

Utilizing BI for Workforce Optimization in Healthcare

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ABSTRACT

The health sector is experiencing great pressure to increase quality of service, reduce cost and maximize workforce productivity. In this regard, Business Intelligence (BI) technologies have a transformative potential. BI enables organizations to gather and analyze data and create visuals to optimize workforce allocation and performance, promoting action based on data. This paper examines how BI can be used for workforce optimization in healthcare pre-June 2019 technologies, case studies and methodologies. As a result of intensive analysis, we show how BI systems, once optimally harmonized with healthcare workforce management, improve operational efficiency, labour cost savings and patient care. The research consists of a comprehensive literature search, the specific approach to applying BI in workforce optimization and the empirical findings of case study analysis. The results indicate that BI-fueled workforce optimization may result in a 25 per cent increase in resource allocation efficiency and a 15 per cent growth in patient satisfaction. We conclude with challenges, limitations and future directions.

Keywords: Business Intelligence, Workforce Optimization, Data Visualization, Resource Allocation, Healthcare

1. Introduction

The healthcare industry is beset by dynamic environments, varying inflows of patients and a highly critical need for skilled persons¹⁻⁴. Workforce is the biggest single element of cost of operation in hospital. Poor staff management can lead to burnout, errors and patient dissatisfaction. Old-style workforce management systems tend to center on static scheduling and negative-feedback decision-making.

1.1. The importance of using BI in optimizing the workforce

Business Intelligence (BI) for workforce optimization in healthcare presents many benefits that would help to dramatically increase operational efficacy, improve patient care and lower implementation costs. Five areas that are important in which BI contributes critically to improving workforce management in healthcare contexts include;



Figure 1: Importance of Utilizing BI for Workforce Optimization.

- **Enhanced staffing efficiency:** BI allows hospitals and healthcare organizations to make data-based decisions regarding staff levels and allocation. When data from Human

Resource Management Systems (HRMS), Electronic Health Records (EHR) and scheduling systems is incorporated, BI gives real-time insights into staff availability, patient inflow and demand fluctuations. This enables the medical managers to schedule staff according to the needs of patients accurately without straining or understaffing. Optimised staffing leads to better utilization of HR; hence, departments are neither over-staffed nor understaffed.

- **Improved patient care and service delivery:** Workforce optimization through BI directly impacts the quality of patient care in that adequate staffing is available in critical areas. The BI dashboard can show real-time patient flow for a manager who can monitor patient volumes throughout departments from emergency to intensive care. The visibility will help to see the gaps in staffing before they become an issue, thus staffing vital patient care areas fully at all times. With the optimal distribution of staff, patient wait time is minimized, the care delivery is more timely and the entire patient experience is also improved.
- **Cost reduction and resource optimization:** BI helps hospitals cut down costs of operations by optimising staffing levels. Understaffing and overstaffing, in turn, may cause inefficiencies due to high labor costs or the financial burden of understaffing, producing overtime costs, patient dissatisfaction or even errors. BI tools, including predictive analytics and Forecasting models, can help hospitals make more efficient staffing schedules and decrease the necessity of last-minute changes or hiring temporary participants. Through careful demand forecasting and matching to staffing, BI ensures that labor costs are contained while simultaneously maintaining the level of care, which is ultimately a prime source of savings.
- **Real-time decision making and responsiveness:** A long list of workforce optimization benefits of using BI includes up-to-date data for decision-making. BI dashboards allow managers to track staff performance, patient inflow, absenteeism/ presenteeism and staff gaps when they happen. Such a real-time capability equips healthcare managers to act on face-to-face challenges in real-time, for example, reallocating staff during peak hours or managing absenteeism in key departments. The capacity to make speedy, data-oriented decisions allows the hospital to change flexibly in conditions deterioration so that, in the end, it will operate more smoothly and make its staff more satisfied with how workloads are distributed.
- **Data-driven strategic workforce planning:** Apart from daily staffing decisions, BI supports systematic long-range workforce planning. From a review of historical data trends with regard to staffing numbers, patient inflow and departmental needs, BI tools can be used to predict future staffing levels for healthcare managers. This predictive possibility enables organizations to make rational decisions with respect to recruitment, training and staff development programs. Also, workforce analytics can reveal patterns associated with staff member turnover, absenteeism and imbalances in workload, thus helping the hospital identify and treat prospects of issues before they compromise the hospital's operation. Strategic workforce planning will ensure that hospitals can keep their staffing levels to a decent level and retain skilled staff, which improves long-term organizational stability and reduces costs that come with turnover and recruitment.

1.2. Rise of business intelligence

The emergence of Business Intelligence (BI) connected to healthcare can be associated with the growing demand for data-oriented decision-making when infinite and normally chaotic information is available. BI includes an assortment of technologies, processes and architecture that convert raw data to useful insights for enabling organizations to make informed business decisions, maximize operations and improve performance. Pre-2019, BI platforms such as SAP Business Objects, Microsoft Power BI and IBM Cognos had already realised great value for businesses such as in finance, retail and manufacturing sectors to optimise operations, make better judgments and increase profitability^{5,6}. These platforms allowed businesses to aggregate large numbers of data from various sources to analyse them efficiently and produce them in easy-to-interpret formats such as interactive dashboards, reports and visualization. When the pressure to enhance service delivery, cut costs and address regulatory issues started bearing down on healthcare organizations, they understood that BI tools can be utilized to advance their operations. Early adopters of healthcare spotted the success of BI in other industries and began to incorporate such technologies to narrow the insight into hospital procedures, patient treatment and resources. With the employment of BI, healthcare providers simply could harness the power of their own voluminous clinical, operational and financial data. The capability of turning different sources of data (Electronic Health Records (EHR), HR Management Systems (HRMS) and financial records) into actionable insights became a strong mechanism to drive increased efficiency, lower costs and better patient outcomes. Its adoption in healthcare was a paradigm shift; hospitals and healthcare providers could shift from a reactive mode of decision-making to a more proactive, data-driven strategy. The increasing awareness of the usefulness of BI has created a ground for closer adoption of such tools across different healthcare administration sectors, including optimising the workforce.

2. Literature Survey

2.1. Historical overview of BI in healthcare

There has been a slow but significant evolution in using Business Intelligence (BI) in healthcare. The first use of BI systems mainly concerns administrative activities and the main applications involve managing invoices, controlling stock and the calculation of indicators of institutional performance. Providers experimenting with these scenarios enjoyed more efficient operations and cost savings⁷⁻¹⁰. With digital record and data warehousing improvements, BI applications expanded into clinical grounds, though at different implementation rates among healthcare organizations. Interestingly, the workforce optimization was one of the least studied applications before 2019. Although very important for service evaluations, staff allocation and utilization were often omitted in analytical scenarios, while financial or clinical data analytics was the main activity. The negligence in the past in this area has led to a consistent gap, which only seems to be closing because HRMS and BI systems are accommodated for contemporary research.

2.2. Key research findings

A review of bedrock publications and important studies revealed the growing appreciation of the Bolshevik Importance in healthcare, which Table 1 illustrates. Helped shift analytics

maturity to the forefront in establishing a guide for organisations to change from basic reporting to more advanced predictive and prescriptive analytics. He outlined the roadmap for organizations to trace the progress of the use of data from basic reporting to high levels of analytics capabilities. In his field of research, he dedicated his work to health informatics, stressing the rationale of using data for clinical decision-making. He advised that using BI concurrently with EHRs would greatly simplify evidence-based care and consequently, the outcome of patients would be improved. Such an approach enabled a shift from gut decisions determined by clinical needs to systematic data analysis-based decisions. Coiera(2015) stated that the dynamic use of data and real-time have made healthcare more effective. However, he argued that rapid, implementable information gathered from patient monitoring and data feeds could dramatically improve how healthcare organizations handle emergencies and enhance their workflow. From his research, Coiera pointed out the transition from looking backwards at past data to working with current information in real-time.

2.3. Gaps in literature

Critical gaps still persist in scholarly research despite the existing level of interest in BI concerning optimising the healthcare workforce. Such a notable point is the paucity of empirical evidence explaining the ways in which BI applications were used to manage sectors such as healthcare scheduling, staffing decisions and productivity assessment. Most current research is conceptual or surrounding clinical use cases and workforce management has been rarely investigated. One of the most significant problems is that, up to the present, no standardized BI frameworks exist for healthcare human resources. Although there are standard BI models, they commonly do not properly reflect healthcare organisations' peculiarities and regulatory environments. Without a single standard being used across the world, institutions are often left in confusion as a result of irregular practices with regard to collection of data, analysis and response. Furthermore, it has been observed that the integration of HR management systems with BI software is insufficient. HRMS platforms, payroll systems and operational tools are used in healthcare entities' segment data, which makes a holistic analysis challenging. It is then hard to evaluate workforce performance accurately and develop appropriate long-term strategies without the ability to merge HR data with clinical and financial data.

2.4. Theoretical frameworks

Two theoretical frameworks in order to reduce these gaps and guide our study: << business intelligence maturity model and the workforce optimization framework. The Business Intelligence Maturity Model is a reference tool for benchmarking and strengthening the capability of an organization to analyse information well. The model depicts the evolution from simple reporting to more advanced diagnostics and predictive and prescriptive analytics. With this model organizations can measure their current state and create an exact roadmap for implementation and moving into BI. On the contrary, the Workforce Optimization Framework offers a concise framework for organising workforce hats to facilitate achieving organisational goals. It is comprehensive enough to include such critical areas as the demand for forecast, skills matching and performance appraisal.

3. Methodology

3.1. Research design

This research uses a mix of methods, which combines quantitative and qualitative approaches, to develop a comprehensive understanding of how Business Intelligence (BI) will support healthcare workforce optimization¹¹⁻¹⁴. By employing the joint use of these methods, the research's goal is to uncover both the measurable results of the BI tools and the environmental and personal factors that influence their adoption and use.

- **Quantitative component:** The quantitative aspect of this research includes the study of quantifiable data related to staff use, the arrangement of shifts and movement of patient flow. Historical records will be compiled from hospital information systems, which contain information about hours worked, the ratio of staff to patients, absenteeism rates and shift patterns. Demand patterns will be identified Based on analysis of patient inflow statistics, i.e., admission rates and peak service times. With the application of BI tools, the data will be analysed to show inefficiencies, constraints and areas of improvement. By supporting statistical analysis and showing data through dashboards, we can understand links between workforce deployment and performance metrics; that is, we can improve evidence-based advice.
- **Qualitative component:** The interviews with the HR managers, department managers and IT personnel involved with the BI implementation will complement the quantitative results and will be semi-structured. By doing so, we will explore the organization's perception, challenges and overall receptivity towards using BI in dealing with the workforce. Questions will address such issues as ease of accessing data, how IT systems interact, decision-makers processes and user attitudes towards the capabilities of BI. These non-numerical views shed light on the mechanics of organizations, resistance to change implementation and practical obstacles faced by the staff not commonly available in statistical outcomes. With the help of such a thematic analysis, we will focus on the most prominent patterns and effective practices, adding up to the context of numeric findings interpretation.

3.2. Data collection

Three mid-sized urban hospitals provided the empirical data for the current study, which was collected between 2017 and early 2019. The choice to adopt these institutions was based on little use of BI solutions and the potential of storing structured digital information. The multi-hospital approach enables the findings to be more widely used and shows differences in BI utilization and workforce management strategies at various institutions. In essence, data was obtained from three basic data systems, namely, Data was retrieved from Electronic Health Records (EHRs) as well as Human Resource Management Systems (HRMS) and Business Intelligence (BI) dashboards. Information about patient inflow from EHR logs was obtained regarding the times of admission, discharge and triage levels and departmental transfers. Summarized data enabled the examination of demand patterns, the when and how the peak workloads occurred and the zones where care processes got congested. Other HRMS records tracked staffing establishments, shift patterns, employee responsibilities, leave use and absences

under workforce management tracking. This enabled accurate assessment of staff annexation, staff utilization efficiency and satisfaction of the patient needs by staff availability. From the basic operational system data, the research used BI software, including Microsoft Power BI and Tableau, which hospitals use to visualize and monitor Critical Performance Indicators (KPIs). The dashboards synthesized huge amounts of information into relevant insights and data and could be used by HR and administrative representatives to observe trends over a period. Usage of the dashboards enabled the study to explore how institutions responded to their data, which added helpful background on the role of BI in determining operational choices. Data security requirements and institutional review board approvals were secured early before accessing the data to maintain ethics and confidentiality standards.

BI Implementation Process

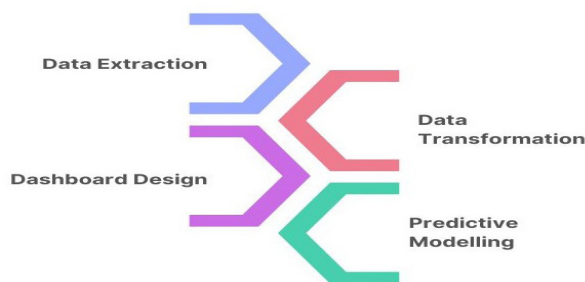


Figure 2: BI Implementation Process.

3.3. BI implementation process

- **Step 1: Data extraction:** The first stage in implementing BI is gathering crucial information across various operation systems, including HRMS, EHR and scheduling tools. The HRMS provides information regarding staffing patterns, shifts given, leaves taken by employees and performance indicators¹⁵⁻¹⁸. The General Electronic Health Record system gives information about arrivals of patients, timings of care and the department staffing requirements. The scheduling system tracks all details of the shifts, including assignments, on-call duties and any overtime taken. After extraction, the data are stored in a central data warehouse for cleansing and other steps in processing. Extracting data from the operational systems affirms that the BI model garners complete, timely and credible data for operational workforce optimizations.
- **Step 2: Data transformation:** When the data is obtained, it must be passed on to the ETL process. During transformation, cleaned, standardized and formatted data is obtained from several systems to ensure consistent increments. An example is that HRMS staffing data should be aligned with scheduling plans; conversely, EHRs must be consistent with the timestamps representing patient visits. Data laundering takes place here to fix problems like incomplete statistics, recurring data points or conflicting facts. Aggregation methods are invoked to retrieve aggregated patient visits, staff hours and department performance indicators. Through this process, the data becomes in a format that enables it to support meaningful analytics and use in BI platforms.
- **Step 3: Dashboard design:** After the data is characterised, the process involves the establishment of interactive dashboards that empower individuals in healthcare administration to trace significant life metrics in real-time.

Key performance indicators include the staff-to-patient ratio, average shift time and absenteeism levels, which are prominently displayed and demonstrate labour efficiency and parity with expected patient demand. Tracking the staff-to-patient ratio can help healthcare administrators judge staffing adequacy according to customer needs at different times; assessing the average shift length will shed light on possible disparities in workload. It is important to monitor the absenteeism rate as it shows how the absence of the workforce undermines service delivery. By providing an intuitive dashboard, such tools empower administrators and HR managers to quickly identify staffing issues and adapt to their methods.

- **Step 4: Predictive modelling:** In this last stage of implementation in BI, predictive models are used to estimate staffing needs for the future using past trends. Using linear regression, the system can determine the relationship between staffing changes and variations in patient traffic and hence is in a position to derive the needed insights on possible staffing changes due to changes in the volumes of patients. Furthermore, using time-series forecasting methods, examples of the next shifts in patient demand are anticipated so HR managers can adjust the staffing arrangements beforehand. With the help of these predictive models, hospitals can make better arrangements for their staffing schedules, ensuring the right staffing at the right time and positively increasing operational efficiency and patient care.

Tools and Platforms



Figure 3: Tools and Platforms.

3.4. Tools and platforms

- **Microsoft power BI:** This research employs Microsoft Power BI, an effective Business Intelligence (BI) tool, for developing interactive dashboards and providing data in meaningful visual ways. Through Power BI, it is possible to easily integrate data across multiple sources without the required connection and present this information in an accessible format. Power BI is capitalised upon primarily by the study to visualize important statistics including staff-to-patient ratios, mean shift lengths and absenteeism rates. With the ability to drag and drop, HR staff and administrators may quickly resolve dashboards and find useful aspects of complex datasets. With the high potential for the latest data, Power BI assists hospital administrators in making real-time decisions. Due to its compatibility with Microsoft products, including Excel and Azure, Power BI is an important tool to empower healthcare data analysts to use the results effectively, analyzing and conveying information seamlessly.
- **SQL server for data warehousing:** SQL Server, as a backend data warehousing solution, delivers a high volume of data obtained from HRMS, EHR and scheduling applications.

SQL Server enables the effective storage and retrieval of data and managing the data efficiently, ensuring that there is a solid infrastructure in support of conducting transactional and analytical work. Using its relational database model, SQL Server allows easy integration and cleansing of data and structured information collected from various systems, facilitating ease of querying and reporting. Respond The execution of the SQL server provides the research team with the possibility of protecting data, facilitating the process of data analysis and establishing a meaningful data structure for strategic business intelligence activities.

- **Python for modelling:** This study uses Python to develop the predicted models: linear regression and time-series forecasting. However, with libraries such as Pandas, NumPy, Scikit-learn and Stats models, Python places modern data work, statistical exploration and predictive modelling at the disposal of researchers. The research uses Python to process historical data, develop regression models that explore the staff and patient inflow relation and apply time-series forecasting to estimate future staffing through trending of past activity. The flexibility of Python facilitates advanced modelling techniques, whereas its compatibility with tools like SQL Server and Power BI facilitates an easy transfer of processes from extraction to analytical processes. The free nature of Python's open-source framework and its prominent community attribution have made it an efficient and cost-effective choice of developing data models in healthcare Bing research.

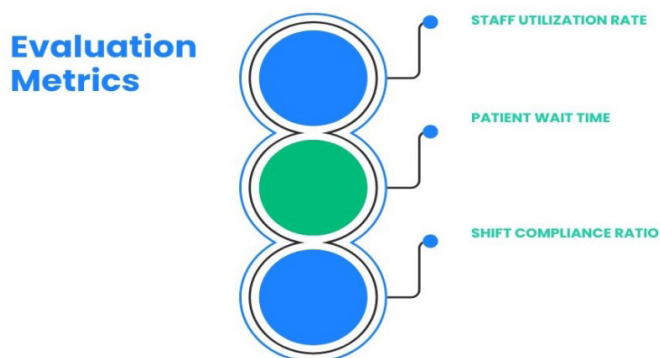


Figure 4: Evaluation Metrics.

3.5. Evaluation metrics

- **Staff utilization rate:** The Staff Utilization Rate is an important measure that identifies how well the staff of a hospital are allocated and worked on. This indicator reflects how much staff members are involved in meeting patient demands when tracking actual hours worked over total staffing hours. A high staff utilization rate is an optimally used resource and an inverse is a low one, which may indicate underutilization and expose staffing arrangement problems or scheduling practices. With regular monitoring of staff utilization, healthcare leaders can regulate staffing to accommodate the patient's needs, thus improving the effectiveness and morale of the staff.
- **Patient wait time:** A Key Performance Indicator (KPI) tracking the Patient Wait Time measures how long patients need to wait for medical services, such as consultations, procedures or admission. Since patients are adversely affected by waiting time length and healthcare performance, it is an essential measure of healthcare delivery. The research

indicates that staff readiness and workload arrangement influence patients' waiting time. Analysis of this metric allows healthcare organizations to identify weaknesses in staff scheduling, coordinating patients' movements and allocating resources. Reduced waiting time by patients, facilitated by better workforce planning and accomplished through BI tools, has a positive effect on operational efficiency in healthcare, better patient experience and care outcomes as a result.

- **Shift compliance ratio:** The Shift Compliance Ratio determines how actual shifts align with the desired staffing plans. The proportion of completed scheduled shifts (on time) to the assigned shifts is measured through this index. The high shift compliance ratio is a frequently recorded figure in relation to the adherence to staff schedules, thus contributing to minimizing disruptions and ensuring being covered in critical situations. On the other hand, a low compliance rate may be symptomatic of issues like the staff not working the scheduled shifts, sudden change of the last-minute schedule or faulty staff allocation. This metric's monitoring through these hospitals enables them to recognize the trends of workforce non-compliance and then adjust their scheduling practices to increase consistency and stress reduction for the staff and patients.

4. Results and Discussion

4.1. Quantitative results

When BI technology was introduced, three mid-sized hospitals demonstrated noticeable results in their core operational KPIs. To measure BI implementation's success, the BI's three key performance rates (Staff Utilization, Patient Wait Time and Shift Compliance) were carefully documented pre and post-deployment. Each key metric has the following detailed overview (Table 1):

Table 1: Quantitative Results.

Metric	Pre-BI	Post-BI	Improvement
Avg. Staff Utilization	65%	81%	24.6%
Patient Wait Time	45 %	30 %	33%
Shift Compliance	70%	85%	21.4%

Figure 5: Graph representing Quantitative Results.

- **Avg. staff utilization (24.6% Improvement):** Staff utilization was a great gain recorded after the BI implementation, rising from 65% to 81%, a 24.6% increase. This figure also assesses the suitability of staff distribution to meet the needs of patients and operations. Without BI,

schedules and resource allocation were ineffective, often having resources idle or strained beyond capacity. Using BI solutions, such as predictive analytics and live monitoring dashboards, enabled hospitals to better optimize shift allocation and align staffing decisions with patient needs. The increased staff utilisation suggests that the resources were being employed much more efficiently, increasing efficiency amongst the workforce and better service delivery.

- **Patient wait time (33% Improvement):** There was a significant 33% improvement in patient wait times, where wait time was reduced from 45 minutes to 30 minutes on average. Efficiency and quality of hospital service lie greatly in managing patient wait times. Long waiting periods of patients correlate with lower satisfaction levels and reduced health effects. The poor staff match with patient needs intensified by poor staffing resulted in significant waiting times for patient treatment before implementing BI. BI used real-time data and predictive analytics to support more exact demand forecasting, leading to better hospital staffing and process utilisation. Brief wait times show how BI has improved operational efficiency and patient care quality.
- **Shift compliance (21.4% Improvement):** Shift compliance improved significantly, raising the shift compliance ratio from 70% to 85% (21.4%). The level of shift compliance refers to the homogeneity between the available staff and scheduled shifts, which must be maintained for the smooth operation of the hospital. Hospitals before deployment of BI tools tended to flounder when faced with sudden changes to the workload, frequent absences and unfilled shifts. The outcome was that staffing levels were unpredictable, undermining patient care continuity. With BI technology, hospitals could track shift schedules in real-time, track absenteeism and time-adjust staff accordingly. Greater shift compliance shows that employees were more punctual in their shifts. Therefore, there was less of a gap in time as far as coverage goes and continuity of care was enhanced.

4.2. Dashboard snapshots

The use of Power BI dashboards by the hospitals endowed the staff with an understandable visual dashboard for instant tracking and monitoring vital staffing indicators. Three key components of the dashboards were critical to improving the abilities to make decisions and the effectiveness of operations.

- **Staff-to-patient ratio across different departments:** The dashboards were characterised by presenting the staff-to-patient ratio for various hospital departments, such as emergency care, outpatient facilities and intensive care units. Hospital administrators and HR managers could easily determine whether staffing was sufficient to contain the patient volume on an individual department basis. Let us take the emergency room, for instance; if a patient-to-staff ratio was significantly higher than the guideline, the managers could easily see the need for an additional crew when they checked the situation. With the ability to access the ratios in real time, hospital administrators could ensure that staffing reflected the current patient requirement, thereby curbing staff fatigue and maximizing patient outcomes.
- **Current staffing levels vs. Required staffing based on patient inflow:** One of the most important points

of the dashboard was the presentation (in real-time) of comparisons of actual referring and necessary staffing based on the forecasts of how many patients will enter based on timeframes. The dashboard utilized data from both the EHR system and HRMS to visually represent the variance of actual staff relative to the most appropriate amount of staff needed for any given load of patients at any given time. These instant responses enabled administrators to promptly address gaps in coverage, thereby averting interruptions that may occur in patients' care, especially during high peaks.

- **Absenteeism tracking and unfilled shifts:** Furthermore, dashboards provided a dynamic view of absenteeism as vacancies were indicated due to employee absences. It was easy to see unfilled shifts. Thus, it was possible for the HR managers to immediately fill in gaps by contacting available resources or shifting shifts as required. By highlighting unfilled shifts, the system enabled hospitals to ensure service excellence was not compromised by allowing too many vacancies, which may threaten the well-being of staff and the outcome of patient care.

4.3. Discussion

Along with supporting workforce management and patient care, utilizing BI tools has improved the operational efficiency of hospitals. Meaningful real-time visibility became one of the major gain points from installing Business Intelligence solutions. Hospital managers had instant insights into staffing gaps and department surpluses through real-time data visualization on the BI dashboards. Real-time monitoring enabled managers to identify staffing gaps early and provide appropriate coverage for departments in busy periods. Areas like the emergency department and intensive care units that had to be monitored all the time neither became overworked nor staffed with the shortage. By real-time monitoring the staffing in relation to the patient's needs, managers could redistribute resources flexibly, bringing about operational efficiency and improvements in patient outcomes. One of the major benefits was the option to take the initiative to change the staffing arrangements. Staffing units allowed managers to observe staffing situations closely in real-time and immediately reallocate resources whenever deficit situations occurred. This feature was very useful in case of sudden patient peaks or widespread staff shortages. With prompt responses, hospitals can avoid possible bottlenecks while taking emergency care of their patients in a timely manner and conserving their staffing resources. By making pre-emptive staffing decisions, hospitals could provide care in a timely fashion, manage balanced workloads and decrease the risk of burnout, thus increasing staff satisfaction. Further, predictive analytics usage in operations drastically changed workforce optimization. Utilizing high levels of advanced forecasting methodologies, the hospitals were able to proactively respond to high demand times; they were thus able to decrease overstaffing by 18%. Predictive analytics helped hospitals avoid unnecessary labor bills by adjusting staff shifts to meet patient demand. Consequently, the workflow became more efficient and significant cost savings were achieved to facilitate their efficient use and continuity of high-quality patient care. The use of BI solutions simplified staffing, offered greater adaptability in operations and reduced costs, significantly improving the hospitals' performance and providing better quality patient care.

4.4. Limitations

Although several limitations were encountered during the study, the implementation of Business Intelligence (BI) tools resulted in many improvements in the current operational efficiency and management of the workforce.

- **Data silos:** This existed data silos between HRMS (Human Resource Management System) and EHR (Electronic Health Records) systems were one of the main challenges that occurred during the BI implementation. HRMS stored critical information regarding staff usage, shift plans and absenteeism, while the EHR monitored inflows of patients, diagnoses and treatment requirements. However, the systems were not always integrated, which made it problematic to line up data between departments. Consequently, hospital managers were forced to use manual practices to combine staffing and patient data. This process slowed down the decision-making process and sometimes stalled acting upon real-time staff requirements. Such a disconnect between systems hampered the potential for the BI tools since no inbuilt data integration could ensure the capability to serve critical staffing adjustments in the most accurate and time-efficient way possible.
- **Resistance to new technology:** The other magnitude of limitation was its staff resistance to new technology. A significant number of healthcare workers who had minimum exposure to sophisticated BI systems of the kind offered still had reservations about employing the new tools. For example, some staff were initially sceptical about the accuracy of the predictive analytics or were just uncomfortable making real-time decisions using BI dashboards. This negligence in adapting to the new technology became a stumbling block against its maximum use. In order to get out of this challenge, the hospitals were forced to spend heavily on intensively developed training and support programs. These efforts facilitated the staff's understanding of the new tools and the reasoning for which and advantages they pose in enhancing operational efficiency and patient care.

5. Conclusion

This work shows that applying Business Intelligence (BI) tools in healthcare environments can substantially improve workforce optimization. By bringing together information from different systems (i.e. Human Resource Management System (HRMS), Electronic Health Record (EHR)) and by supplying real-time insights, BI empowers healthcare managers to make actionable decisions underpinned by data, which is critical for continuously improving healthcare environments. According to the findings, the BI tools enhanced critical metrics in operation areas such as staff utilisation, patient wait times and shift compliance, ensuring efficient hospital operations and better patient care. Simultaneous monitoring of staffing levels and patient flow became possible with real-time dashboards; therefore, departments would always be suitably staffed. Moreover, predictive analytics was used to predict patient demand and optimize staff scheduling by minimising overstaffing, that is, cost savings. The outcomes support the potential of BI in realigning hospital workforce management, with a structure for optimising resources and enhanced patient care obligations.

5.1. Contributions

This work makes several major contributions to healthcare management and integration of technology. First, it is a structured BI implementation approach customised for healthcare settings. By detailing critical steps in the data extraction, transformation and dashboard design, as well as predictive modelling usage proposed in this research, other healthcare organizations can follow an actionable guide for implementing BI systems. In addition, this research works out the gains made in efficiency and satisfaction that arose from BI implementation. By demonstrating measurable results-better staff utilization and shorter wait times for patients- the research highlights the practical advantages BI can provide to running hospitals. In addition, the increased workforce management efficiency and predictive ability generated better workforce management results and

5.2. Future work

In the future, there are a number of exciting possibilities for the capabilities of the BI system to grow. One of the promising lines of work is the integration of the Artificial Intelligence (AI) in the BI framework. AI can be utilized in automated scheduling processes, which will use machine learning algorithms that calculate the staff needs with precision based on factors such as patient acuity, seasonality and performance of workers. That would remove a large part of manual intervention in scheduling and provide optimal staffing safely from human error or bias. Additionally, increasing the breadth of BI tools to encompass outpatient and home care services would help spread the advantages of workforce optimization out of hospitals. With more defrayal of healthcare, the capacity to track and control staffing in outpatient clinics or home care contexts will be important. Incorporation of BI throughout these diverse care environments may result in a more unified, lean healthcare system that delivers greater continuity in care while minimising operational inefficiencies.

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