needed, that is, its ability to provide “just-in-time” information for effective decision-making. This requires more than a base level of detailed data (Baragoin et al., 2001). Just-in-time information is computed data that usually reflects complex relationships and is often calculated on the fly (Baragoin, et al., 2001). Analyzing and modeling complex relationships are practical only if response times are consistently short (Baragoin, et al., 2001). In addition, because the nature of data relationships may not be known in advance, the data model must be flexible (Baragoin, et al., 2001). A truly flexible data model ensures that OLAP systems can respond to changing business requirements as needed for effective decision making (Baragoin, et al., 2001).

Table 3: Specific examples of use of BI for healthcare organizations

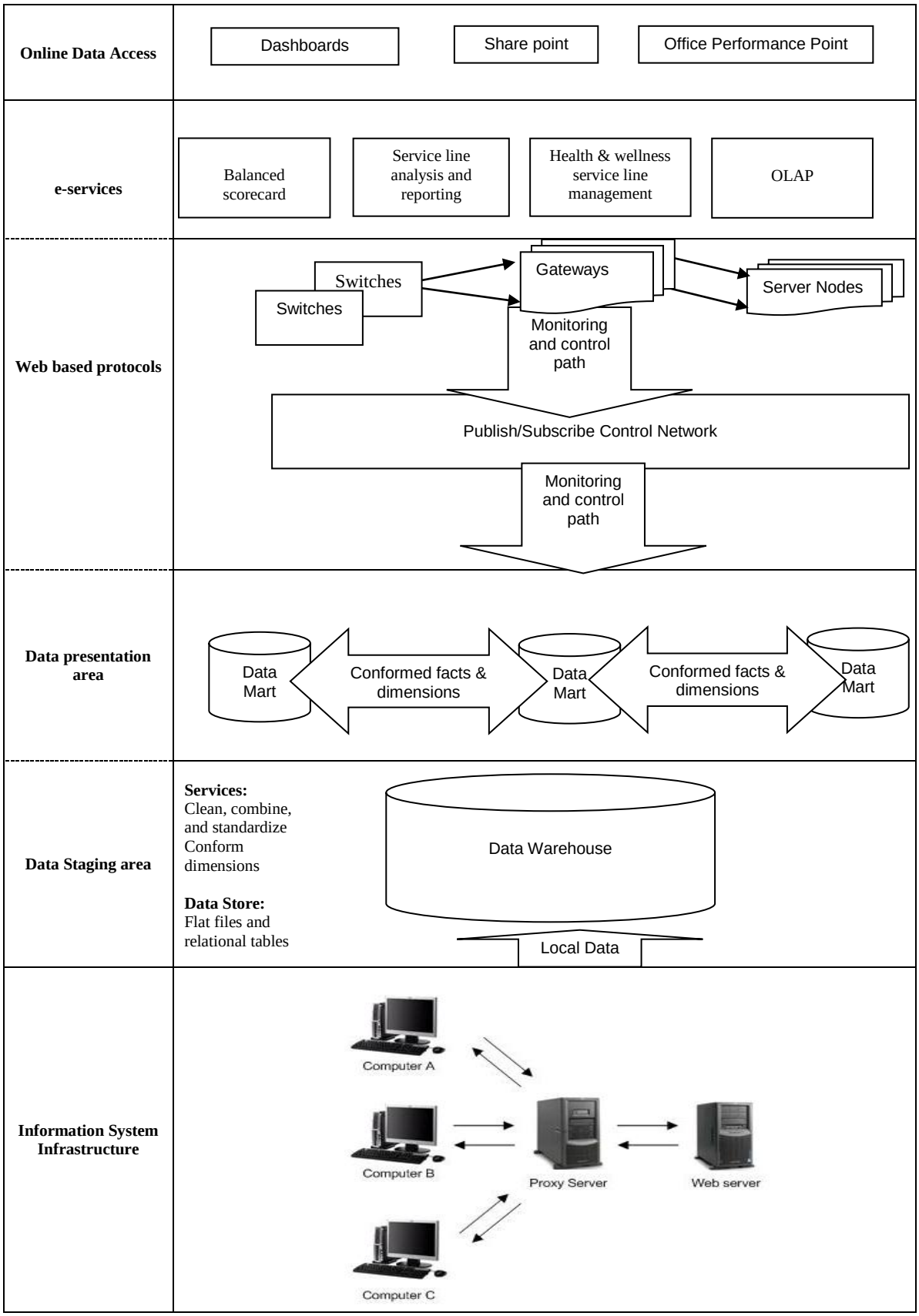

Figure 3: The intelligent e-performance management framework. Adapted from (Moghimi, Wickramasinghe, 2011)

3.4. Incorporating IPM solution to the Orthopaedic Operating Room (OOR)

In general, total hip and total knee replacement surgeries in orthopaedic care contexts, are successful and relatively typical solutions for people experiencing pain associated with degenerative joints (Davidson, 2008). However, other types of partial hip and knee replacements are often complex and involve a multiplicity of different risk factors (Davidson, 2008; Dijkman, 2008) which impact patients' treatment performance as well as surgical outcomes. Since these risk factors are associated with a decrease in quality of life (Dijkman, 2008), this in turn makes the decision making processes connected with these procedures of significant importance. In addition, hip and knee implants are undergoing a constant state of innovation and improved technology (Wickramasinghe, 2009). Taken together, this serves to underscore that performance management in this context is clearly complex, dependent on multi spectral data and information and has far reaching consequences. Therefore, our IPM Framework should be an effective and efficient solution in such a context.

This, to illustrate the role for our IPM Framework, we have categorized the OOR issues, particularly hip and knee replacement, into four key components as follows in an attempt to systematically capture the key risk factors (Moghimi, et al., 2011):

- Physiological issues followed by importance of quality of life.
- Technological issues based on new technologies and their performance.
- Biomedical issues on conditions of patients' bones to do the surgery.
- Financial issues regarding the costs of these high-quality technologies and type of surgery.

Table 4 then, serves to illustrate how the key e-services depicted in figure 3 can then be transformed and translated into a specific context; in this instance the context of the OOR specifically focussing on hip and knee replacements.

IPM components	Benefits to improve the OR performance management	Description (How)
Balanced scorecard	- To improve financial issues - To improve biomechanical issues	By developing relevant measurements & KPIs
Service line analysis and reporting	- To improve financial issues - To improve biomechanical issues - To improve physiological issues - To improve technological issues	By making analytical & multidimensional reports
Health and wellness service line management	- To improve biomechanical issues - To improve physiological issues	By real-time monitoring & controlling patients' clinical conditions
On -Line Analytical Processing (OLAP)	- To improve biomechanical issues	By making ad-hoc & real-time analytical reports

Table 4: The role of IPM components to improve performance management in OOR

4 Discussion

Currently, the integration and assimilation of e-health into the workflow of healthcare is becoming a strategic necessity in OECD countries. However the key question now becomes: is the performance of e-health services reliable and trustworthy and thereby likely to lead to superior healthcare delivery? In order to answer this question, the IPM framework is proposed to improve performance management of e-health services using intelligent and web based solutions. As presented in table 5 below UK, Canada, Australia & USA are exemplar

countries that have already developed their healthcare performance frameworks as well as performance indicators. Therefore, healthcare systems in these countries should apply these controlling indicators into the proposed IPM framework as well, in order to develop their modified IPM model in their respective e-health contexts.

	UK	**Canada**	**Australia**	**USA**
Type of health care system	Nationalized, but with recently devolved responsibility; publicly funded	Federal, territorial, and provincial, with common principles; mixed but mainly public funding	Federated, shared national and state roles; public and private driven; mixed funding	Pluralistic, with combined state and federal regulation; private- sector driven; mixed but mainly private funding
Performance framework	Coherent national framework, with a comprehensive set of indicators and targets aiming at six areas of performance; multi-domain local use of PIs being entrenched	Coherent national framework, with indicators for health and health system performance; supported by those for community and health system characteristics	Evolving coherent national framework and indicators; nine-dimension approach; monitoring inputs, outputs, and outcomes	Weak coherent, national approach; proposed a six-domain performance framework; sturdy set of operational (i.e. locally used or health care plan specific) indicators
Conceptual basis for framework	Based on a balanced scorecard approach; to be reported as a 'performance star' ratings system	'Roadmap Initiative' to improve quality, utilization, comparability, information dissemination, and functioning of health system	Three-tier relational concept to respect the impact of system performance and health determinants on health status and outcomes	Purchaser dependent and quality management framework; supported by a population health model and patient oriented performance reporting

Table 4: Summary of national frameworks for health system performance. Adapted from (Arah, et al., 2003)

Our initial modelling and findings to date based on our work in progress exploratory research highlight the following key research issues:

First, we know that data in the web are typically semi structured (Buneman, 1997). Hence, this nature of data may introduce serious challenges with regard to accuracy to reiterative data through a real-time and on-line data warehouse.

Another important issue is the difference between type and efficiency of such intelligence services in order provides useful solutions. This in turn has far reaching consequences with regards to choosing a vendor as well as choosing the appropriate solution. Lastly, designing appropriate security levels and permissions through this application is also a significant issue especially given the typically multi-disciplinary nature of the care teams in healthcare.

We note that while participants (patients, providers and healthcare organisations in particular) believe that the Internet could and should play an important role in the delivery of health services, there remains significant concern about the lack of evidence about the effectiveness of Internet delivered services for healthcare. Our own review of the literature and research on e-health and e-mental health sites largely supports these concerns. This serves to underscore the importance of empirical testing of the proposed framework. However, empirical testing of the framework is likely to face a several challenges including identifying common metrics for measuring the performance indicators.

5 Conclusions and future research

This study has outlined a research in progress to examine the key role of web based performance management for e-health contexts. In an attempt to answer the major research question "how can e-performance management be incorporated into e-health contexts?" our discussion of these intelligent solutions serves to demonstrate that an intelligent e-performance application enables the realisation of reliable and trustworthy and thereby superior performance management for healthcare. In order to realise this, we then developed an IPM framework suitable for healthcare contexts noting that specific changes need to be made given the type of healthcare system in place as well as the existing healthcare performance frameworks currently in place. In addition, we provided a case vignette of the application of our IPM framework in the context of the OOR. Our future work will focus on generating confirmatory data to show the full benefits of the proposed framework. We contend that trying to incorporate the tools, techniques and strategies of e-performance information into e-health contexts is critical in order to truly deliver reliable, trustworthy and superior e-health solutions and thus close by calling for more research in this area.

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