Framework Implementation for Data Integration and Data Analytics Applying technology for evidence-based decision making

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Abstract

Healthcare services are vital components of society. With the passage of time healthcare services have transformed themselves into distinct entities by embedding several vertical siloed functions under their umbrella e.g. Pathological services, counsellor services, testing laboratories, and dietician services *and the list is growing as medical science and technology gallops along*. Each of these functions generates its own data set. However, practitioners in healthcare services are required to make decisions based on these data sets which act as evidence. The process of making decisions based on this evidence poses its own set of issues and challenges such *as not having access to integrated data* and the *quality of data*. In addition, to these issues and challenges, another equally important concern that is frequently observed is seeking the answer to the question: *Can technological advancements assist practitioners in making evidence-based decisions*? *Can technology assist practitioners in performing data analytics operations*? For, decision-making in healthcare services requires access to current *descriptive* data which must be integrated from different units, and also the ability of this integrated data to demonstrate future trends and patterns so as to eliminate the possibility of making wrong decisions are eliminated or minimized. It is in response to these issues and challenges this research paper is developed by the authors. The research paper thus seeks to link theoretical concepts with the practical implementation of technology to assist practitioners in the process of making decisions and providing solutions to the above issues, challenges, and questions posed by healthcare practitioners.

The focus of the paper is on the integration of the data set and on the practical scenario of how to link the theoretical perspectives to the practical form of the working framework. The development of the framework is compared in parallel to the software development life cycle approach. This is done so as to provide a concrete technology-based healthcare system that will operate on integrated data which is stored in a database from where data analytics functions are performed which will assist the decision-makers. In other words, the approach of the paper takes into consideration the various frameworks, identified in the literature review, links them to the software development life cycle, stores integrated data, and hence enable the decision-makers to make decision-based on evidence. The managerial implications demonstrated by this paper include the following (a) demonstration of a practical approach to the process of developing an integrated system by means of a work breakdown structure.

Keywords: *Data integration, Framework, System, Healthcare services*

1. INTRODUCTION

Healthcare service practitioners today are concerned with fundamental questions such as a) how to make use of technology in integrating the data of different units in an organization. And b) how to apply this integrated data to the process of making decisions based on evidence (Leonard-Barton, Dorothy and William A. Kraus, 1985; McMurray JJ, 1998). To address these questions, a review of extant literature outlines the concept of application of evidence-based medicine (EBM) which is "*conscientious, explicit, judicious and reasonable*

use of modern, best evidence in making decisions about the care of individual patients" (Masic, Izet, Milan Miokovic, and Belma Muhamedagic; 2008, Canadian Health Services Research Foundation, 2000, Sackett, David L, *et. al*, 1996). The EBM concept forms the base for integrating the information derived from research findings with the current knowledge, expertise, and diagnostic excellence possessed by an individual (David L, *et. al*, 1996).

The practice of EBM is widely used among clinicians, public health professionals, purchasers, planners, and the public (Sackett, David L, *et. al*, 1996; Rodrigues, Roberto J., 2000; Alavi, SeydeHajar, *et. al*, 2015) with greater emphasis on putting to practice the theory of EBM. However, the base of EBM being "*medicine by authority*", it was gradually replaced by Evidence-based practice (EBP). EBP works on the premise of adopting a pragmatic approach by applying scientific principles and practices using endorsed and systematic treatment of information (Evidence-Based Medicine Working Group, 1992; Sackett DL *et. al*, 1995). EBP makes use of systematically compiled peer-reviewed researched data by health care professionals and managers and others involved in the decision-making process (Berkvits M., 1998; Sackett DL *et. al*, 1995; Rosenberg W, Donald A. Michaud GC *et. al*, 1996; McKibbon KA; Odunsi KO, Cooke IE, Olive DL; Lindberg DA, Humphreys BL, 1997). However, the decision-making process requires integration and exchange of information among healthcare professionals outside the boundary of scientific, technical, and administrative literature (Dickinson E., 1998). For eg., Individual patient care requires information exchange from various units such as admin, sanitation department, pathological department and food safety department.

The growth of internet technologies has provided a base to integrate, exchange and update information from various repositories of clinical, administrative, and other research findings for making decisions (Eng TR, Gustafson DH (eds)., 1999). Technological advancements have brought a significant transformation in the application of data analytics to complex operations in healthcare services. For example, Data analytics is able to provide an answer to what is happening currently, what will happen in the future and what actions are required to get optimal results (Mohamed Khalifa and Ibrahim Zabani, 2016). Further, different types of Information systems are evolved such as Laboratory testing, Radiology, administrative and managerial systems in an attempt to improve the quality and productivity of healthcare systems (Mantzana, Vasiliki, and Marinos Themistocleous, 2004). In the same context, researchers (Pronovost, Peter, Alan Ravitz, and Conrad Grant, 2017) argue that healthcare services operate in an environment that is complex and cumbersome, and functional units of healthcare services are siloed to produce respective data sets and integration of these respective data sets enable practitioners to carry out data analytics and hence evidence-based decisions. However, healthcare practitioners can derive benefits once the design of the healthcare system is conceptualized and technology takes over. The design of a healthcare system is not an easy task and poses various challenges to be overcome before integration through technology can apply data analytics and assist decision-making (Pinem, Ave Adriana *et. al*, 2015)

In order to design an integrated healthcare system with technology as the driver, issues concerning the type of framework, the data generated by these frameworks, and the linkage between the frameworks need to be identified. Each framework generates disparate, homogenous, heterogeneous, and integrated data which gets injected into the system (Anyanwu, K., e*t al*.2002). A Framework is a structure that deals with a set of connected concepts each of which describes the purpose, subject, and outcome of the interconnectedness

(Miller and Islam 1988, p.1). for eg. The patient-oriented framework deals with the concepts of management of patient record systems, patient follow-up systems, and patient education systems. Each of these concepts generates an outcome that is disparate and homogenous and when integrated with one another produces heterogenous data which sets up a task for data analytics and the advent of the decision-making process (Gordijn, Akkermans et al. 2000a; Osterwalder, Pigneur et al. 2005). In short, frameworks provide a structure to *store* data at a common place wherein data analytics and technology co-integrate to enable practitioners to make decisions based on evidence.

Frameworks are developed to generate and store data in a centralized place. However, as healthcare services operate in a varied contextual environment, the data so generated and stored includes contextual factors (eg. Patient health data includes details pertaining to income, industry in which the patient works highly stressed industry, sedentary office environment, and the like). The following frameworks are considered in this paper for integration and subsequent data analytic operations using technology. The selection for the framework by the authors is done on the basis of practical consideration in terms of ease of use, practicality, ease of use by the intended users, and technology considerations.

1.1. Benefit evaluation Framework (BE Framework)

The BE (Lau, Hagens, & Muttitt, 2007) takes into consideration the contextual aspects pertaining to the information quality, the ease of implementation of technology advancements, and the support required to sustain the framework. It also takes into account the user comfort level, productivity issues, and other factors such as the scalability of the framework. From the practical design perspective, technological advancements can assist in creating and developing the system in terms of ensuring correct data goes, and is, generated by the system, creating or designing user interfaces that assist the end users to operate with ease the system. On the other hand, technology will work at the backend to generate data analytics from the correct data as leaves no space for incorrect decisions.

1.2. Clinical Adoption Framework (CA Framework)

The CA Framework (Lau, Price, and Keshavjee, 2011) is an extension of the BE framework. It takes into consideration a more pragmatic approach to the successful adoption of the framework by including organizational and contextual considerations. Further, by following a layered approach to the framework, the implementation becomes easier. From the practical design considerations, the technology will address the issues pertaining to the implementation, changes, and modification of the organizational policies. Alternatively, the technology will assist the framework users (healthcare users) in developing data sets controlled by a centralized operation. The application of data analytics will enable policymakers to observe and forecast trends based on the current data sets.

1.3. Clinical Adoption Meta-Model Framework (CAMM)

The CAMM framework (Price & Lau, 2014) includes aspects such as the sustainability of the framework in terms of usage and benefits. It takes into consideration the outcome, the data generated by the users, and other aspects pertaining to the quality of the implemented framework. The technology can assist the decision-maker in understanding the usage of the

framework in clinical operations and identify trends and patterns based on the current evidence for improvisation and optimization.

1.4. E-health Economic Evaluation Framework

The E-health economic evaluation framework (Bassi & Lau, 2013) takes into consideration the various aspects pertaining to planning, conducting, reporting, and appraising the evaluation system of frameworks. It also takes into consideration the economic issues, the time frame required, and the cost implications in the scalability of the frameworks. The technology can assist the decision makers to develop and creating new reports to observe the trends and patterns based on the evidence that is the data set and to work out the economic policies.

1.5. Pragmatic HIT Evaluation Framework

This framework (Warren, Pollock, White & Day, 2011) takes into consideration the dynamic information pertaining to healthcare services. The framework includes multi-criterion and multi-dimensional aspects of various data sets generated by different frameworks and thus allows users to consider information from several perspectives and to take decisions. This framework will ensure that the real power of technology is put into action based on the 5V's of the big data concept that is Volume, Veracity, Validity, Volatility, and Velocity.

2. Analysis, Methodology & Outcome

2.1. Designing the Healthcare system based on an integrated framework with technology

The design of a healthcare system follows a structured approach pertaining to the Software Development Life Cycle (Lehman, Tobin J., & Akhilesh Sharma, 2011). A software development life cycle is a set structured series of activities that are required to develop the software. The activities are required to be executed in a sequential manner. The following are the activities

2.2. Requirement gathering and analysis

Requirements gathering is the most important and crucial stage of the healthcare system. The process of gathering requirements processes and is a "human center journey" (Stephen Lane, Paidi O'Raghallaigh & David Sammon,2016). The aim of the requirement gathering stage is to gain clarity on the requirements of different users and thus exercise effective decisions to proceed to the next stage of the healthcare development system. For the purpose of this paper, requirements were segregated into two parts (a) requirements pertaining to the functioning of the healthcare processes and (b) requirements pertaining to the designing of the system that is from the technical perspective. the users are classified on the macro, meso and micro levels (Lau, Price and Keshavjee, 2011; Lau, Hagens, & Muttitt, 2007; Price & Lau, 2014; Bassi & Lau, 2013). The micro-level users include the patients, the front-end users, and other staff members who directly interact as an interface in the healthcare system. The meso-level users include the actual staff members who carry out the work and act as interfaces between the management and the front-end users. These include clinical staff members and support staff functions. The macro level users include the management of the organization who are

responsible for drafting and formulating policies and changes to the policies from time to time and on the business and market requirements.

For the purpose of this paper, the requirements gathering was done in a systematic process covering healthcare units of the NCR region. The sample size covered for this paper was 32. It included the healthcare units comprising nursing homes, medical stores, clinics, counsellors and Health club fitness centres. On the other hand, the patients sample size included 52.

The choice of including nursing homes was based on the criterion of their availability of service on a 24 x 7 basis a minimum supporting staff member of size 40 and a panel of clinicians from different specializations. For medical stores, the criterion included medical stores which operated on a 24 x 7 basis and were attached to nursing homes or were located in close proximity to the hospital and those medical stores which did not follow a 24 x 7 basis operation. The prime reason for inclusion in these medical stores was to study the behaviour of data analytics operations. The choice for inclusion of clinics was those who operated on fixed time periods such as 10 am to 9 pm or those who operated with a break on their operational timings such as 10 am to 2 pm & 5 pm to 9 pm. The choice of counsellors and health club fitness centers was fact that they too covered a part of the healthcare services.

The evidence generation by means of data capture and storage was performed by means of a well-developed structured 25 questions. The questionnaire captured the demographic profile of the respondents who worked in healthcare service units. As the sample included a diverse set of respondents the questions were segregated according to the healthcare unit in which they were employed. On the other hand, the patient's information questionnaire included aspects such as age, gender, previous history of the disease, and aspects such as quality of treatment, insurance claims, and the like. Some of the questions were close-ended while some of them were multiple-choice. Further, some of the questions included the Likert Scale for data capture.

The technical requirements were collected from the technical experts and software developers. The requirements included the aspects such as the design of interfaces, the database growth size, and the sustainability of the system in operation. The other considerations included the aspects such as data analytics tasks, the type of reports generated, and the requirements pertaining to the decision-making with evidence in the form of data as a base.

2.3. Design the system

This is the stage wherein an attempt is made to convert the requirements in an abstract form to a form that can be translated into a technical interface easily (Guindon, Raymonde, 1990). The end of this stage is the formulation of the database and the finalization of the various interfaces of the healthcare system through which the data will flow while being stationed at a centralized location for further data analytics tasks and the decision-making process.

The design of the research activity was planned in a structured manner. Starting with the literature review, gaps were identified and an attempt was made to link the theoretical research work with means and mechanisms to link it with the practical design of the healthcare system.

The design of the healthcare system included the requirements pertaining to the type of siloed healthcare processes at the macro, meso, and micro to be included in the system as a whole. For eg. The macro level included the top management; the meso level included the actual practitioners such as doctors and other core function staff members while the meso level included the receptions help desk and the patient who avail the services of health care units. Once these siloed processes were identified, the next in the design process included the aspect of the number of users or stakeholders who will actually use the healthcare services or processes. Once these are identified, their functional set of requirements is identified, and then the data which forms these requirements is identified. In addition to the identification process, the linkages of the function and interlinked data issues as well as data quality are taken care of. The data captured process was carried out by means of developed data-captured forms in terms of their functionalities and what information is required to be injected into the system. Other design considerations included the aspects such as the technology to be used, the database to be used, and how the implementation will be taken care of. At the other micro level, the issues pertaining to the standards and quality issues were identified and their details pertaining to integration in the healthcare unit were drafted. These included aspects such as coding standards, the technical documentation that would be developed, and other training materials which would be provided to the users.

2.4. Developing the system

This is the stage wherein the operational processes of healthcare care are actually transformed into the software which is to be used by the intended users (Bisson, Simon, 2016). This stage is responsible for the actual software requirements of users into a form that is ready to be deployed for immediate use that is it prepares the healthcare system to develop forms and interfaces to gather data with data quality requirements by means of interfaces to be stored in the database tables from wherein subsequent data analytics task is performed (Price & Lau, 2014; Bassi & Lau, 2013). For example, the initial form that is filled in by the patient at the time of admittance is developed. The issues pertaining to data quality are taken care of as any incorrect and ambiguous data will not enter the system unless and until the correct entries are made in the form. In other words, before ensuring that the patient is availing the services of a healthcare system, he is required to provide information that is correct, unambiguous, and which can be accounted for else the subsequent services will produce incorrect output.

The development of the healthcare system included aspects such as developing the database, writing the code for the healthcare system, and developing quality checks and test cases to ensure that the healthcare system is able to meet the requirements of the intended users who will actually use the system. In addition, the system is developed keeping in mind the data analytics requirements and the scalability issues f the system.

2.5. Testing the system

The function of this stage is to check whether the healthcare system is developed to meet the requirements of the healthcare system (Klimov, Kirill, 2016). In other words, this stage is responsible for maintaining the data quality requirements of the healthcare system. This stage involves the determination of quality at various levels such as data storage level, data flow at the information exchange level, and the storage of data at the database level. Further, this stage seeks to ensure that the various data analytics results and reports generated at various

levels are able to assist the decision-makers with the set of requirements including the data provides and the optimum environment for taking evidence-based decisions.

2.6. Implementation

This is the stage that actually transfers the developed healthcare system onto the system at the organizational level (Fichman, Robert, G., & Scott A. Moses, 1999). This is the most crucial stage of the healthcare system. in essence this stage of the system development ensures that it is able to provide the services that it is able to meet the requirements in an environment of the client and with the client data set and is able to perform the data analytics function to enable evidence-based decision-making process.

This stage included the implementation aspects such as testing the system with the client data set and verifying the reports and other data analytics tasks for evidence-based decision-making. In other words, this stage will signify that the client is ready to accept the system.

2.7. Posting the system for the intended users

In this stage, the system is floated to the intended users, who will actually use the system for making decisions and other day-to-day operations. This is the stage wherein the developed system is put to test in reality.

3. Results, Limitations & Conclusion

The research has provided a new dimension of the theoretical perspective of various siloed processes of healthcare services and how they can be converted into practical scenario. The managerial implications commence with the first set of identifying the requirements of the healthcare system in terms of functional requirements and managerial requirements. The functional requirements include aspects such what the healthcare system must do. In other words, it answers the question as to why should I buy your healthcare system as proposed by you. On the other hand the requirements in terms of managing the requirements such as identifying the varied sets of users after identifying the sample data set which will provide the response. From this, the design aspect again proposes managerial implications in terms of functional design and technical design. The functional design includes designing controls so as to ensure that only correct data goes into the system. In other words, controlling the data at the entry-level by means of designing and implementing various managerial controls so that data-related problems and issues are sorted out at the beginning. This ensures decisions are taken on the basis of high-quality evidence in the form of evidence that goes into the process. On the other hand, when the issues pertaining to data quality are taken care of by the system the subsequent processes and operations pertaining to data analytics provide a transparent picture. Another issue related to the managerial implications is the process of integrating the dataset from different functional as well as from technical perspectives so as to assist the practitioners in taking decisions based on evidence. The aspect covered in the paper is in terms of execution wherein the paper covers the use and application of standards during the process of developing the system. The set of standards ensures that the team members are all at the same platform and ambiguity exists while executing the system. in an essence the managerial implication that comes out from the research indicates that data is the important component and it all becomes easier for the data when the direction is clear as to what

function generate which type of data, duration of the data and how much time the remains in transit.

4. Limitations

The limitations that have surfaced while developing the paper include the design of the paper, (in terms of theoretical perspective), the number of sample respondents, and the varied types of respondents taken for developing the system. The limitations of smaller number of sample respondents to the tune of 40 and 52 respectively provide the limitations in terms of testing of the system when a large number of people will access the healthcare system and the deficiencies will surface. The deficiency may be in the form of the system becoming unresponsive, the inter-related data may lose out in terms of data quality that only some of the data sets are updated while other data sets may not, the output of the data analytics reports may generate incorrect findings and thus provide an incorrect base to make decisions. The other limitations that the design of the healthcare systems stems from the fact that the perspective has taken into consideration only the units of the clinic, hospitals, medical stores, and fitness clubs and have thus neglected the aspects pertaining to dieticians, testing laboratories, radiologists, and the like. By including these verticals a comprehensive healthcare system can be designed and implemented. The other limitation that this study has failed to consider includes the aspect of different verticals of the healthcare stream such as ayurvedic and homeopathic streams of practice. For, they do have interfacing units with one another, and combining them with the system will provide a new study,

5. Conclusion

The study has provided the answer to the research question of linking technology in the process of integrating the data from different units of a healthcare system and applying this data analytics process to the interlinked data set to assist the practitioners in the process of making decisions based on evidence. The research paper has demonstrated the process of understanding the theoretical perspective and converting it to the process of a practical system wherein the data is controlled from the beginning and is stored in the database in the form of evidence to assist the practitioners in taking evidence-based decisions.

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