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Business Process Re-Engineering Application in Healthcare in a relation to Health Information Systems

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Abstract

Technology application such as health information system in health care affects health care delivery including its clinical process. Health information system is used extensively in healthcare to support the infrastructure of medicine. Improving clinical process enables better understanding of healthcare systems as technology and clinical process need to be aligned to each other. One of the introduced techniques which improve clinical process is business process re-engineering (BPR). The aim of this paper is to investigate the application of BPR and its effectiveness in healthcare related to health information systems (HIS); this paper also highlights critical success factors for healthcare organizations to consider while implementing BPR in their process. In conclusion, application of BPR before implementation of HIS or even after implementation can be helpful to improve effectiveness of HIS. Application of IT can also be an enabler for redesign process, particularly in integration of multiple processes and process automation.

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Keywords: Information Systems; Health Information System; Business Process Re-engineering; Healthcare; Clinical Workflow

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1. Introduction

Information technology (IT) is used in many industries today, with substantial benefits. “Medical information science is the science of using system-analytic tools to develop procedures (algorithms) for management, process control, decision making and scientific analysis of medical knowledge” [1]. On one hand, the ability of healthcare organizations to perform their function (such as order entry, report writing and decision support systems), reduce errors (medication and diagnosis) and achieve their goals can be provided by using information technology-based systems, also known as Health Information Systems (HIS) [2, 3]. On the other hand, some hazards such as its failure and its negative effects on patient or user related to application of HIS have been reported [2]. However, healthcare organizations must strive to achieve their best possible performance. So, evaluation of HIS is crucial to ensure that maximum benefits are gained by HIS. If the new technology that applied in health care is not adapted to the current user activity, it may causes dissatisfaction of users and they refuse to accept new technology. In other word, evaluation of HIS enables the assessment of the extent to which HIS are fulfilling decision makers and users objectives in supporting the services of healthcare delivery [2, 4, 5].

Based on reviewed literature, 45% of HIS were rejected due to user resistance [6-8]. It was reported that misfit between system and clinical practice were more common, so, the ability of the new technology to fit to the clinical environment became important. Therefore, it is essential to evaluate and redesign the clinical process and workflow to make sure fit between clinical processes and HIS as implementing of information technology in healthcare needs workflow redesign in order to achieve success [9].

Process defines as "a structured, measured set of activities designed to produce a specified output for a particular customer or market. It implies on a strong emphasis how work is done within an organization" [10, 11]. Business process is defined as "a set of logically related tasks performed to achieve a defined business outcome." [10, 12]. The definition of clinical process can be similar to business process; with the difference which it involves clinical activities. Clinical process includes steps that govern how to use resources to create services based on customer requirements. A customer, in this definition, is a patient, a nurse or a specialist. Clinical pathway also refers to clinical process, and was first introduced by Zander in the early 1980s to healthcare [13].

Since the 1980’s, quality management methods have been introduced to be applied to healthcare organizations. In the last decade, these methods have been used particularly to improve the quality of healthcare, as well as improve healthcare processes. A number of management techniques were proposed and applied to enhance adoption of HIS to clinical setting and the selection of methods depends on several factors such as existing needs and particular work environment, available resources and available knowledge and objectives. One of the methods of study on clinical process and clinical workflow is business process reengineering (BPR). BPR can enable us to further understand the adoption of health information systems in actual clinical settings [14]. Another suggested method in literature is Lean, which for optimizing clinical workflow [15]. Lean method is used to focus more in details of the process as BPR has a holistic view about the workflow. When BPR implemented in clinical process, the role of Lean method is to remove waste and increase efficiency of clinical workflow in the re-engineered process more specifically in details for each sub-process. However, if an organization aim to identify defects (perhaps through statistical analysis), then Six Sigma method is preferable choice [16].

Since application of information technology in healthcare affects the flow of clinical process, we need to apply BPR to assure about the fit between HIS and clinical setting. As application of HIS is not only limited to one or some specific processes, it is necessary to investigate all involved processes in clinical workflow as a whole. So, we need to explore how BPR method improves the clinical process that relates to health information systems. Hence, it is essential to explore the use of BPR method in improving clinical process and

represent the key findings of a reviewed literature in clinical practice. In addition, the adaption of BPR to clinical setting is important to ensure about successful implementation of BPR. This paper focuses on BPR concept and techniques which are applicable in health care especially to improve the effectiveness of HIS. A number of factors which influence BPR application are also highlighted in this study.

Based on our research question, the following search string was defined: “business process re-engineering”, “Health Information System" and “clinical workflow” to fetch the literature addressing application of BPR in healthcare which is related to HIS. We adopted an open search to find all articles addressing the topic. Titles, abstracts, keywords, and full texts were searched. We selected all the conference and journal papers and manually analyzed the articles and selected papers eligible for inclusion in this research. We first considered the titles, then the abstracts and finally the full texts. If abstracts were not available, we reviewed the full text of papers.

2. Business process re-engineering

To understand the business process re-engineering, first we should know the meaning of process, business process and re-engineering separately. We defined process and business process in introduction part. However, process should have a starting and ending point involving human spanning across organization boundaries. In addition, clinical workflow can be used interchangeably with the clinical process definition.

It was reported that BPR concept was appeared during 1990s [17]. Business process re-engineering is defined as “a management approach that rethinks present practices and processes in business and its interactions. It attempts to improve underlying process efficiency by applying fundamental and radical approaches by either modifying or eliminating non-value adding activities and redeveloping the process, structure, culture” [18]. Business process re-engineering as an integrated and systematic approach, enhances analysis and re-design of the functions, workflows and structure of the organization to improve service quality and cause cost and time reduction.

In BPR method, first we should map the exits clinical process and decompose it into activities that are involved in the process. The mapped process is named “as-is” process. Within the mapped clinical process, we should identify all non-value added activities and unnecessary steps [18]. By analysis of the “as-is” process the bottlenecks would be identified. Afterward, the new clinical process that is named “to-be” process should be modeled [19, 20]. In some issues, modification of the process is not enough and may it needs to be redesigned or even remove wasteful activity completely [21].

Benchmarking in the “to-be” process can help to compare the performance of the organization’s process to find the areas that require changes and redesign. Also, like the “as-is” process, we can deploy an activity based costing tool to evaluate different designed “to-be” scenarios and trade-off between important factors to identify the best “to-be” scenario. The “to-be” process should be confirmed by process owner before implementation based on best practices which identified in designing the “to-be” process. Making a simulation based on “to-be” scenario could be helpful to reduce the errors and avoid too much expenses [22].

2.1. Business process re-engineering steps

Five steps were identified in BPR implementation. It includes define the vision, identify the process, understanding of the exist process, define the methodology, and prepare a prototype. In the first step (define the vision), the objective of BPR such as reduce process cycle time should be identified based on customer needs [10, 23]. In “identify the process” step, we should declare which process should be redesigned based on cost analysis or revenue generation of process. Some methods such as High-Impact and Exhaustive approach could help in selection of the process. The high-Impact approach focuses on the most important process which

necessary to be re-designed based on selected criteria. In the Exhaustive approach, we should first identify all of the processes and then prioritize them to be redesigned. The "understanding the process" step aims to prevent repetitive and old mistakes based on measurement of the current process and provide a baseline for future improvement. In the next step (define the methodology), it is essential to select a methodology to do the re-design process. Some tools and techniques are available to assist us in re-design process vary from problem analysis, solution testing and workflow diagram. After selecting a methodology we should design a prototype for new process. It means that we should design a prototype of future process before implementation [10].

2.2. Business process re-engineering tools

There are many tools available to facilitate BPR process. These tools that assist BPR vary from the simplest flowcharting software to the most complex data modeling applications. These tools assist us for analysis, redesign and modeling of the process. We can classify these tools to static modeling and dynamic modeling. Static modeling such as flowcharting and dynamic modeling likes simulation of the process. None of the tools can completely support BPR and cover all the aspects [24].

Some workflow modeling applications are available to map the workflow. For example Business Process Modeling notation and Unified Modeling Language (UML) are introduced to model the workflow visually. Graphical tools such as UML, models the process to enhance the degree of interoperability between the people who are participating in the BPR. In addition, process control flow is a tool which uses in business process re-engineering and address the flow of information as well as task and activity optimization [24]. These tools help people to elicit, formalize and share their process in order to help decision making [24].

3. BPR application in healthcare

There are so many reasons that why hospitals should implement BPR in their processes. The most important one, that was reported based on a study in USA in 1996/1997 was cost reduction [25, 26]. BPR in healthcare focuses on clinical process to redesign it. To realize the benefits of technology, especially health information system, HIS needs to be reassesses and evaluated to find the redundant parts. redundant parts called waste and need to be eliminated [27]. In order to achieve cost reduction, they can eliminate some extra costs such as simplifying the process and eliminating some steps or roles [26, 28]. BPR is also meant for improving clinical performance, empowerment and satisfaction of employees [26].

Some selected reviewed papers which reported the application of BPR in healthcare is shown in Table 1. The selected journals were based on successful application of BPR which was applied in different areas related to healthcare. Based on the reviewed literature, the impact of BPR was classified into time, cost, quality and flexibility. It means that decreasing cycle time, reducing execution cost, improving quality of care and increasing flexibility to react to the variation are the reported results of BPR implementation [22, 29].

On the other hand, some literature investigated the role of IT in BPR process. Technology especially information technology enhances the redesign process. Information technology is an enabler to the BPR process as it helps to the team to collect, analysis, and store and distribute information more effectively and also increase communication and collaboration [19]. As Hammer mentioned, IT is a key enabler for BPR that causes "radical change". It is more than just automating of the process. It focuses on "fundamentally reshape the way business is done" and improve "Transactional, Geographical, Automatically, Analytical, Informational, Sequential, Knowledge Management, Track and Disintermediation" of organization in the BPR process [10, 30].

Based on the reviewed papers there are some limitation and also critical points which are essential to be considered for the successful implementation of BPR, were reported. In the next two sections we discuss about them more in detail.

Table 1. Reviewed literature: Application of BPR in healthcare

Authors	Theme	Findings
Jansen-Vullers et al. 2005	Investigate the application of colored Petri nets tools in redesign process in a mental healthcare institute	The colored Petri nets tools is well suited in modeling and simulation of business process to reduce workflow time and service time (reduce time)
Patwardhan et al. 2008	Examined BPR as a quality management method based on past publications in healthcare systems, appraisal of BPR experiences in UK healthcare	To achieve success it is important to apply BPR in the right circumstances. Reduce waiting times and length of stay along with faster diagnostic processes (reduce time and increase flexibility)
Sini et al. 2008	Making the clinical process safe and efficient using RFID in healthcare, identify all possible areas of impact on processes and on the organization	Re-engineering the RFID pilot application, including new functions, improving system integration (increase quality and flexibility)
Bertolini et al. 2011	Investigate application of BPR in surgical ward	BPR tools enhances the analysis and simulation of the exist process to design the future state to improve efficiency of the ward. Apply Delphi method to identify area of improvement (increase quality)
Elkhuizen et al. 2006	Investigate available evidence on patient care redesign process in 86 studies in hospital	Reduce length of stay, cost reduction and resource utilization was reported as the most frequently mentioned in the reviewed articles. (reduce cost, increase quality)

4. BPR success factors

According to the reviewed literature, some important points are necessary to be considered through redesign process. BPR as a top down approach, needs participation of those who are get involved in the redesign process. In addition, top management commitment is one of the critical points in successful BPR implementation. It means that acceptance and ownership of BPR in the grass root levels is important and essential [10, 31].

Although top management sponsorship is important, the ownership of BPR must rest with line operators because they are the most familiar with gaps, issues and processes. Even with partnership of operational line,

expertise engagement to apply their knowledge is also necessary. BPR gives the opportunity to the employees to review the process in detail and comments about the selected process to increase efficiency [18]. One of the best practices is that to get involve all the stakeholders in redesign process and consider their feedback. Stakeholders in healthcare environment are defined as patient, family, nurse, specialist and a physician.

Re-engineering team composition and their understanding about BPR is another aspect that should be considered. BPR team composition includes some technical people, some members from outside, some customers if possible and those who know the process completely and the impact of processes as well. It means that communication and collaboration between both in-house employees and consultants, working together as a team, is a key factor in any successful BPR project. Also, the team should be manageable in size. This means that if the team is too big, decisions get made more slowly and the entire process becomes more difficult to execute effectively. Therefore, a large team will slow down the whole process.

Even after implementation of HIS in health care, re-designing of the implemented HIS to update existing workflow after a period of time to meet new requirements is essential. In this situation, the automated workflow that includes some software application and database or data warehouse should be evaluated properly. Consistency and completeness of database is as important as integration of all features [32, 33]. It is essential to assure all functions work properly, meet user requirements and compatible with user activity. However, usability test method can be conducted to assure about compatibility [34, 35].

Another important point that necessary to be considered is clinical process includes some sub-processes. If redesign process is applied just on the sub-processes to improve them, a dramatic improvement result in workflow may not to be achieved. Even if we sub-optimize the sub-processes, the whole process may not work efficiently as the entire sub-processes are interconnected and affect each other [21]. Since the processes are interconnected to each other, in BPR we need to redesign the processes as a whole.

5. BPR Limitation

Some limitations of BPR application in healthcare have been reported in reviewed literature. As BPR is a top down approach and employee involvement is necessary, resistance to change exists. Employees are not involved in planning and change management, so the process is not well understood by them and causes employee de-motivation or ownership lost [18, 36]. Also structural and cultural changes need time to be accepted and developed in all levels in healthcare settings. Regarding to mentioned points, we can conclude that BPR is a high risk and high cost solution for the organizations[18].

Even though some reviewed literature reported about successful implementation of BPR, a number of reasons have been identified from the pertinent literature that point to the causes of BPR failure. It was reported that there is no success story available about BPR implementation in healthcare [18]. Some of the reasons are lack of advanced technology people who ignore the role of IT as a key enabler that improve BPR process. In addition, they do not involve IT people as a team member. Other reasons of failure include lack of management commitment, realistic goal, leadership and resistance to change [10].

To overcome limitation, customer involvement can be a good practice. A customer in a healthcare organization can be defined as a patient, family, nurse, and specialist. Since specialists and software analysts or developer team have their own point of view, vocabulary and methods regarding the process, their communication and close co-operation is essential in re-engineering process and redesign [37, 38].

However, even though BPR as a technique helps to reduce cycle time and decrease cost, it is a lengthy process which requires much work and resources.

6. Discussion and conclusion

Business process re-engineering has been applied in health care over decades. It has potential to improve efficiency through reduced cycle time, operational cost and increase quality and flexibility of care delivery. This goal could be achieved by identifying and eliminating wasteful activities, editing roles and responsibilities of employees to simplify the process.

However, we should be careful about the tradeoff between time, cost, quality and flexibility dimensions, as an improvement in one of the factors may have an adverse effect on the others. So, one of the methods to predict the impact is to simulate the tradeoff between these factors. For example, simulation can evaluate cost or flow time of input for redesigned process [39, 40].

In addition, user involvement is an important aspect in BPR implementation. Participation of operational staff is important as they are most familiar with the process and it would be better to give them the ownership of BPR. In BPR, it is essential that specialists and software analysts or developer team to communicate effectively and work in close cooperation as they have their own perspective, vocabulary and methods about the process. User training, management commitment, clear tangible goal as well as sponsor for BPR project are important as the other critical success factor of BPR implementation [10, 33, 37, 38, 41, 42].

The automated clinical work flow does not have the limitation of manual clinical process, such as managing recorded information about patient, as information technology improve clinical workflow regarding storage and retrieval of information. On one hand, implementation of information technology in health care is important; on the other hand, re-design the process before implementation of IT should also be considered as it helps to optimize the workflow. Automated clinical process is not just a mirror of manual workflow. Optimized workflow could increase effectiveness of HIS application. So, we can suggest to implement BPR before implementation of HIS and apply it continuously even after HIS implementation in order to improve effectiveness of the automated workflow and manage changes. The integrity of features such as database or software application to the clinical settings is the most important aspects of HIS that could be implemented through BPR.

BPR includes change management across a number of functions that needs two to four years to implement. Performance improvement can be attained from lessons learned and previous experiences. This paper is useful for researcher who wants to conduct study on business process re-engineering application in health care to increase efficiency of health information systems.

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References

[1]. Shortliffe, E.H., The science of biomedical computing. Informatics for Health and Social Care, 1984. 9(3-4): p. 185-193.
[2]. Ammenwerth, E., et al., Evaluation of health information systems—problems and challenges. International journal of medical informatics, 2003. 71(2): p. 125-135.
[3]. Bates, D., et al., Reducing the frequency of errors in medicine using information technology. Journal of the American Medical Informatics Association, 2001. 8(4): p. 299-308.

[4]. Yusof, M.M., S. Khodambashi, and A.M. Mokhtar, Evaluation of the clinical process in a critical care information system using the Lean method: a case study. BMC Medical Informatics and Decision Making, 2012. 12(1): p. 150.
[5]. Kaplan, B. and N. Shaw, People, organizational, and social issues: Evaluation as an exemplar. Yearbook of Medical Informatics, 2002. 2.
[6]. Dowling Jr, A.F., Do hospital staff interfere with computer system implementation? Health Care Management Review, 1980. 5(4): p. 23.
[7]. Anderson, J.G. and S.J. Jay, Use and impact of computers in clinical medicine1986: Springer-Verlag New York, Inc. Secaucus, NJ, USA.
[8]. Zheng, K., et al., Understanding technology adoption in clinical care: clinician adoption behavior of a point-of-care reminder system. International Journal of Medical Informatics, 2005. 74(7-8): p. 535-543.
[9]. Lau, F., M. Price, and K. Keshavjee, From benefits evaluation to clinical adoption: making sense of health information system success in Canada. Healthc Q, 2011. 14(1): p. 39-45.
[10]. Malhotra, Y., Business process redesign: an overview. IEEE Engineering Management Review, 1998. 26: p. 27-31.
[11]. Davenport, T.H., Process innovation: reengineering work through information technology1993: Harvard Business Press.
[12]. Davenport, T.H. and J.E. Short, The new industrial engineering: Information technology and business process redesign. Operations management: Critical perspectives on business and management, 2003: p. 97-123.
[13]. Quaglini, S., et al., Guideline-based careflow systems. Artificial intelligence in medicine, 2000. 20(1): p. 5-22.
[14]. Carayon, P., et al., Incorporating Health IT Into Workflow Redesign: Request for Information Summary Report, 2010, Rockville MD, USA: Agency for Healthcare Research and Quality Publication.
[15]. Vats, A., K.H. Goin, and J.D. Fortenberry, Lean analysis of a pediatric intensive care unit physician group rounding process to identify inefficiencies and opportunities for improvement*. Pediatric Critical Care Medicine, 2011. 12(4): p. 415-421.
[16]. Schweikhart, S.A. and A.E. Dembe, The applicability of Lean and Six Sigma techniques to clinical and translational research. Journal of investigative medicine: the official publication of the American Federation for Clinical Research, 2009. 57(7): p. 748.
[17]. Hammer, M., Reengineering work: don't automate, obliterate. Harvard business review, 1990. 68(4): p. 104-112.
[18]. Patwardhan, A. and D. Patwardhan, Business process re-engineering–saviour or just another fad?: One UK health care perspective. International Journal of Health Care Quality Assurance, 2008. 21(3): p. 289-296.
[19]. Netjes, M., et al. BPR Best Practices for the Healthcare Domain. 2010. Springer.
[20]. Hammer, M. and J. Champy, Reengineering the corporation: A manifesto for business revolution. 1993.
[21]. Brock Jr, J.L., J.P. Finedore, and D.A. Davis, Business Process Reengineering Assessment Guide1997: DIANE Publishing.
[22]. Jansen-Vullers, M. and H. Reijers. Business process redesign at a mental healthcare institute: A coloured petri net approach. 2005. Citeseer.
[23]. Nonaka, I. and H. Takeuchi, The knowledge-creating company: How Japanese companies create the dynamics of innovation1995: Oxford University Press, USA.
[24]. Bertoni, M., et al., PLM paradigm: How to lead BPR within the Product Development field. Computers in Industry, 2009. 60(7): p. 476-484.
[25]. Walston, S.L. and R.J. Bogue, The effects of reengineering: fad or competitive factor? Journal of healthcare management/American College of Healthcare Executives, 1999. 44(6): p. 456.
[26]. Albery, L.R., The effects of reengineering on hospital performance indicators, in Dissertations & Theses2001, Western Michigan University.
[27]. Lu, Z. and J. Su, Clinical data management: Current status, challenges, and future directions from industry perspectives. Open Access Journal of Clinical Trials, 2010. 2010.
[28]. Harlin, T. and E. Schmid, Charting reengineering potential: a PFCA benchmark study. A first look at outcome measures across reengineering hospitals. PFCA review, 1996: p. 2.
[29]. Brand, N. and H. Van der Kolk, Workflow analysis and design. Deventer: Kluwer Bedrijfswetenschappen, 1995.
[30]. Short, J., The new industrial engineering: information technology and business process redesign. Sloan Management Review, 1990. 31(4): p. 11-26.
[31]. Bashein, B.J., M.L. Markus, and P. Riley, Preconditions for BPR success and how to prevent failures. Information System Management, 1994. 11(2): p. 7-13.
[32]. Barrie, J. and D. Marsh, Quality of data in the Manchester orthopaedic database. British Medical Journal, 1992. 304(6820): p. 159.
[33]. Terazzi, A., A. Giordano, and G. Minuco, How can usability measurement affect the re-engineering process of clinical software procedures? International Journal of Medical Informatics, 1998. 52(1-3): p. 229-234.
[34]. Beuscart-Zéphir, M.C., et al., User-centred, multidimensional assessment method of Clinical Information Systems: a case-study in anaesthesiology. International Journal of Medical Informatics, 2005. 74(2-4): p. 179-189.
[35]. Wixon, D. and C. Wilson, The usability engineering framework for product design and evaluation. Handbook of human-computer interaction, 1997. 2: p. 653-68.
[36]. Jones, M., The contradictions of business process re-engineering. Examining Business Process Re-engineering, The Cranfield Management Series, London, 1995: p. 43-59.
[37]. Nayak, N.P., D. Mrazek, and D.R. Smith, Analyzing and communicating usability data: now that you have the data what do you do? a CHI'94 workshop. ACM SIGCHI Bulletin, 1995. 27(1): p. 22-30.

[38]. Bernonville, S., et al., Integrating the SE and HCI models in the human factors engineering cycle for re-engineering Computerized Physician Order Entry systems for medications: Basic principles illustrated by a case study. International Journal of Medical Informatics, 2010. 79(4): p. e35-e42.
[39]. van der Aalst, W.M., J. Desel, and A. Oberweis, Business Process Management Models, Techniques and Empirical Studies. 2000.
[40]. Jansen-Vullers, M. and H. Reijers. Business process redesign at a mental healthcare institute: A coloured Petri net approach. in Proceedings of the Sixth Workshop and Tutorial on Practical Use of Coloured Petri Nets and the CPN Tools (PB-576). 2005.
[41]. Bashein, B.J., M.L. Markus, and P. Riley, Preconditions for BPR success and how to prevent failures. Information Systems Management, 1994. 11(2): p. 7-13.
[42]. Davenport, T.H. and D.B. Stoddard, Reengineering: business change of mythic proportions? MIS quarterly, 1994: p. 121-127.