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Original Article

Evaluating the Role of Real-Time Business Intelligence Dashboards in Enhancing Healthcare Performance Monitoring

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Abstract *- This paper gives a description of the role of Business Intelligence (BI) tools in Healthcare Systems, fostering new innovation in the field of Healthcare Performance Monitoring process. Clinical and administrative problems of the healthcare sectors are impacted by BI tools, which is one of the primary objectives. In addition to this, the study suggests automation of administrative tasks, reduction of cost overheads and objectifying the areas that need to be improved. This also aims at the implementation of instrumental strategies that lead to efficient decision-making to determine the possible future workflow processes to take place. The study highlights a set of information and analytical aspects which determine the development and usability of the real-time dashboards and their application across the healthcare setting. The consideration of healthcare datasets and their implementation across an analytical dashboard is expected to help in enhancing the credibility of administrative bodies to undertake data-driven decisions. However, the issues that lie within its implementation might have a significant impact on the areas of data management, such that maximum compatibility can be attained while sustaining the scalability of operations. Insights into the changes that are revealed through the help of artificial intelligence help in programming the dashboards in such a way that visual insights provide an indication of the effectiveness of decisions that take place across a healthcare setting.*

Keywords *- Business Intelligence, Real-Time Business, Dashboards, Healthcare Monitoring, Electronic Health Records, Artificial Intelligence.*

1. Introduction

1.1. Background of the topic

Real-time data analytics refers to the capability of allocating and visualising data after its generation [1]. This offers decision-makers to put a mark on the uprising trends, opportunities and associated risks. This ability is condemned in the business environment, where if there is any delay in insight could lead to a great financial loss. The periodic growth in complexity and volume of data gave rise to the deployment of intelligence systems that contribute to efficient analysis of complex data generated for organisations. Data visualisation tools provide the solution to complex datasets through charts, graphs, dashboards and many other visual aspects. These tools provide governance facilities to monitor services and report performances, and simplify the complications of databases [1].

1.2. Motivation

Digital transition and increasing competition have caused organisations to be data-driven for understanding the current situation of the market, based on customer engagement [2]. This consists of integrating the customer segment and effective strategies within the BI framework. Healthcare institutes can deploy Business Intelligence Dashboards to analyse different datasets of different healthcare units with ease and generate meaningful insights that can contribute to efficient decision-making and business strategies for the betterment of the healthcare system.

1.3. Importance of Real-Time Business Intelligence (BI)

Business Intelligence (BI) is incorporated by institutions to change the conventional data analysis and decision-making procedure. Healthcare organisations are able to learn valuable lessons that are concealed in big data [3]. It is one of the most important points in regard to either a clinical or an operating system, where a high degree of accuracy regarding real-time data is needed. BI tools provide the rigorous analysis of large amounts of data, leading to a sound decision-making process. Such aspects as patient record, treatment outcomes and financial report need to be dealt with systematically. Conversely, such BI tools can be used to forecast the results based on the past data, and they can be used to cure the diseases in their initial stages, as well as assist in training for possible outcomes in case of health crises. BI tools may also trigger the handling of massive storage overheads and implement the exploitation of available assets in the inventory. These tools provide certain security functions, such as audit logs, sensitivity labelling, and row-level security to increase the transparency of the data [4].

1.4. Objectives

The current situation requires Real-Time Business Intelligence to be used in order to support smart business analysis and work with complex data. The complex datasets that emerge within different healthcare units do not help the organisations which offer healthcare services. To counteract them, business intelligence tools intervention is needed that will provide a more expeditious solution to the information issues experienced by the healthcare institutes. The study narrates the various ideologies that outline the requisite steps that can be taken by the Healthcare Services in promoting innovation within the healthcare systems. The final objective is to find a strategic value in healthcare so as to improve the quality of care and the effective functioning of the health systems.

2. Related Work

2.1. Business Intelligence Systems in Healthcare

Healthcare systems face challenges of efficient resource management. The environment in which healthcare units run precise resource allocation so that patient care is not compromised, and the prevention of unnecessary delay in the proceedings. BI tools in the healthcare field have brought a real improvement with an increase in the number of research studies in the data field [5]. Implementation of the BI tools in healthcare units has led to predictive analysis by which general traits can be obtained that objectify the portions which require proper attention. This promotes a revolution in the patient care system. The regions that undergo resource constraints and disparities in population health, BI tools target those regions on the basis of demographic, geospatial and service utilisation data patterns. Real-time interactive dashboards and key performance indicators (KPIs) provide visibility of the workflow leading to optimisation of performance strategies [6].

2.2. Real-Time Analytics and Data Visualisation Technologies

Business Intelligence applications come up with real-time observation of key performance indicators (KPIs) like the waiting time of patients, utilisation of beds, availability of the medical supply, available ambulances and oxygen supply [3]. Real-time clinical alarm, ICU or wearable patient monitoring and real-time patient health surveillance need the advantage of Business Intelligence applications. BI tools help in the summarisation of resource utility, increase in disease rate in a region, fatality rate and predicting birth rate. BI tools help in the automation of routines by deriving insights from data warehouses. A skilled analytics team can contribute to the supply chain with deep analysis of functionalities. This data plays a vital role as historical data to understand future trends and acts as a boon to face challenges at the initial stages.

2.3. Performance Monitoring in Healthcare (KPIs, metrics, dashboards)

The development of the dashboard questions the Knowledge Performance Indicators (KPIs), which are the base of interconnections and also act as a driving force for the performance report systems [7]. KPIs are the entities through which the determination of the performance traits is obtained. The variabilities in KPIs determine the strategic approach for institutions. Some common KPIs in healthcare institutes are the waiting time of patients, utilisation of beds, availability of medical supplies, available ambulances and oxygen supply [3]. Aligning business metrics with expected goals, healthcare services can involve proper resource allocation and ensure better patient care. Historical metrics play a significant role in smart decision-making strategies and opening a channel to further workflow. BI tools contribute to the visualisation of datasets by removing complexities and presenting of interactive, simpler overview of meaningful insights. The real-time latest data leads to the updating of the dashboard, which is itself an advantage for the healthcare system, preventing regular updating at each interval of time. They also foster comparative studies for different healthcare system models [8].

2.4. Benefits and Challenges of BI Implementation

The challenges of BI implementation are immense. Firstly, traditional solutions related to BI are restricted to a specific domain and since they are supportive of managing an excessive load of data. It is the reason why obtaining data and information is time-consuming. In addition to this, the implementation of BI is also time-consuming. Implementation of data fusion functionalities and advanced approaches also creates issues in the management of time, thus leading to difficulties in the management of BI implementation [9]. The benefits of BI implementation include proper data modelling and design, strong extraction of data, the generation of reports with strong analysis and the distribution of the data [10].

2.5. Existing Research Gaps

The existing literature gap related to the research involves the limited information about the incorporation of BI dashboards within the functionalities of the healthcare systems. In addition to this, the role of the employees in accepting and utilising such real-time dashboards integrated through BI is also limited. Thirdly, the real-time engagement of the manual functionalities with the BI-induced functionalities has created a strong contrast, thus imposing more limitations in the process. Further research on this topic could be effective in addressing these limitations.

3. Methodology

3.1. Analytical Framework

Dashboards are digital summaries that help integrate clinical information for the ultimate form of decision-making. The multiple sources, such as patient monitoring devices, pharmacy imaging, pathology and electronic patient records, are integrated within the dashboards.

The dashboards are also responsible for processing data and calculating higher-order variables from the raw data. Therefore, dashboards are used for monitoring the condition of the patients and improving the outcome of inpatients in the settings of healthcare settings [11]. In relation to this, the analytical framework of research is integrated through three primary dimensions:

Efficiency of decision-making (E): improvement in decision quality and speed.

- Accuracy (A): reliability and correctness in the representation of the data.
- Timeliness (T): the ability to reduce the latency of the data.

Therefore, the effectiveness of the dashboard (De) could be expressed through the following:

$$De = T+A+E$$

3.2. Data Collection

The data was collected by involving the healthcare professionals of a 200-sample size in the global context, and it was also supported through the inclusion of the peer-reviewed journals of 2020 to 2025 from open datasets such as the WHO Global Health Observatory, along with Google Scholar. The important keywords for the collection of the data through Google Scholar are business intelligence, dashboards, and healthcare. Performance monitoring and real-time collection of the data.

3.3. Data Analysis

Data analysis is the most crucial part that is responsible for not only interpreting the data but also making the result of the analysis more effective and accurate simultaneously [12]. The data was analysed through various elements. Firstly, the data was analysed through descriptive statistics, which was effective in understanding the changes in the key performance indicators and usage of the metrics, all related to real-time monitoring of the data and information through the use of the dashboards in monitoring the performance of healthcare. Secondly, the data was also analysed through correlation, which was effective in understanding the use of dashboards and their correlation with the increase in healthcare performance. In addition to this, the research was also facilitated with regression modelling, paired t-test and structural equation modelling to understand the influence of strength before versus after the implementation of the dashboards. Lastly, the structural equation modelling has been effective in understanding the complicated relationship between dashboards and monitoring the performance of healthcare.

3.4. Ethical Considerations

Ethical consideration is a fundamental part that contributes to the wellness and significance of the research [13]. The ethical valuation of the research is strongly integrated by presenting the information sheet and consent form of the participants. It has not only redefined their rights but also put them at ease regarding the complete procedure of questionnaire focus research conducted through a survey. The responses of the participants were kept confidential, and they were supposed to be de-identified post-completion of the research. In the context of the peer-reviewed journals, the names of the authors were cited in the areas where the statements related to the authors were cited. All the data and information are carefully anonymised to enhance the ethical valuations of the research with immaculate accuracy.

4. Results and Discussion

4.1. Performance Monitoring Impact Metrics

Percentage of KPI improvement

$$\textit{KPI improvement (\%)= ((KPI (after)-KPI (before)/KPI (before))*100}$$

This metric can evaluate the role of real-time dashboards in business intelligence and influences the key performance indicators of healthcare, specifically in the area of bed occupancy, readmission rates and patient wait times. In relation to scholarly evaluation, it is observed that healthcare organisations are increasingly dependent on tools related to business intelligence for capturing, analysing, and presenting data related to performance metrics, thus optimising the performance of the healthcare organisations [14].

Improvement towards speedy decision-making

$$\textit{Reduction of decision time (\%)= (Time (before)- Time (after)/Time (before))*100}$$

This metric is responsible for gaining insights about decision-making after the introduction of the real-time dashboards. Connecting with the scholarly evaluation, it is observed that the optimisation of a proper decision-making model is important for better allocation of resources [15, 16]. Expanding the process of decision-making through artificial intelligence further assists in predicting the outcome of the patients. Further evaluation has also outlined that business intelligence (BI) not only improves clinical decisions but also enhances operational efficiencies in the process.

4.2. Dashboard Adoption & Usage Metrics

Adaptation rate of the users

Rate of user adoption (%)= (Number of active users/total intended users)*100

The metrics indicated the rate of user adoption of BI dashboards in monitoring the performance of healthcare. The dashboards related to BI have enabled the real-time process of decision-making, specifically in the operational process, and have transformed the clinical functionalities. The real-time dashboards are also responsible for the management of resources, and the following image specifies early adaptation of such dashboards in the healthcare system [17].

Duration of average session = Time spent per session/ Total sessions

This metric is responsible for understanding the duration of the average session by time spent per session when divided by the total number of sessions.

Rate of feature utilisation = (Number of features utilised/ total features available)*100

The metrics related to the above formula indicated that the rate of feature utilisation of BI dashboards is immense in monitoring the performance of healthcare. Related to this, the scholarly valuation indicated that a dynamic dashboard is responsible for not only understanding the perception of the customers, with proper growth and learning leading to better financial returns [18].

4.3. Efficiency and Productivity Metrics

Time saved in reporting (%) = ((manual reporting time -dashboard reporting time)/manual reporting time)*100

This metric is responsible for understanding the reduction of time caused by the use of the dashboards integrated through BI. The scholarly valuation indicated that AI-integrated BI dashboards can reduce the coordination burden through equal distribution of the workload, intensifying the monitoring of performance in healthcare.

Time of alert response = response time per alert/total alerts

These performance metrics are responsible for understanding the time alert response of utilising the real-time dashboards integrated through BI for monitoring the performance of healthcare.

Percentage of task efficiency (%) = (Completed tasks within dashboards/ total assignment of the tasks)*100

The metrics are responsible for understanding the task efficiency of the dashboards, followed by the total assigned times. BI dashboards have the capability of enhancing the accountability of the tasks, which is the reason why their efficiency is strongly increased in every aspect [19].

4.4. Dashboard Performance Metrics

System uptime (%) = (total time availability - downtime / total time availability)* 100

These performance metrics are responsible for understanding the performance of the dashboards in monitoring the performance of healthcare and understanding their utility in gaining a positive outcome for the patients.

Load time of dashboard = duration of page load/ total page requests

The load time of the dashboard is calculated by the duration of page loading, followed by the total page requests. It is effective to understand the performance of the dashboards better with utmost clarity in monitoring the performance of healthcare.

4.5. Discussions

The evaluation of BI dashboards for real-time analysis of the data of healthcare is successful in capturing the reliability of the system, efficiency, and influence of performance, along with the increase of adoption rates. The metrics of dashboard adoption calculated through the estimation of total intended users and active users, and the rate of user adoption, have presented direct metrics about how the system was widely adopted in the healthcare system. The contemporary metrics, such as the rate of feature utilisation and average session duration, orchestrated the analysis of the functionalities of the dashboards that involve not only analysing the raw data but also evaluating it well for monitoring the performance of healthcare. Contrary to

this, the scholarly article outlined that the adoption rate of BI dashboards is consistently low, identifying the need to adopt them to support the speedy process of decision-making [20].

In addition to this, the utilisation of the formula reflected the engagement of the users and effectiveness in the accumulation of the training programs to increase the efficiency of the employees in handling the dashboards for real-time monitoring of the performance within the healthcare sector. The engagement of users is thoroughly connected with communication, which empowers evaluation through scholarly articles, indicating that communication is the most important aspect that leads to the sharing of data and information. This is done by incorporating training and development that is involved in not only increasing the work efficiency of the employees but also enhancing their productivity simultaneously [21]. Furthermore, monitoring the metrics of performance has quantified the influence of dashboards on the outcome of healthcare. Connecting with the scholarly valuation, it is observed that the influence of BI dashboards is immense in not only enhancing strategic forms of decision-making, but it is also beneficial in monitoring the performance of healthcare well [22]. Metrics related to productivity and efficiency have demonstrated operational valuation in the context of productivity and efficiency. The efficiency of staff tasking has been effective in illustrating the performance of the workplace through real-time evaluation of the dashboards. The metrics of the dashboards here have evaluated the robustness of the technology that orchestrated a better understanding of the reliability of the dashboards to enhance the efficiency of the operations and gain a positive outcome of the healthcare performance.

5. Conclusion and Future Scope

5.1. Conclusions

Driving conclusion from the aspect of real-time business intelligence dashboard in healthcare stated that adoption of a technologically advanced method of tracking activities can help in meeting quality constraints. Performance monitoring is observed to be one of the most effective outcomes that can be generated from using a dashboard, as it helps in enhancing the efficiency of the operations by maintaining system reliability. Using a dashboard also promotes the facilitation of a quantifiable approach, with the help of which real-time decision making can be promoted and improve the services through accuracy. Healthcare organisations utilise such a dashboard to manage the daily operations to improve their services not only in terms of accuracy but also in resource optimisation. Thus, helping in reducing the complexity that lies within operations management, enabling data-driven evaluation to take place, supporting strategic decisions and promoting responsiveness to service requests.

5.2. Future work

As implemented on different industries, real time business intelligence dashboard tends to give focus on the application of the technologically advanced decision making and service management methods. Since, BI has a broad spectrum of advanced techniques, e.g. predictive analytics supplied with artificial intelligence and mission learning in the sense that proactive intervention may occur. The use of such technologies as a component of healthcare is commonly helpful in the identification of the disease as a result of the early identification of the risk factor, making medical practise possible to occur effectively. Research conducted on a global scale has affirmed that application of technological advancements in health care has the potential of enhancing the long-term effect on the clinical outcomes by enabling a dashboard through which patient information is easily monitored. Cross-institutional comparisons also provide implications for the ability of the infrastructure possessed by healthcare settings to ensure services offered to the patients are enhanced. Thus, in future applications use of such dashboards can help in tracking patient activities not only during the treatment phase but also throughout the operations taking place across a dynamic healthcare environment.

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