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PROFESSIONAL PAPER

Development of Performance Dashboards in Healthcare Sector: Key Practical Issues

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ABSTRACT

Background: Static nature of performance reporting systems in health care sector has resulted in inconsistent, incomparable, time consuming, and static performance reports that are not able to transparently reflect a round picture of performance and effectively support healthcare managers' decision makings. So, the healthcare sector needs interactive performance management tools such as performance dashboards to measure, monitor, and manage performance more effectively. The aim of this article was to identify key issues that need to be addressed for developing high-quality performance dashboards in healthcare sector. *Methods*: A literature review was established to search electronic research databases, e-journals collections, and printed journals, books, dissertations, and theses for relevant articles. The search strategy interchangeably used the terms of "dashboard", "performance measurement system" and "executive information system" with the term of "design" combined with operator "AND". Search results (n=250) were adjusted for duplications, screened based on their abstract relevancy and full-text availability (n=147) and then assessed for eligibility (n=40). Eligible articles were included if they had explicitly focused on dashboards, performance measurement systems or executive information systems design. Finally, 28 relevant articles included in the study. *Results*: Creating high-quality performance dashboards requires addressing both performance measurement and executive information systems design issues. Covering these two fields, identified contents were categorized to four main domains: KPIs development, Data Sources and data generation, Integration of dashboards to source systems, and Information presentation issues. *Conclusion*: This study implies the main steps to develop dashboards for the purpose of performance management. Performance dashboards developed on performance measurement and executive information systems principles and supported by proper back-end infrastructure will result in creation of dynamic reports that help healthcare managers to consistently measure the performance, continuously detect outliers, deeply analyze causes of poor performance, and effectively plan for the future.

Key words: Dashboards, performance management, healthcare sector, Key Performance Indicators

1. INTRODUCTION

Healthcare organizations are increasingly faced with the challenge of providing the high quality service in affordable cost (1). Effective management and improving performance of such challenging systems require identification and optimization of multiple variables. So, static performance reporting systems are not able to completely satisfy healthcare managers' decision support needs and more interactive tools must be developed to transmit, organize, analyze, and display performance data in real or near real-time (2, 3). In response to this need, Executive information systems (EISs) were used in the 1980s and 1990s to aid analysts and executives in decision-making through graphical displays and accessible interfaces. More recently, EIS has been replaced by more interactive tools called performance dashboards (4).

As an interactive performance management tool, performance dashboard is a layered information delivery system that presents on a single screen the most important information about strategic objectives attainment enabling managers to measure, monitor, and manage performance more effectively. If supported by a proper IT infrastructure and well organized based on performance measurement principles, performance dashboards enable managers to focus on more important activities,

identify problem areas that need corrective actions, analyze root causes of poor performance, forecast trends, and establish benchmarks (5-10). However, development of these interactive tools requires meeting a variety of issues to ensure their efficiency and effectiveness (11). The main objective of this article was to identify practical issues that need to be addressed for developing high-quality performance dashboards in complex environment of healthcare sector.

2. RESEARCH METHOD

To conduct a literature review on performance dashboards development, we searched peer-reviewed articles in research databases including Scopus, Pub Med, IEEE Explore, and Google scholar; and e-journals collections including EBSCO, Science direct, Emerald, Springer Link, and Wiley. Furthermore, printed journals, books, dissertations, and theses were hand- searched for relevant studies that were not captured from the databases. The search strategy interchangeably used the terms of "dashboard", "performance measurement system" and "executive information system" with the term of "design" combined with Boolean operator "AND".

Articles were identified by conducting title searches. The search process was limited to articles written in English (either in print or in online journals) and published between 2004 and 2014. Eligible articles were included if they had explicitly focused on dashboards, performance measurement systems (PMS) or executive information systems (EIS) design.

The records were screened for relevance to topic of the study. Articles seemed to be relevant, retrieved and read in full. The lists of references within the relevant articles were also hand-searched. Some articles were excluded due to irrelevancy to the topic or inaccessibility to their full text. Remained full-text articles were assessed for eligibility. Finally, 28 relevant articles included in the study. Figure 1 illustrates the flow of information through the different phases of review process. Included articles were reviewed and their contents were categorized based on performance dashboards development features.

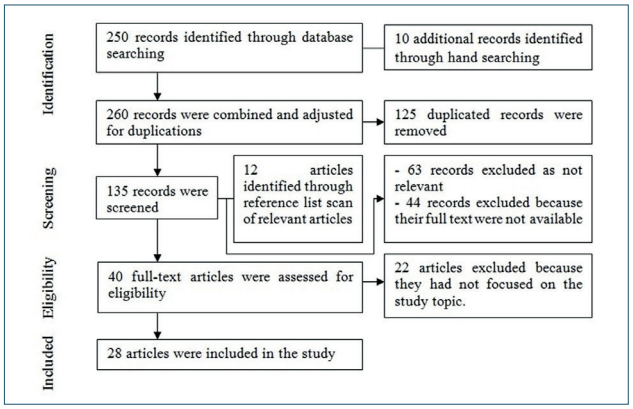

Figure 1. Information flow through different phases of review process

3. RESULTS

Performance dashboard concept stems from PMS and EIS literature. PMS design principles generally relate to what to measure and how to structure the performance measurement system (12, 13), while EIS design principles deals with data creation, data collection, data analysis, and information presentation processes (14). So, creating high-quality performance dashboards requires addressing both PMS and EIS design issues. Covering these two fields, identified contents were categorized to four main domains as follows:

* Performance Measures (PMs) and Key performance indicators (KPIs) development
* Data Sources and data quality
* Integration of dashboards to source systems
* Information presentation

3.1. PMs and KPIs Development

PMs that dashboards capture and display are just as important as their other design features, as dashboards will be useful only if the data they provide are valuable (10). As the most valuable content of dashboards, KPIs (that are performance measures in key areas of a service) provide the foundation for performance measurement, and help to measure progress against predefined targets or benchmarks, spend more time on critical activities, and compare performance across the organization. Well-defined KPIs exactly indicate where corrective actions should be adopted (15, 16). So, Key issues that need to be addressed regarding KPIs are mainly focused on their selection and development:

Focusing on few measures can potentially lead to ignore other important performance areas or functional and environmental features. Furthermore, isolated measures, developed separately, will not provide a comprehensive, consistent and fair assessment of performance. Establishing a well-categorized (not necessarily balanced) set of KPIs initially requires a well-defined methodology and considering different dimensions of performance (17, 18). In this regards, a variety of reference models, such as The Performance Pyramid, balanced scorecard (BSC), and The Performance Prism are used to incorporate a range of well-categorized measures to produce a more rounded picture of performance and ensure that different aspects are incorporated in the performance measurement process (19-21).

Identification of KPIs should be through evidence-based academic literature or consensus of experts to ensure their validity (22). Considering different stakeholders' views is also essential for usability of measures (9).

In order to create results-oriented performance management tools, all KPIs should be aligned with organization's goals and mapped to specific strategic objectives to provide dashboards ability to measure, monitor and analyze their attainment (23).

Development of metrics dictionary is also suggested to get detailed understanding of the individual metrics including their name, purpose, equation, target, thresholds, units of measure, frequency of recording and reporting, and data source(s) (24). Furthermore, to ensure management commitment to KPIs, the owner(s) of each KPI should be assigned (25).

Interconnectivity between selected measures is an important concern in dashboard development as well. In this regard, establishing hierarchical structure of measures or identifying lead and lag measures (i.e. manageable against result measures) is necessary for investigating their mutual impacts and providing drill down capability of each KPI (26).

The number of KPIs should be limited. It means that KPIs should be concerned to high priority areas (15, 16).

3.2. Data Sources and data quality

Identifying sources of data and the processes used for data generation are important issues in dashboards development (25). Key issues in this regard are mainly focused on data sources, and generated data quality:

Identifying the source of data for each KPI is one of the most essential aspects to develop dashboards, as data may be stored in several inconsistent source systems such as organization information system, accounting system, human resource systems, etc,. Furthermore, inconsistencies in the meaning and definition of data elements should be resolved to ensure consistent reporting (25).

Feasibility of selected KPIs is ensured by data availability. So, some new processes may be required to record existing data or generate new data (27).

Voluminous amounts of irrelevant data and poor data quality and reliability are of main key factors to utilize dashboards to the maximum extent and to produce reliable results. In order to address issues related to the quality and reliability of data, it is very important to concentrate efforts on improving data generation processes (28).

3.3. Integration of dashboards to source systems

Systems and procedures that capture and process data enable measurements to be made regularly (27). Key issues in this regard are mainly focused on IT infrastructures used to capture data from various data sources, integrate these data and link them to dashboards in the most appropriate way (10). Designing a proper architecture to support the dashboards requires understanding different types of data hosting structures, different ways of data replication and delivery methods, and the best query language for these data structures (29). Choosing a system suited for organization IT infrastructure is an important issue for developing efficient dashboards:

Data hosting structures may differ depending on the diversity of data sources and type of reports and queries. Relational online transactional processing (OLTP) databases are applied to develop fixed reports and queries that are very similar to the data entry form. However, integration of different data sources, creating flexible reports and multidimensional analysis require BI-based back-end infrastructure including data warehousing and online analytical processing (OLAP). Data warehouse captures data from different data sources and transform them to usable format by extraction-transform-loading (ETL) process, while OLAP ensures high dashboards' interactivity, drill down capability, and multi dimensional analysis (30-32). However, there are dashboard systems that utilize associative technology, meaning that it can gather data from multiple sources without having to store the data in intermediate storages (25).

Delivering data to dashboards in a standard way requires applying service oriented architecture (SOA) due to its web-based open platform, minimum data transformation, and real-time delivery (33).

Updating dashboards requires complete data processing procedure. So, the speed of this process determines dashboards data refresh rates and updating intervals from real-time to hourly, weekly, etc., (29).

3.4. Data Presentation

Data presentation generally relates to dashboard (as an interface) design features. As to dashboards design, visual and functional features should be distinguished. These features are usually used in combination to improve cognition and interpretation (9):

Visual features design is concerned with how efficiently and effectively information is presented to the user (9). Poor visual design may confuse the user and interrupt decision making. So, a good balance between visual complexity and information utility is necessary (34-35).

Effective dashboards visualization requires considering interactions of visual features with kind of the tasks; users' personality background, cognitive profile and analytical skills; and complexity of decision environment. According to cognitive fit theory, graphs are more useful for tasks that require identifying relationships (i.e. comparing, clustering, ranking, forecasting, and pattern recognition) while tables are better for tasks that require extracting specific values and combining them into an overall judgment. Also, decision makers with a low level of analytical skills make better decisions when they use graphical format compared to tabular format. Furthermore, when the complexity of the decision environment increases, tabular formats are generally preferred to graphical formats (36-40). However, considering the option to change display format (i.e. to tabular format or graphs) based on users need is essential for dashboard visual flexibility (9).

Dashboards functional features describe what they can do. Real-time notifications and alerts, drill-down capabilities, and scenario analysis are main functional features of performance dashboards (7, 9). Moreover, more reporting features such as expand and collapse groups, interactively sorting data, book marking, and Parameterization are elements of dashboards interactivity which enables user to manipulate report's appearance during run time (41).

It is important that the functional features of the dashboard fit with its purpose(s), otherwise, it may result in incorrect decisions (9). All dashboards share a common purpose- that is, to present right information quickly for right decision making. More specifically, dashboards include a wide range of purposes such as consistent measuring, monitoring, planning, and multi dimensional analysis. Moreover, according to the nature of the problem that needs to be solved, these purposes may vary from static reporting to knowledge discovering (7, 10, 42). So, exact distinction among these purposes is a major determinant of dashboards functional features. For example, real-time notifications are in need when dashboard is used as a monitoring tool, scenario analysis is a necessary feature when it is used as a planning tool; or drill down is necessary for a more detailed analysis (9).

4. DISCUSSION

Static nature of performance reporting systems in health care sector due to several reasons, such as lack of consensus on Key measures, inconsistent data sources, poor data quality, lack of IS support, etc., has resulted in inconsistent, incomparable, time consuming, and static performance reports that are not able to transparently reflect a round picture of performance and effectively support healthcare managers' decision makings (43, 44). Therefore, there is a clear demand for interactive performance management tools in this area.

In response to this need, performance dashboards as interactive tools of performance management have been proposed to satisfy decision-support needs by incorporating new features such as outliers detection, drill down capabilities and scenario analysis in addition to high visual display.

This study was established to organize practical issues for developing performance dashboards. The issues were mainly organized based on a combination of PMS and EIS development issues. So, this study implies the main steps to develop dashboards as information systems for the purpose of performance management.

As a whole, developing high-quality performance dashboards in complex context of healthcare sector with its data-intensive and technology driven environment, needs to address several issues about KPIs development, data sources, data quality, dashboards integration to source systems, and data presentation to users.

As for limitations, this study mainly focused on design phase of performance dashboards and other phases of dashboards development life cycle were not included in the scope of this study. So, more studies are being designed to cover those fields.

Moreover, the effect of top management support and sponsorship on technology adoption should not be neglected. Most of managers tend to view information technology as an expense rather than as a strategic asset. This is also true for adoption of advanced technology in healthcare sector. In this regard, development of performance dashboards in this sector also needs top management knowledge about evidenced-based decision making and their sufficient support in development process. This is supported by Armstrong et al. study indicating that for a BI solution (including dashboard) to be implemented across an enterprise, it is important that the top management supports the implementation. Only then there can be easier adoption across the organization (45). Also, according to Yeoh et al. study, committed management support and sponsorship are of critical success factors for advanced technologies adoption (27).

Another point that should be considered is the cost of dashboards development. Although dashboards need proper back-end infrastructures such as warehousing and OLAP to survive in the healthcare data-overloaded environment, setting up this architecture is quite expensive due to the costs of implementation, customization, maintenance, training and so on. Furthermore, these structures need additional interfaces, networking topologies, and security features. According to Hwang et al. study, the complexity and the high costs of implementation and maintenance are the most barriers on using data warehouse solutions (46). So, it is necessary for top managers to pre-evaluate these BI solutions based on their merits and return on investments. Moreover, there is a significant need to accurately understand the availability of existing data before implementation of BI solutions (47).

5. CONCLUSION

Performance dashboards developed on performance measurement and executive information systems principles and supported by proper back-end infrastructure will result in creation of dynamic reports that help healthcare managers to consistently measure their performance, continuously monitor KPIs to detect outliers, deeply analyze causes of unacceptable performance, and effectively plan for the future.

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CONFLICT OF INTEREST: NONE DECLARED.

REFERENCES

1. Purbey S, Mukherjee K, Bhar C. Performance measurement system for healthcare processes. International Journal of Productivity and Performance Management. 2007; 56(3): 241-251.
2. Gordon BD, Asplin BR. Using online analytical processing to manage emergency department operations. Acad Emerg Med. 2004;11(11): 1206-1212.
3. Marcus A. Dashboards in your future. Interactions. 2006; 13(1): 48-49; 59-60.
4. Watson HJ, Rainer Jr RK, Koh CE. Executive information systems: A framework for development and a survey of current practices. MIS Quarterly: Management Information Systems. 1991; 15(1): 13-30.
5. Brown DS, Aydin CE, Donaldson N. Quartile dashboards: translating large data sets into performance improvement priorities. JHQ 2008; 30(6): 18-30.
6. Maheshwari D, Janssen M. Measurement and benchmarking foundations: Providing support to organizations in their development and growth using dashboards. Government Information Quarterly. 2013; 30((Suppl. 1)): S83-S93.
7. Pauwels K, Ambler T, Clark BH, LaPointe P, Reibstein D, Skiera B, et al. Dashboards as a service: Why, what, how, and what research is needed? Journal of Service Research. 2009; 12(2): 175-189.
8. Ford A. How dashboards can increase efficiency. Health management technology. 2012; 33(11): 8.
9. Yigitbasioglu OM, Velcu O. A review of dashboards in performance management: Implications for design and research. International Journal of Accounting Information Systems 2012 Mar; 13(1): 41-59.
10. Eckerson W. Performance Dashboards: Measuring, Monitoring, and Managing Your Business. second ed. Hoboken, U.S.: John Wiley & Sons, 2011.
11. Karami M, Safdari R, Rahimi A. Effective radiology dashboards: key research findings. 20130503 DCOM- 20130712(0198-7097 (Print)). eng.
12. Nudurupati SS, Bititci US, Kumar V, Chan FTS. State of the art literature review on performance measurement. Computers and Industrial Engineering. 2011; 60(2): 279-290.
13. Franco-Santos M, Kennerley M, Micheli P, Martinez V, Mason S, Marr B, et al. Towards a definition of a business performance measurement system. International Journal of Operations and Production Management. 2007; 27(8): 784-801.
14. Marx F, Mayer JH, Winter R. Six principles for redesigning executive information systems-findings of a survey and evaluation of a prototype. ACM Transactions on Management Information Systems. 2011; 2(4).

15. Parmenter D. Key performance indicators: developing, implementing, and using winning KPIs. 2 ed. Hoboken, NJ: John Wiley & Sons, 2010.
16. Smith R, Mobley R. Key Performance Indicators. In: Smith R MR, editor. Rules of Thumb for Maintenance and Reliability Engineers. Burlington: Butterworth-Heinemann, 2008: 89-106.
17. Safdari R, Ghasisaeedi M, Mirzaee M, Farzi J, Goodini A. Development of Balanced Key Performance Indicators for Emergency Departments Strategic Dashboards Following Analytic Hierarchical Process. Health Care Manag (Frederick) 2014; 33(4): 328-334.
18. Hooper VD. Meaningful and Useful Measures of Performance: Building a Comprehensive Dashboard of Measures. Journal of PeriAnesthesia Nursing. 2012 Aug; 27(4): 303-305.
19. Bisbe J, Barrubés J. The Balanced Scorecard as a Management Tool for Assessing and Monitoring Strategy Implementation in Health Care Organizations. Revista Española de Cardiología (English Edition). 2012 Oct; 65(10): 919-927.
20. Najmi M, Etebari M, Emami S. A framework to review Performance Prism. International Journal of Operations and Production Management. 2012; 32(10): 1124-1146.
21. Wedman J. The Performance Pyramid. Handbook of Improving Performance in the Workplace. 22010: 51-79.
22. Wakai A, O'Sullivan R, Staunton P, Walsh C, Hickey F, Plunkett PK. Development of key performance indicators for emergency departments in Ireland using an electronic modified-Delphi consensus approach. European Journal of Emergency Medicine. 2013; 20: 109-114.
23. Seitz V, Harvey C, Ikuma L, Nahmens I, editors. A case study identifying key performance indicators in public sectors. IIE Annual Conference and Expo, 2014, 31 May- 3 June; Saint-Antoine OuestMontreal. Canada; 2014: 371-377.
24. Lohman C, Fortuin L, Wouters M. Designing a performance measurement system: A case study. European Journal of Operational Research. 2004 Jul; 156(2): 267-286.
25. Lempinen H, editors. Constructing a design framework for performance dashboards. 3rd Scandinavian Conference on Information Systems; 2012 August 17-20; Sigtuna. Sweden; 2012: 109-130.
26. Sørup CM, Jacobsen P, Forberg JL. Evaluation of emergency department performance - a systematic review on recommended performance and quality-in-care measures. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2013; 21: 62.
27. Bourne M, Mills J, Wilcox M, Neely A, Platts K. Designing, implementing and updating performance measurement systems. International Journal of Operations and Production Management. 2000; 20(7): 754-771.
28. Yeoh W, Koronios A. Critical success factors for business intelligence systems. Journal of Computer Information Systems. 2010; 50(3): 23-32.
29. Rasmussen N, Chen CY, Bansal M. Business Dashboards: A Visual Catalog for Design and Deployment. Hoboken, NJ: John Wiley & Sons, 2009.
30. Hensley N. Data warehousing: The brains of the big data operation. IBM Data Management Magazine. 2014; (2).
31. Stancu AMR. OLAP systems–Solutions for multidimensional data analysis. Quality–Access to Success. 2014; 15(Suppl.2): 75-80.
32. Oktavia T. Implementing Data Warehouse As A Foundation For Decision Support System (Perspective: Technical And Nontechnical Factors). Journal of Theoretical and Applied Information Technology. 2014; 60(3): 476-482.
33. Papazoglou MP, Van Den Heuvel WJ. Service oriented architectures: Approaches, technologies and research issues. VLDB Journal. 2007; 16(3): 389-415.
34. Amer TS, Ravindran S. The effect of visual illusions on the graphical display of information. Journal of Information Systems. 2010; 24(1): 23-42.
35. Anderson JC, Mueller JM. The effects of experience and data presentation format on an auditing judgment. Journal of Applied Business Research. 2005; 21(1): 53-61.
36. Dilla WN, Steinbart PJ. The effects of alternative supplementary display formats on balanced scorecard judgments. International Journal of Accounting Information Systems. 2005 Sep; 6(3): 159-176.
37. Huang Z, Chen H, Guo F, Xu JJ, Wu S, Chen W-H. Expertise visualization: An implementation and study based on cognitive fit theory. Decision Support Systems. 2006 Dec; 42(3): 1539-1557.
38. Kostov V, Fukuda S, editors. Development of man-machine interfaces based on user preferences. IEEE International Conference on Control Applications; 2001 September 1-5; Mexico City. Mexico; 2001: 1124-1128.
39. Cardinaels E, van Veen-Dirks PMG. Financial versus non-financial information: The impact of information organization and presentation in a Balanced Scorecard. Accounting, Organizations and Society. 2010 Aug; 35(6): 565-578.
40. Read A, Tarrell A, Fruhling A, editors. Exploring user preference for the dashboard menu design. 42nd Annual Hawaii International Conference on System Sciences; 2009 January 5-9; Waikoloa. HI. United States, 2009.
41. Price C, Jorgenson A, Knight D. Building Performance Dashboards and Balanced Scorecards with SQL Server Reporting Services. Indianapolis, Indiana: John Wiley & Sons, 2014.
42. Adam F, Pomerol JC. Developing Practical Decision Support Tools Using Dashboards of Information. Handbook on Decision Support Systems 2. International Handbooks Information System. Berlin Heidelberg: Springer; 2008.
43. Marchand M, Raymond L. Researching performance measurement systems: An information systems perspective. International Journal of Operations and Production Management. 2008; 28(7): 663-686.
44. Bourne M. Researching performance measurement system implementation: The dynamics of success and failure. Production Planning and Control. 2005; 16(2): 101-113.
45. Armstrong CS, Barth ME, Jagolinzer AD, Riedl EJ. Market reaction to the adoption of IFRS in europe. Accounting Review. 2010; 85(1): 31-61.
46. Hwang HG, Ku CY, Yen DC, Cheng CC. Critical factors influencing the adoption of data warehouse technology: A study of the banking industry in Taiwan. Decision Support Systems. 2004; 37(1): 1-21.
47. Isik O, editor. Business intelligence success: An empirical evaluation of the role of BI capabilities and organization's decision environment. Fifteenth Americas Conference on Information Systems; 2009 August 6-9; San Francisco. California: AMCIS, 2009.