SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 206

USE OF BUSINESS INTELLIGENCE TOOLS MANAGEMENT IN THE EXAMPLE OF IN THE HEALTHCARE SECTOR

Marcin CHABIOR[1], Anna BLUSZCZ[2*]

[1] Silesian University of Technology, Doctors' School; marcin.chabior@polsl.pl,
ORCID: 0000-0001-5289-055X
[2] Department of Safety Engineering, Silesian University of Technology, anna.bluszcz@polsl.pl,
ORCID: 0000-0001-9724-5706
* Correspondence author

Purpose: The aim of this article is a presentation of a case study describing the stages of Business Intelligence (BI) system implementation in healthcare organisations and the reasons for this implementation. The implementation practices used are described and the benefits of the project are demonstrated.
Design/methodology/approach: The article presents the process of designing a BI system, which took place in subsequent stages such as: defining business goals, identifying data sources and developing a data flow structure diagram, defining functional needs and the form of presentation of management data.
Findings: The implementation of the BI environment in a healthcare facility brings the following benefits: Support for decision-making processes in the hospital management area, ensuring monitoring and analysis of the use of hospital resources, identifying the causes affecting the service time, risk management and data management.
Practical implications: The paper presents the process of implementing a BI system in healthcare facilities, indicates the validation and testing process, and demonstrates numerous advantages of implementing a BI system.
Originality/value: The study is a valuable material that can be used by both theoreticians and practitioners. The presented procedures can be successfully used in other industries to build BI systems.
Keywords: Business Intelligence, BI, Decision Support Systems, Healthcare, Data Driven Management, Big Data, IT tools.
Category of the paper: research paper**.**

1. Introduction

Healthcare is currently one of the fastest growing sectors of the economy (Gupta et al., 2024). It integrates the results of scientific advances from many fields and combines them with the latest advances in technology and information technology. Healthcare leaders need tools and solutions to help them improve their business processes, especially in terms of decision-making in the administrative management of units, while optimising activities that improve patient care. Hence the trend for hospital executives to turn to Business Intelligence (BI) solutions (Basile et al., 2024) to extract information from data sets and deliver it to their audiences in a specific decision-making context. In today's fast-paced healthcare environment, healthcare executives must cope with the increasing demand for administrative and clinical data to achieve management goals in the shortest possible time. In many cases, the use of BI can provide a viable solution to this problem.

The principal objective of this article is to present the process of designing a business intelligence (BI) system, with the aim of facilitating effective decision-making in healthcare institutions. The primary research methods employed in the article include a literature analysis, expert interviews, and a case study. A review of the literature revealed a substantial corpus of publications on the functionality and implementation of systems across a range of industries. As evidenced by Polish literature, examples of BI implementation in medical care and managerial dashboards in e-patients are also worthy of mention. A notable research gap has been identified in the domain of business intelligence (BI) application examples in healthcare, which this publication seeks to address. Expert interviews are an invaluable tool in the design of business intelligence (BI) systems in healthcare. Firstly, experts provide specialist knowledge of clinical processes, which allows for a more tailored adaptation of the system to the actual needs of users. Secondly, interviews can identify key performance indicators that the BI system should monitor, which is crucial for improving the quality of care and optimising costs. Thirdly, interviews also help to understand legal and regulatory requirements, which is necessary to ensure compliance of the BI system with regulations. Finally, the last method was the case study presented, which demonstrated the implementation of BI in a healthcare organisation.

The article identifies a research gap in the lack of standardisation and integration of Health Information Systems (HIS) with Business Intelligence tools for effective reporting both at management level and in support of emergency response. In particular, the period of the SARS-CoV-2 pandemic is highlighted, which revealed numerous problems with the development and sharing of reports, both in terms of their accuracy and their correspondence to the actual situation at a given time. The research question was therefore posed: what are the key challenges and benefits of implementing integrated Business Intelligence (BI) systems in healthcare organisations, with a particular focus on reporting needs?

Thus, the primary objective of the article is to analyse the process of implementing a Business Intelligence system in healthcare entities, focusing on the stages of implementation, the practices used, the tools used and the benefits of implementing such solutions. The article shows how BI systems can support decision making, performance monitoring and resource management in healthcare organisations. It also describes the specific challenges encountered in implementing BI systems.

The article attempts to justify three implicit assumptions:

1. business intelligence (BI) systems can significantly improve decision making in healthcare organisations,
2. standardisation of reporting and integration of data from multiple sources are key to operational efficiency in hospitals,
3. the implementation of BI in healthcare will improve the quality of real-time reporting and help manage crisis events.

This article uses a case study approach to describe the process of implementing a Business Intelligence (BI) system in two healthcare organisations: Prof. L. Giec Upper Silesian Medical Centre in Katowice-Ochojec and Prof. K. Gibiński University Clinical Centre in Katowice-Ligota.

2. Literature review

Business Intelligence (BI) solutions are an environment of interconnected digital components that include tools, technologies and processes that collect, process, analyse and present data to support an organisation's business decisions (Singu, 2021). BI solutions are an effective way of transforming raw data sets into valuable information that can then be used to improve an organisation's operational efficiency, identify new business opportunities or enhance its competitiveness. Business Intelligence (BI) is a key aspect of modern organisations, enabling them to make informed decisions by transforming raw data into meaningful and useful information. The model BI environment that operates within an organisation comprises a set of tools, technologies, processes and practices that are designed and interrelated to collect, integrate, analyse and present business data (Davenport, 2012, pp. 1-12). This environment is an integral part of the decision-making process and enhances the organisation's ability to operate efficiently and effectively in the environment. At the core of any business intelligence environment is data. Almost all organisations generate and interact with significant amounts of data, from customer transactions, supply chain logistics and process handling to employee performance and management reporting (Aws et al., 2021, pp. 155-170). The main objective of a BI environment is to use this data to provide access to the kind of information that leads to effective and timely business decisions. This is achieved through components such as data

sources, data warehouses and stores, data integrations, analytical tools and reporting mechanisms. Data sources can include internal systems such as enterprise resource planning (ERP), customer relationship management (CRM), industry systems such as a health information system (HIS), and external data sources such as market reports, social media channels, government databases and other public data. Data from these sources is often disparate and in different formats. The challenge for the BI environment is to effectively integrate these different types of data into a single format that can be analysed. These integration activities are managed by extract, transform and load (ETL) processes (Wendy et al., 2022, pp. 34-41). ETL is therefore a key component of the BI environment, responsible for taking data from different sources, transforming it into a standardised format and loading it into a central repository, often referred to as a data warehouse (Palpanas, 2000, pp. 88-100). The transformation phase ensures that the data is cleaned, validated and organised so that it is ready for further use in the analysis process. This activity can include data aggregation, deduplication, error correction and standards implementation. Effective ETL processes are essential to maintain the accuracy and reliability of the data needed to extract the desired information.

A concept closely related to business intelligence is the data warehouse, which acts as a central repository to store integrated data and whose architecture supports data analysis and reporting processes. Unlike operational databases, which are optimised for transaction processing, data warehouses have a structure that focuses on building complex queries and analyses. At the same time, data warehouses provide a stable environment in which to store historical data that can be used to identify trends, patterns and anomalies over time. In addition to data warehouses, modern BI environments also have data stores, which are storage repositories that can hold significant amounts of raw, unstructured or semi-structured data (Maaitah, 2023). These are designed to hold data in its native format until it is required for use in the analysis process. This flexibility allows organisations to store all of their data while ensuring that it can be processed on an ad hoc basis when required. The data collected in a BI environment also requires the use of analytical tools to extract knowledge and information. These tools allow users to explore data, run queries and perform any type of analysis required. Analytical tools can range from simple reporting tools to more advanced applications used in data mining or machine learning processes. They enable the creation of dashboards, advanced visualisations of data summaries and reports that summarise and support management decisions. Visualisations such as different types of charts, graphs and heat maps make it easier to interpret large data sets, identify trends and understand complex relationships in data. Business Intelligence environments typically have sophisticated reporting mechanisms that provide insight into various aspects of the business, such as financial performance, operational efficiency, customer satisfaction or organisational development trends. BI reports can be customised to meet the specific needs of the organisation's various stakeholders. The ability to share reports, publish them directly online using BI functionality, and their native

transformation to mobile devices makes them a highly effective tool with high dissemination efficiency within the organisation, which translates into both speed of decision making and a positive impact on wider communication. The role of BI in decision making cannot be overstated. By providing timely, accurate and relevant information, a BI environment enables decision-makers to make objective, data-driven decisions. This can lead to better strategic planning, optimised business processes and increased competitive advantage (Niu et al., 2021). Through BI analysis, it is possible to identify future opportunities and threats, better understand customer needs, streamline internal processes, optimise costs and a number of other beneficial aspects to support organisational growth planning. Although the concept of BI is not new, it is sometimes defined in different ways due to the complexity of the processes involved, as can be seen in the literature (Vugec et al., 2020). In the context of this study, BI is understood as a management tool that includes a set of applications, technical solutions and processes that are designed to monitor events and support management decisions. BI systems support the organisation at the decision-making level through the collection, analysis and reporting of internal and external data. The level of BI implementation in an organisation can be determined by considering its maturity and experience in extracting knowledge from data. Similarly, maturity represents 'the capabilities of an organisation with respect to a particular object class and application domain' (Röglinger, 2012, pp. 328-346). Depending on the source, 4-6 maturity levels are defined and the assessment includes some key dimensions (e.g. IT, data integration and information quality, quality of results). Maturity models are intended to help practitioners successfully implement BI initiatives in organisations and provide a benchmark for the organisation to aim for (Vugec et al., 2020). With regard to the logical use of so-called Big Data (large data sets), it is worth noting that in the case of traditional Business Intelligence solutions, data coming from different IT systems, such as the Enterprise Resource Planning (ERP) system, relationship management systems, supply chain management, etc., go through an ETL process (Extraction, Transformation, Load), are then transferred to the data warehouse and, in the final stage, various analyses are performed on them. An important element included in the Big Data architecture is the data processing cycle, which, according to K. Krishnan, "can be defined as the collection, processing and management of data resulting in the generation of information for end users" (Krishnan, 2013). The data collected as part of BI is structured and discrete in nature. BI-based activities also include the continuous improvement of the organisation's decision making. Therefore, BI environments and the processes that take place within them can be seen as adaptive activities - any inference made based on BI tools can and should be verified over time. Lessons learned from the analyses performed should be incorporated into the inference algorithms, which in turn will lead to their ever-increasing effectiveness. Therefore, when designing a BI environment in an organisation, an assessment should be made of the potential use of its components in the future or in a wider context. It is therefore important to ensure that they are both efficient for the present and scalable for future operations.

A review of the literature revealed a comprehensive database of publications on the functionality and implementation of systems across a range of industries. The Polish literature provides several examples of business intelligence (BI) implementation in medical care, including a case study of BI implementation in a medical care facility (Głód, 2014). Additionally, it presents examples of the use of managerial dashboards in the context of e-patients (Sołtysik-Piorunkiewicz, 2015). It has been demonstrated that there is a significant research gap in the area of examples of BI use in healthcare units, which this publication seeks to address.

3. Research methodology

The principal objective of this article is to present the process of designing a business intelligence (BI) system, with the aim of facilitating effective decision-making in healthcare institutions. The primary research methods employed in the article include a literature analysis, expert interviews, and a case study. The case study was conducted in accordance with the following stages, as illustrated in Figure 1 (Elbanna, 2006, pp. 1-20):

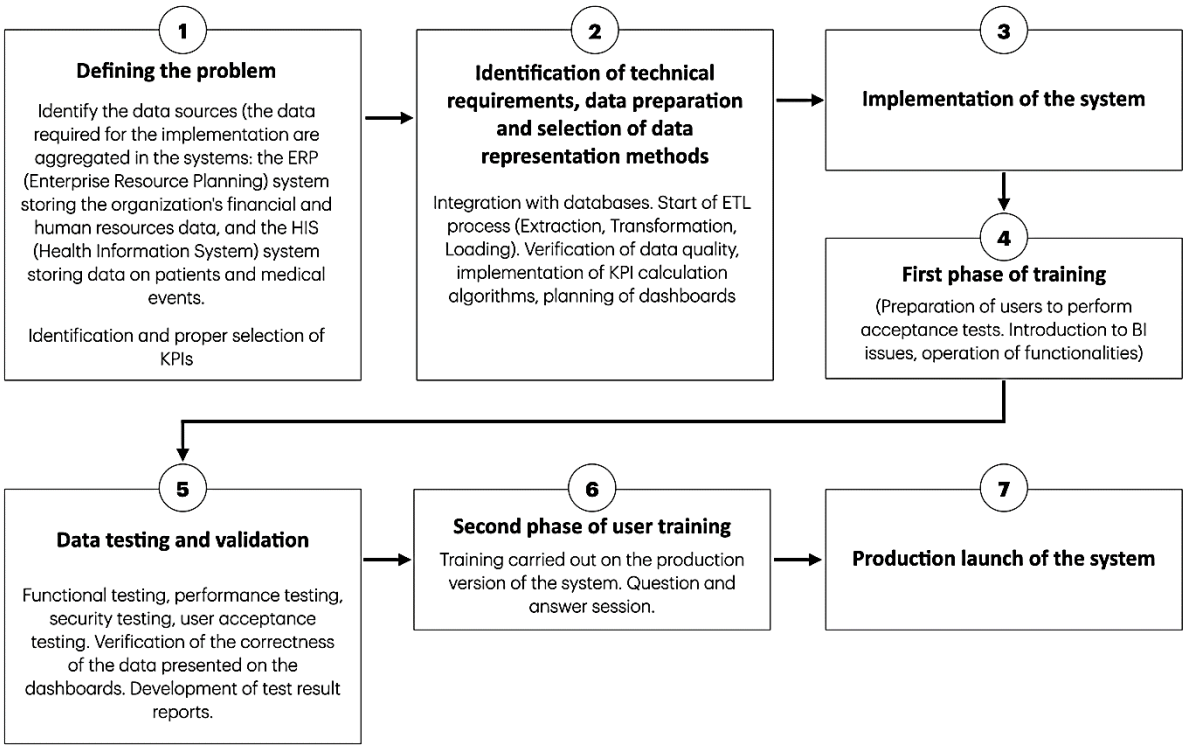

Figure 1. Case study stages.

Source: own study.

In following this process, it is important to ensure that a sufficient number of alternatives are considered, that the consequences of using these alternatives are reasonably foreseeable, and that comparisons are made correctly.

The aforementioned stages are inherently complex, particularly in the context of the contemporary business environment. A number of factors interact with multithreaded processes, making decision-making more challenging (Svenson, 1979, pp. 86-112), particularly in healthcare units. The principal challenges in this domain can be broadly categorised as follows:

1. *Many alternatives to choose from.* What appears to be a desirable state of affairs, and what information systems provide, is the large number of possible solutions to a given problem. Supported by artificial intelligence tools, predictive analytics tools can provide such a large pool of possible solutions that choosing the right one becomes extremely difficult. Since the rejected alternatives are a kind of proof of the possibility of following another path, the managerial decision becomes a burden for the person or persons who are obliged to identify only one. Although this is a purely psychological factor at the decision-making stage, it can have legal consequences in the longer term.
1. *Regulations.* The plethora of internal and external rules and regulations is not an ally when it comes to making decisions that must be made in full compliance with them. As a result, the decisions taken require a great deal of consultation, which is particularly difficult for managers when urgent action is required.
2. *Competition and changing public demands.* These factors are measurable and predictable in the short term, but at the same time highly sensitive to events of an unpredictable nature (political decisions, ideological influences, undesirable internal events affecting the image, etc.).
3. *The need to make decisions quickly and effectively.* Management effectiveness is defined in terms of both the accuracy of decisions and the time it takes to make them. It is difficult for an organisation to be effective in today's marketplace if it learns by trial and error, which used to be the norm.

The above factors mean that managersin particular in healthcare units need to be more sophisticated - they need to have access to new tools and techniques specific to their field. Evolving information systems have moved from traditional accounting into much more complex areas of management. Their potential is now being exploited from the design stages, through process monitoring, to the use of analytical methods to evaluate proposed predictive actions.

It can therefore be concluded that the development of information technology has clearly contributed to facilitating the development of decision support methods and analytics, and has also created a kind of ecosystem of interconnected components that can be broadly defined as Business Intelligence (BI) solutions. Logically, BI solutions consist of:

1. *Data*. In the context of BI, data is the raw form of as yet undefined information and is primarily transactional or operational records or stored values from which information and insights (new knowledge) can be extracted after processing (Morgan, 2006). Data used in BI environments can be a collection of numbers, text, images, audio, video, etc. Data can be stored in any form, size and location. Granular data is generated whenever an event or transaction occurs. The data used for analysis can be aggregated from a variety of sources, both the organisation's internal systems (ERP, HR, etc.) and external resources such as the Internet, technical devices, social media, etc. Put simply, anything that can be used to derive meaningful business intelligence can be included in the definition of data, regardless of where and how it is generated, whether it is structured or unstructured - it can always be an input to the BI process.
2. *Processes.* This term should be understood very broadly, often as a collection of many sub-processes, and therefore summarised as all the techniques, business strategies, tools, methodologies and activities of an organisation's personnel aimed at achieving a specific goal.
3. *Information.* Data, which is the base layer, becomes information when it is structured and given context and meaning. This meaning-making is done through metadata, which is an explanation and description of how the data should be used and what it should be used for.
4. *Knowledge*. In this case, it is defined as the logical outcome of data mining and analysis to enable decision making. By analysing a particular set of data, it is possible to identify specific trends or patterns, look for correlations and gain an understanding of the bigger picture, which in turn is translated into conclusions and decisions.
5. *Business.* This term in the definition of BI is not limited to commercial enterprises. It is used in a general sense to refer to any organisation that uses BI to improve its operations.
6. *Intelligence*. In the context of BI, this is knowledge about an object or situation. The PWN dictionary defines intelligence as 'the ability to understand, learn and apply one's knowledge and skills to new situations' (https://sjp.pwn.pl/sjp/inteligencja). Therefore, based on the above, it can be concluded that BI provides the ability to understand events based on the data collected in the organisation and to use the knowledge gained to make decisions.

From the above it can be concluded that BI is a concept that does not impose specific technologies, tools, methodologies or management techniques on an organisation. In most cases, BI is also not an off-the-shelf software or tool that can simply be bought, implemented and expected to work automatically. In essence, BI is a philosophy of how to approach data, conclusions and decisions. While BI does not by itself solve an organisation's problems, it certainly helps to identify them by presenting trends, patterns and correlations, by searching for and identifying anomalies and outliers, and by making it easier for the user

(most often the board) to identify problem areas that need attention early on. The fact is, however, that current AI solutions significantly enhance the potential of BI tools by augmenting them with natural language inference, making them far more automated (Eboigbe, et al., 2023, pp. 285-307). However, it is important to emphasise that only a thorough understanding of the issues and expected goals on the part of managers can make BI a tool that effectively improves the efficiency of an organisation's management activities. An inherent element of BI systems is data visualization, which is implemented using dashboards. Dashboards are visually the most recognisable element of Business Intelligence environments. Using a more specific definition of dashboards, we can say that they are dashboards of performance indicators that allow the visualisation of data, phenomena and information using all the visualisation methods and techniques described earlier in this paper (Zheng, 2017, pp. 67-81). Dashboards provide a visual representation of important information, consolidated and arranged on a single screen so that information can be covered at a glance, easily drilled down and explored. A typical dashboard in a hospital BI system contains numerous hospital-specific KPIs (Negash, 2008, pp. 175-193) and events occurring in the HIS (Health Information System) (Abouzahr et al., 2005, pp. 578-583). The information it displays is intended to provide the unit's management with quick access to an accurate set of information about the functioning of the healthcare unit. The dashboard is characterised by three levels of information:

1. Monitoring, i.e. graphical, abstracted data to monitor key performance indicators.
2. Analysis, which is a summary of dimensional data to analyse the root cause of problems.
3. Management, which focuses on detailed operational data that determines what actions need to be taken to address a specific problem.

By using layers, dashboards can contain multiple pieces of information on a single screen. The main challenge in designing a dashboard is to present all the necessary information on one screen, clearly and without distraction, in a way that can be assimilated quickly. To improve the assimilation of information, it is important to place it in context. This can be done by comparing the numbers of interest to other baseline or target values, indicating whether the numbers are good or bad, determining whether the trend is better or worse, and using display components to establish a comparative and evaluative context. Some of the typical comparisons that are made in Business Intelligence systems include comparisons with past values, forecast values, target values, baseline or average values and values of other metrics. Even with comparative measures, it is important to clearly indicate whether a number is good or bad and whether it is trending in the right direction. Typically, bespoke visual objects (e.g. traffic lights) or visual attributes (e.g. colour coding) are used to set the context of the assessment. Colour coding is most often used in conjunction with metrics to determine whether a KPI has exceeded/achieved a certain value. Although performance dashboards and information visualisation dashboards are used differently in different organisations, they all share certain design characteristics. First and foremost, they all fit into larger business analysis and/or performance measurement systems. This means that their underlying architecture is that of

a BI environment or the performance management architecture of a larger system. Secondly, all well-designed dashboards and other information visualisations share the following characteristics:

1. Use visual elements (e.g. charts, performance bars, indicators, gauges, graphical markers, alerts) to highlight at a glance the data and exceptions that require action.
2. Are transparent and legible to the user, requiring minimal training and therefore easy to use.
3. Combine data from different systems into a single, aggregated, unified picture that represents the specific state of an organisation or part of its operations.
4. Allow drill-down to primary data sources or reports, providing more detail for comparative and evaluative context.
5. Present a dynamic view with timely or real-time refreshes of data, enabling the end user to keep abreast of changes in the organisation.

4. Results

The research results were implemented in accordance with four principal stages. The initial stage of the research project was to define the primary issue concerning the reporting of the effects of the activities of the healthcare unit under study.

STAGE 1 – Defining a problem

The design and implementation of a business intelligence (BI) system was conducted in the following healthcare unit. The Medical University of Silesia in Katowice, which is the founding body of the teaching hospitals in the Silesian Voivodeship, has identified two multi-specialty medical units, i.e. the Upper Silesian Medical Centre named after Prof. L. Giec in Katowice-Ochojec and the Prof. K. Gibiński University Clinical Centre in Katowice-Ligota, as hospitals in which Business Intelligence solutions should be implemented, as part of the "eCareMed" project (https://app.ecaremed.pl/) for the centralisation of medical services. Prof. L. Giec in Katowice-Ochojec and Prof. K. Gibiński University Clinical Centre in Katowice-Ligota, as hospitals in which business intelligence solutions will be implemented, aimed at multi-thematic reporting on patient care and financial status. The project will be implemented in the period from 01.01.2022 to 30.06.2023.

The period of the SARS-CoV-2 pandemic became a particular management challenge for many organisations, and particularly for healthcare institutions. Hospitals were those institutions that had to work harder than usual because of the special conditions in which they had to operate and the need to provide medical care to a larger number of patients than usual, while at the same time facing a high risk of losing staff due to sickness absence caused by

infection (Plagg et al., 2021, pp. 3987-3992). In addition to the medical measures taken, hospitals also faced many administrative challenges related to the rapid reconfiguration of wards to meet new needs, the effective management of space and bed availability, and the use of specialised medical equipment. Most importantly, these activities were accompanied by numerous reports to crisis management centres, government agencies or directly to the Ministry of Health. These reports were expected in the shortest possible time to show, for example, the actual status of bed availability, which was not a simple operation and, due to the delay in communication, did not translate into information that reflected the actual situation by the time the report was read. A hospital with a few free beds equipped with ventilators could become a shortage hospital within an hour. Once vaccination had begun, there was a further need to report on the number of people in the medical unit who had been vaccinated. Again, the time lag meant that it was impossible to keep the reports fully up to date. The activities of the hospital administrations, despite their reliance on reporting based on information systems, could not be effective for the following reasons, among others:

1. Lack of experience of administrative staff in creating non-standard reports not defined in the hospital information system
2. High complexity of producing reports for which the required data comes from more than one source
3. Lack of a defined reporting standard on the part of the requesting entity, or an imposed standard that is not implemented in the hospital's information system
4. Excessive complexity of communication (report approval processes, sending and receiving using different communication tools, need for certain people to be available in the communication chain)
5. The need for ad hoc reports when other staff tasks are required, often necessary for the continuity of the work of the healthcare entity.

The experience of the SARS-CoV-2 pandemic clearly demonstrates the need for mechanisms to compensate for the above-mentioned disadvantages, which could be achieved through the implementation of reporting tools that:

1. Allow the downloading of data from hospital systems in real time.
2. Provide a set of data based on a set of data collected in the system.
3. Come with ready-made sets of measures and indicators, the inclusion of which in the report does not require IT or statistical expertise on the part of the reporting staff.
4. Can be made available online as a cloud service.
5. Can be presented clearly on mobile devices.
6. Be able to be aggregated, i.e. provide the recipient with reporting totals from two or more reporting entities.
7. Provide dynamic presentation of data, both retrospective and prospective.
8. Automate the search for deviations or the achievement of pre-defined thresholds.

Management, especially crisis management, requires reliable information to be available as quickly as possible in order to make effective decisions. It is also important to provide different information or a different form of visualisation for specific individuals or organisational units. Similarly, it is important to enable authorised personnel to drill down into the data, i.e. to move dynamically from general information, such as the number of beds available in the hospital, to information on which wards these beds are located and how many patients are currently hospitalised per doctor on the ward. Only with this information can a rational, data-driven decision be made about transferring patients from other hospitals or recruiting additional staff. In this respect, business intelligence solutions are the solution that can meet the expectations for effective reporting. Healthcare organisations are recognising the need for IT solutions that, in addition to collecting medical and administrative data, will become a source of new knowledge to support hospital management processes based on the processing of large amounts of data (Batko et al., 2022). In recent years, healthcare systems have been severely disrupted by excessive and uneven demand for medical services. The SARS-CoV-2 pandemic has caused a number of difficulties that have significantly disrupted healthcare systems in many countries around the world. As a result, the adoption of technology-based solutions to streamline and optimise the operations of healthcare providers has become critical to the healthcare industry as a whole. This has led to increased demand for BI solutions. As a result of the SARS-CoV-2 pandemic, the global healthcare BI market is predicted to reach $8.37 billion by 2028 (Rehman, et al., 2022, pp. 26-35).

The first stage of the research led to the result such as:

- Identification of the following KPI indicators.
- Identification of data sources and development of a data flow diagram,

Business objectives, as defined, are clearly defined, measurable results that an organisation wants to achieve within a given period of time (Fischer et al., 2020). Before defining them, it was assumed that each objective should be SMART, i.e. specific, measurable, achievable, relevant and time-bound (Latham, 2020, pp. 10-20).

1. To reduce by 50% within one year the time taken to obtain reporting information relevant to the organisation through the implementation of KPIs related to financial management and the efficiency of the use of hospital resources in relation to patient care.
2. Provide at least two pre-defined management dashboards within one year for each of the groups entitled to receive reports, enabling real-time monitoring of KPIs.
3. To standardise, within one year, the scope and presentation of the reports from both healthcare entities by the University.
4. Ensure, within one year, the availability of the ability to make reports available online to external entities (such as crisis management centres, ministries, etc.) in case of need.

Step I also included the identification of key KPIs, their critical thresholds and the assignment of rights to user roles, which were also defined as part of this phase. In total, more than 30 such indicators were identified in the process of developing the BI system implementation documentation, including:

1. *Profitability, liquidity, efficiency and debt ratios* at a given point in time and changes in the ratios over time. Indicator determined on the basis of the Regulation of the Ministry of Health of 12 April 2017 on economic and financial indicators necessary for the preparation of the analysis and forecast of the economic and financial situation of independent public health care institutions.
2. *The liabilities* due on a given date and the change of the indicator over time.
3. *Performance* of the contract with the National Health Fund (NFZ) by each contracted product, taking into account the number of services at a given point in time and the change in the indicator over time. Employment in specific groups of health care institutions.
4. *Employment* in each professional group, broken down into persons (numbers only) and full-time equivalents at a given point in time, and their change over time.
5. *The number of in-patients* at a given point in time and the change in this indicator over time.
6. *The number of inpatient beds*, broken down into free and occupied beds, per point in time and the change in the rate over time.
7. *The bed throughput rate* per point in time and the change in the rate over time.
8. *The average length of stay* per patient per target date and the change in the indicator over time.
9. *Number of people waiting for admission* to hospital/outpatient/hospice - by urgent and stable cases per target in time and change in the indicator over time.
10. *Waiting times for inpatient/outpatient/outpatient services* - by urgent and stable case per point in time and change of indicator over time.

The stage of defining business objectives and performance indicators was also required:

1. Appropriate prioritisation of objectives and needs. This was done using the MoSCOW method (Kravchenko et al., 2022, pp. 188-199), which categorises all pre-identified needs into those that are:
   a. *Must be realised*, i.e. understood as necessary for the organisation when implementing a BI solution to support business decisions.
   b. *Should be implemented,* i.e. not critical needs, but their implementation will significantly increase the effectiveness and usefulness of the use of BI tools.
   c. *They could be* implemented as long as their implementation does not become technically and organisationally complex, leading to increased implementation costs and a significant extension of the implementation period.

   d. *They will not be realised now*, but technical and functional solutions should be considered during the implementation phase to enable such needs to be met in the future.
2. Adequate involvement of stakeholders from the entities affected by the BI system implementation. The first step was to identify the stakeholders, both in the management group of the entities and in the groups of future users and IT staff working with the contractor in the area of integration and configuration. The next step was to create a stakeholder matrix (Bahadorestani et al., 2020) and assign them to one of four groups:
   a. Stakeholders with a strong influence on implementation and an interest in being kept informed of progress.
   b. Stakeholders who have a high level of influence over implementation, but who have other responsibilities within the organisation, should only be informed of progress against key milestones.
   c. Stakeholders who have little influence on the implementation, but who have a high interest in all its functionalities due to future exposure to the implementation product.
   d. Stakeholders with little influence on implementation and who, due to their episodic involvement in the implementation process, do not require the full attention of the process.

In order to ensure effective communication with stakeholders, an online schedule of implementation meetings was set up, and their proceedings were recorded on video. This allowed stakeholder representatives who were unable to attend a particular implementation team meeting for objective reasons to view the material at a time convenient to them. In parallel, notes and memoranda of agreement were produced covering all relevant issues raised during the implementation phase.

Identification of data sources and development of a data flow diagram

Identifying the organisation's data sources prior to implementing a business intelligence system is a key step in the process of creating a fit-for-purpose dataset and subsequent analysis. In both healthcare organisations, the data required to develop algorithms that calculate the values of KPIs according to the set objectives is stored in the databases of two systems: ERP (Enterprise Resource Planning), a system for managing the organisation's financial and human resources, and HIS (Health Information System), a system for recording medical events and patient services. In each of these units, the source data was stored in relational databases that allowed queries to be built using the SQL language. The comparison of objectives and data showed that there was no need to integrate with other data sources beyond ERP and HIS systems. However, it was also useful to analyse the transactional systems that operate alongside the ERP environment and entity-specific applications. The potential need to use external data sources was also examined. This approach is necessary to obtain a complete set of information

to identify current and future integration needs. The Phase I activities, using the MoSCOW analysis, identified both the requirements necessary to achieve the organisation's objectives and future needs. This in turn determines the need for a full inventory of internal and external resources, the type of databases, their granularity and data export capabilities. In addition to technical issues, it is not uncommon for the use of certain resources to require the involvement of source system vendors or updates to licensing policies. Therefore, the process of identifying data sources should be comprehensive and take into account potential non-technical barriers. The identification of data sources was carried out by checking the quality of the data, i.e. whether it is accurate, complete, up-to-date and consistent (Fan et al., 2022). The quality of the data used in a business intelligence environment depends on the following factors:

1. *The effectiveness of decisions based on data*. Poor data quality can lead to wrong decisions and conclusions, directly affecting the functioning of the organisation or the credibility of reports prepared for external institutions.
2. *User confidence in BI tools*. Any inaccurate information generated by the system negatively affects the perception of the functionality of the tools provided to the user. This not only leads to a reluctance to use certain solutions, but often becomes a factor that hinders the development of the BI environment in the organisation. The transformation towards a data-driven organisation (Hupperz et al., 2021), if it has such a strategic objective, is thus seriously jeopardised.
3. *Operational efficiency of the organisation*. While in a well-functioning BI environment the knowledge extracted from the data leads to the identification of constraints in the organisation's processes and can serve as a source of information on how to mitigate them, in the case of incorrectly generated outcome data, the effect can be quite the opposite and incorrect conclusions about processes can exacerbate organisational problems.
4. *Regulatory compliance*. In this case, inadequate quality of source data translated into reporting performed in the BI environment can place a legal burden on the organisation if the reporting is subject to financial, contractual or regulatory compliance, which is most often the case.

Based on the analyses performed, a data quality assessment report was produced. Its purpose was to identify and describe data quality issues, assess their impact on the organisation's business operations in the context of the planned BI system implementation, and propose corrective actions. The report described the scope of the source data assessment, the data quality assessment criteria used, and the methods and tools employed. Potential risks and threats associated with poor quality of specific data sets, such as the risk of wrong decisions, financial loss, compliance violations, are presented. For each risk, corrective actions (data cleansing, deduplication, error correction, etc.) and a suggestion for how data quality should be monitored to maintain high standards both after the corrective actions have been applied and in the future are provided. The criteria for assessing data quality were based on the

examination of data samples (McGilvray, 2021) (manual verification and through the use of validation scripts, depending on the technical possibilities and the survey under study) and were referred to:

1. *Accuracy*, i.e. checking how the data reflect reality. This activity refers to the comparison of data with reference data and focuses on finding incorrect numerical values, typing errors, data format errors or incorrect dates.
2. *Consistency*, i.e. checking the uniformity of data from different systems, databases or tables, achieved through cross-checks based on pivot tables and comparison reports.
3. *Completeness*, i.e. assessing whether all required data is available and complete. This activity focuses on identifying missing fields, incomplete records, omitted information extracted from external data sources.
4. *Timeliness*, i.e. verifying that the data in the system are current and reflect the current state of affairs, which is achieved by checking the frequency and extent of data updates and comparing them with the knowledge of those responsible for entering the data.
5. *Reliability*, i.e. verifying that all data comes from the correct data sources and that it has not been inadvertently modified by system operations. This is done by analysing the data collection flow and comparing the process path with the data management policy.
6. *Uniqueness*, i.e. checking that each record is unique and that there are no duplicates, i.e. duplication of data in the system. This involves checking the primary and foreign keys in the databases. The worst case scenario is the identification of duplicate data with different values as a result of different algorithms used to arrive at the final result.
7. *Integrity*, i.e. checking that the data remain consistent in terms of the relationships between them and that the relationships between them are logical.
8. *Accuracy*, i.e. the appropriate granularity of the data, which influences its usability in the generation of reports, where the final value or visualisation is the result of mathematical or statistical operations performed on the data.
9. *Accessibility*, i.e. the ability to obtain data from the source for further processing.
10. *Relevance*, i.e. an assessment of the importance and usefulness of the data in the context of the business objectives to be achieved. Barriers may include redundant information, unusable data formats, or units of measurement that need to be converted into the form expected by the report recipient.

As part of the data source availability analysis, the IT infrastructure requirements for co-location of BI tools were also reviewed and it was decided to allocate virtual space within existing resources for these requirements. On the basis of the analyses carried out, a description of the technical infrastructure was developed as part of the project documentation used as a follow-up to the open tender process for the supply and implementation of BI tools in the two hospitals. The following issues were also highlighted during this process:

1. The data presented on the dashboards must be automatically updated and downloadable at specified intervals (e.g. once a month, once a quarter, once a year).
2. The BI system must be scalable, i.e. it must be possible to use it for data sets other than those coming from the source systems of the healthcare entities (data formats: .xlsx, .json, .xml, .sql).
3. Developing calculation algorithms, i.e. ensuring that if a value is not explicitly stored in the source system, but needs to be calculated, the implemented BI mechanisms will calculate it.
4. Provide data fusion capabilities, which means connecting to at least two data sources, shaping the data as required, and then consolidating it into a single useful query.

The process of describing the data flow required the identification of entry, exit and processing points. This meant that the following were identified and described:

1. Where exactly will the data (records, tables, databases) be retrieved from?
2. Where and in what format will the data be transferred and what technical solutions will be used?
3. How are the results expected by the user, i.e. what performance indicators and forms of visualisation will be used, which will determine the type of algorithms that will process the input data into the resulting form?

One of the online tools was used to map and produce the data flow:

1. *DataFlow Diagram (DFD)* (Li et al., 2009, pp. 85-97), which is a graphical representation of the flow of information in the organisation as expected in the BI system implementation process. For the purpose of this activity, the system boundaries were defined, key processes, data flow directions and dependencies between processes were identified, and data stores were indicated.
2. *A data architecture diagram* that provides a visualisation of how data is organised, stored and managed in a system, thereby facilitating an understanding of the relationships between the different components of the system. Its purpose is to show how data is collected, stored, processed, managed and exchanged within and between system components.
3. *Business Process Diagram (BPD)* (White et al., 2004), which is a representation of the sequence of activities that occur within a specific business process. This diagram illustrates how specific activities, tasks or operations are carried out and how the various components of the organisation (people, departments or systems) are involved in the process.

STAGE 2 Identification of a functional requirements and form of management data presentation

The prior definition of data sources and their scope, together with the identification of KPIs and the prioritisation of objectives, enabled a functional requirements analysis to be carried out. This involved gathering the expectations of the future users of the system, which was done by assigning KPIs to specific user roles that would use them, and then mapping these needs to data sets. The set of requirements primarily defined the mapping of KPIs to specific dashboards, while preserving the need to modify the dashboards if necessary.

The second stage of the research led to the identification of the following requirements for the designed BI system in the healthcare unit under study:

1. Ensure that the data export interface is consistent for all generated reports and allows metadata to be attached to the report (type of report/data, date generated, person responsible) while providing a mechanism/window for reviewing the list of generated reports.
2. Ensure that the BI system allows data to be imported from multiple sources.
3. Ensure that datasets can be a combination of multiple sources that can be filtered and combined to provide new data collections.
4. Ensure that when creating a dashboard, tiles can be moved or rearranged in any way, with the ability to scale, move and hide them to ensure personalisation of dashboards by the system users.
5. Ensure the generation of QR codes to allow access to data.
6. Provide the ability to modify the presentation of data on dashboards using a set of predefined charts and visual forms (more than 20 visual presentation methods defined in total).
7. Providing access to the command language syntax, which is a collection of functions, operators and constants, ensuring the use of formulas or expressions to perform calculations and return results, bypassing the options available from the system menus.

This phase also focuses on issues such as:

1. The layout of the dashboard (dahsboard): the individual components of the dashboard were designed to be intuitive and easy to navigate, while at the same time being divided into thematic sections to present the organisation of information in a clear way. This was done using UX (user experience) design principles (Law et al., 2009, pp. 719-728), which aim to meet the following requirements":
   a. Focus on user needs.
   b. Intuitiveness based on design patterns and standardised terminology and infographics.
   c. Consistency of the interface in terms of navigation, style, colours, fonts, etc.
   d. Simplicity aimed at reducing redundant elements.
   e. Clear communication of key information.

f. Optimisation for maximum usability.
g. Efficiency through the design of optimal information access paths.
h. Effective provision of feedback that is fully understood by the user.
i. Minimalism, which fulfils both an aesthetic function (also important in interface design) and introduces clarity and legibility to all information presented.

2. Choice of visualisation: Appropriate types of visualisation were chosen for the different types of data and KPIs used, including bar charts, line charts, pie charts, heat maps and tables. The choice of visualisation was determined by the type of data and the purpose of the presentation.
3. Colour optimisation: to highlight key information and facilitate quick interpretation of the data, appropriate colours were chosen to indicate positive and negative results while avoiding the introduction of visual chaos.
4. Interactivity and filtering: the dashboards were designed to ensure proper interaction with the user by introducing features such as drill-down (insight into details), drill-through (jump to related reports), hover (display additional information when hovering) and dynamic filtering.

In addition, as is standard for this type of IT solution, requirements for system security, data encryption, compliance with current legislation (RODO, WCAG, interoperability) and system backup were defined. Among other things, the need to ensure:

1. Confidentiality, i.e. protection against disclosure to an unauthorised recipient.
2. Integrity, i.e. protection against unauthorised modification or corruption of data.
3. Accessibility, i.e. the ability to use certain functions of the system on the basis of granted rights.
4. Accountability, i.e. the definition and verification of responsibility for operations performed in the system.
5. Authenticity, i.e. the verification of the identity of entities and the veracity of resources.
6. Reliability, i.e. guaranteeing the expected behaviour of the system and the results obtained through it.

This phase was completed with the production of a full technical specification, describing all the requirements for the system to be implemented.

STAGE 3 Implementing the system

System implementation activities have largely focused on the extract, transform, load (ETL) process (Simitsis, 2003).

The outcome of the third stage of research was the implementation of the system, which made use of the ETL system as an integral component of the constructed data warehouse system and BI environments. The findings of the third stage of the research project can be summarised as follows:

1. *Data extraction*, i.e. the process of extracting data (both structured and unstructured) from different sources, developing technical methods for connecting to databases and the periodicity of data extraction (real-time or scheduled).
2. *Data transformation,* i.e. the transformation and cleaning of data so that it conforms to the formats and standards of the target system. This process includes data cleansing, data transformation, data merging, data enrichment and, in some cases, data anonymisation.
3. *Data loading*, i.e. storing the processed data in the target BI environment (e.g. in a dedicated data warehouse) for use in reporting and visualisation.

ETL tools also transport data between sources and targets, use metadata to document how data elements change during this transport, exchange metadata with other applications as required, and manage all processes and operations at run time (e.g. scheduling, error management, audit logs, statistics). The ultimate goal of the ETL process is to load the warehouse with integrated and cleansed data. As part of the ETL process, data standardisation and duplicate removal mechanisms were implemented, and in the case of data anomalies, such as incorrect values, incorrect use of units of measurement or complete absence of data, appropriate scripts informed the healthcare provider of the situation, complementing the data preparation process carried out in Stage II (identification of data sources and development of a data flow structure diagram). Changes to correct errors in the source data area were made on an ongoing basis, and corrective action was taken at an organisational level in the case of missing data. It should be noted that the user interfaces of the source systems had special functions that allowed the introduction of data that was not ultimately in the database, as there was no obligation to introduce them prior to the implementation of BI solutions. The next step was to create management dashboards based on the requirements from Stage III (defining the functional needs and the form of presentation of management data) and to successively link the results of the work done on the source data, i.e. KPIs, charts, visualisations of historical data and their comparisons with current states. This process was carried out in constant consultation with the end users of the system. Both the correctness of the functions and algorithms were verified, as well as the limits of data mining in the context of the user roles defined in the system. In order to ensure identical solutions for the visualisation of the resulting data, the entire implementation was carried out with the simultaneous participation of representatives of the university implementation team and the two healthcare institutions. This activity involved a constant exchange of concepts and ideas for solving specific problems, which ultimately resulted in high implementation efficiency.

STAGE 4 Testing and Validation

System performance testing, in the context of Business Intelligence (BI) and information systems in general, is a key process for assessing how well a system performs under different workloads and conditions.

The following activities were carried out as part of the implementation of the fourth stage, test scenarios, test cases, test schedule, resources required for testing and the metrics that would be used to assess performance. This phase included:

1. *Functionality testing* - the BI system is equipped not only with dashboards presenting data with the possibility of drill-down, but also with numerous functions for exporting data, publishing reports, sharing reports, creating personalised dashboards, defining alerts, changing the form of data visualisation, filtering data, building custom queries to source databases, etc. The tests therefore focused on report generation, visualisation development, dashboard interactivity, data filtering and integration effectiveness. All these functions were checked for correct operation and adjustments were made where necessary.
2. *Data validation* - users and administrators of the source systems verified the subsequent data components of the dashboard. Both calculation algorithms and the consistency of the displayed data with the source data were checked to ensure that there were no errors in numerical values, dates or text data.
3. *System performance testing* - the process included checking the speed of database queries, the speed of report generation and the level of equipment utilisation, i.e. CPU load and RAM consumption.
4. *Security testing* - as the system was implemented using web technology, security testing was based on the OWASP (Open Web Application Security Project) standard (Bach-Nutman, 2020). They included verification of the system's resistance to the vulnerabilities of the main threats defined and updated by the OWASP organisation, including the system's resistance to SQL injection, man-in-the-middle attacks and DDoS attacks.
5. *Usability testing,* i.e. verifying that the delivered BI solutions are intuitive, easy to use and meet user expectations. These tests were carried out with the active involvement of users, while verifying the requirements written in the documentation.

The final product of Phase V was the production of a report containing the methods and results of the activities undertaken:

1. A list of problems found during testing, with a unique identifier, description and step-by-step instructions on where the error occurred and how it was caused.
2. A prioritisation of the problems, following the nomenclature used in the implementation documentation, which divides bugs into critical, medium and low categories.

3. Recommended corrective actions for each identified problem.
4. Documentation attachments, i.e. screenshots, system logs, performance reports and security test reports generated by automation tools.

The role of the report is not only to document the functional status of the BI system, but it is also an important tool for communicating with stakeholders about test results, system status, risks and remediation plans. It is also an important source of information in the organisation's quality management process, helping to build IT environments with long-term efficiency and reliability.

STAGE 5 Staff training and production implementation

The stage 5 realisation entailed the training of personnel with designated rights within the system. This training encompassed the following:

1. *Introduction to BI issues* - this process is necessary to prepare staff who have not been directly involved in the implementation process, but who will be direct or indirect users of the system. Direct users interact with the system through the use of specific dashboards, while indirect users are primarily recipients of reports and analysis generated by BI. Introducing this latter group of users to the concept of BI systems will enable them to be aware of their reporting needs and expectations, and the potential of the BI environment in the context of business analysis.
2. *Demonstration of the functional capabilities of the BI system* - this process included a presentation of the most important and commonly used functionalities of the system and served as preparation for the next training activity, the practical exercises.
3. *Hands-on training* - was a key element of the training process. They were based on pre-agreed training scenarios and enabled users to exploit the full potential of the system under the control of a specialist trainer. The scenarios were designed to cover all the basic system requirements defined in the implementation documentation.
4. *Question and answer session* - the completed practical exercises, combined with the previous training activities, provided a basis for informed and non-trivial questions about the functionality of the system.

The result of the fifth stage of the research was also:

1. *Training materials* - these included paper documentation and access to web-based materials from within the system. In addition, training sessions held with users were recorded online and added to the training resources.
2. *User support from the contractor* - a contractually guaranteed helpdesk, particularly useful in the early stages of using the system.
3. *Supplementary training* - at the request of users, the possibility of supplementary training has been provided once they have gained knowledge and experience of the system. Supplementary training is an excellent way of supplementing knowledge in areas that require specific knowledge of the BI system.

The completion of the training process has enabled the system to go into production.

5. Discussion

The rapid increase in the use of technology in the business environment has generated huge amounts of digital data as a result of the volume of transactions. Technological advances have made the use of IT tools and techniques a necessity to improve the operational activities of many businesses. Every organisation strives to gain market advantage, and healthcare providers are no different. The healthcare sector encompasses a multitude of stakeholders, including doctors, medical staff, insurance companies, service providers, regulators and government authorities, healthcare providers and, of course, patients themselves, who have a direct interest in the quality and accessibility of the services provided. Maintaining and managing all these relationships between all these stakeholders is a very difficult task without the use of new technologies, and the fact that these relationships ultimately boil down to human health and life makes them even more sensitive to the solutions used. The healthcare sector collects and processes very large amounts of data, so the use of BI solutions in this sector can certainly influence the improvement of decision-making processes. In summary, the correct implementation of a BI environment in a healthcare organisation brings benefits in many areas. In the area of organisational management, these include: support hospital management decision making, provide monitoring and analysis of hospital resource utilisation by optimising bed occupancy, operating theatre occupancy, use of specialist equipment and staff occupancy, resulting in improved cost effectiveness, supporting the identification of causes affecting patient service or length of stay and automating the reporting of deviations and anomalies in process chains, and improve the financial management of the organisation by identifying sources of loss, profitability analysis, optimal contract planning based on data and predictive methods, etc., effective risk management based on appropriately selected indicators and defined thresholds for critical values reported by the BI system, by centralising data, standardising collaboration between the different departments and administrative units of the hospital, ensuring reliable information at the output. Management issues directly related to strategic and operational planning, financial analysis and human resource management, it is worth noting that BI solutions can directly support healthcare areas. For example, in solutions dedicated to supporting patient care processes, BI can be a helpful tool for analysing patient data in real time and supporting medical decisions related to issues such as:

1. *Patient segmentation.* Enables grouping of patients for enrolment in clinical trials, prioritisation of surgical procedures, creation of dynamic queues for transplantation based on decision variables.
2. *Health plan analysis.* It makes it possible to tailor health programmes to the right groups of recipients according to age, place of residence, environmental conditions, etc. It also makes it possible to monitor the performance indicators of such programmes over time and thus to assess their effectiveness over time.

3. *Multi-resource planning.* In this respect, BI supports the analysis of supply chain effectiveness, scheduling and the correct matching of treatment appointments to room occupancy and staff availability.
4. *Analysis of treatment outcomes.* This area includes analyses of the duration of specific therapies, hospital stays, the number and type of tests performed, and the cost intensity of each of these processes. The results of such analyses can be used as a basis for introducing corrective and optimising solutions aimed at guiding the patient through the treatment process, selecting the best solutions and reducing costs.
5. *Evidence-based medicine*. This is an area of medicine that focuses on applying the best available evidence, obtained through the scientific method, to clinical decision making. The use case is to suggest medical guidelines based on patients' previous treatments, which in turn are based on analyses supported by BI tools.
6. *Drug withdrawal.* This is arguably a specific and important use case for BI solutions, ensuring the implementation of fast and effective procedures for the withdrawal of a specific drug by quickly identifying all patients to whom it has been prescribed.

In order to make responsible decisions, it is important not only to have a good understanding of BI tools and to define data sources accurately, but also to define objectives correctly, not only at the level of the organisation, but also at the level of crisis action centres, marshal offices, medical universities and the Ministry of Health. Decision-makers at different levels of health management need real-time information to manage data well and extract information that can improve health services and reduce risks in crisis situations. Technically, in terms of the availability of infrastructure and tools, it is possible to implement centralised reporting and reasoning systems, and the provision of real-time data seems crucial for the efficient management of such an important area of social life. The safety and quality of health care services can be improved by measuring the effectiveness of the measures taken and, on the basis of the lessons learned, eliminating irregularities while striving for standardisation. This, in turn, should lead to the integration of activities within healthcare entities and the flow of information, while measuring KPIs in real time. For an organisation to build a BI environment that meets its needs, it should ensure that the following issues are properly and responsibly addressed:

1. Define clear, SMART business objectives and communicate them to all stakeholders, highlighting the tangible benefits to the organisation and its people that will result from the implementation. At this point, it is important to ensure that the implementation of BI solutions is in line with the organisation's strategy.
2. Conduct a detailed audit of the organisation's existing data sources, systems and interdependencies between processes and, based on this, develop the expected model of data flow into the warehouse or data warehouse.

3. Develop a matrix of roles and responsibilities associated with the implementation of BI solutions to ensure the required quality, security and compliance of the data captured for the final reports generated by the implemented tools.
4. Research and evaluate BI solutions available on the market based on the organisation's specific needs, budget, scalability and ease of use.
5. Develop a strategy for data extraction, transformation and loading (ETL) processes to ensure effective data integration.
6. Ensure proper data quality by implementing data cleansing and validation procedures and mechanisms to ensure that the data used in the BI system is accurate, complete and reliable.
7. Plan the implementation with scalability in mind to ensure that the BI environment can grow over time as the needs of the organisation increase.
8. Develop a data security plan, with particular emphasis on protecting sensitive data from unauthorised access and integrity breaches.
9. Develop an implementation roadmap with milestones and frequency and scope of progress reporting.
10. Ensure the ergonomics of the BI system by maintaining good UX design practices and understanding the needs of future users.
11. Develop a comprehensive training programme.
12. Provide user support services, including access to documentation, training materials and technical advice.
13. Establish maintenance processes for the BI system, including updates, patches, data quality checks and performance tuning.

It is very important to properly address the cultural change of the organisation related to the implementation of a BI system (Arefin et al., 2015, pp. 263-285). Indeed, this is a key step in the organisation's transformation to a data-driven organisation. It is therefore important to continuously communicate the benefits to staff, provide ongoing support to the teams involved in the implementation and involve other stakeholders to overcome resistance to change. During the transformation phase, it is good practice to regularly gather feedback from users, identify areas for improvement and implement updates and new features in the BI environment.

In the same way that BI dashboards use key performance indicators to inform users about the health of individual processes, an organisation's entire BI environment should be monitored to ensure the success of its implementation. It makes sense to regularly measure user satisfaction, analyse system performance and review its impact on the overall performance of the organisation in the areas to which BI is directly linked.

6. Conclusions

The principal conclusions of the case study, as set forth in the article, indicate the necessity for business intelligence (BI) solutions that facilitate real-time reporting and data analysis, which is pivotal to enhancing crisis management in terms of automation and immediate access to data. It is similarly important to guarantee the standardisation of healthcare reporting at the national or regional level, if not beyond. Business intelligence tools utilising consistent data sources can serve as a valuable repository for management and planning information. The implementation of BI also offers additional benefits, such as the ability to utilise predictive analytics or integrate with other systems that provide a more comprehensive range of information. These advantages contribute to the effectiveness of healthcare entities and their strategic role in managing crisis events.

This article presents the methodology employed in the design and implementation of a Business Intelligence class system for a healthcare entity. The epidemiological situation has created a necessity for the implementation of an effective reporting system within healthcare units, with the objective of facilitating decision-making at the national level in the context of crisis management. This paper presents a comprehensive description of the five-step process of designing and implementing a BI system. Given the complexity of the issue, the article identifies the most important aspects and notes that each stage of the activities carried out constitutes a separate area of analysis. The article is a valuable resource for both theoreticians and practitioners in the field of business analytics. The article offers new insights into the practical implementation of BI in healthcare, as evidenced by the literature review. As each BI system is tailored to the organisation, the identified steps of the designed system can be used as a model for other industries. However, examples of key indicators, specialised data sources or dashboards identified at each stage are unique to each industry. The topics and scope of future research in the area of BI development will be broad and focus on integration with modern technologies and artificial intelligence.

The article presents the process of designing and implementing a business intelligence system to meet the needs of a healthcare unit. The epidemiological situation has created a necessity for the effective reporting of the current situation in healthcare units for the purpose of decision-making at the national level in the field of crisis management. The article presents a comprehensive account of the five-stage process of designing and implementing a BI system. Given the complexity of the issue, the article indicates the most important aspects, but it should be noted that each of the stages of the activities carried out constitutes a separate area of analysis. The article provides a valuable resource for both theoretical and practical scholars in the field of business intelligence. The article contributes new insights into the practical implementation of BI in a healthcare setting, as evidenced by the literature review. As each BI system is bespoke to the organisation in question, the identified stages of the

designed system can be used as a model for other industries. However, the sample key indicators, specialist data sources or dashboards identified in the individual steps are unique to each industry. The topic and scope of future research in the field of BI development will be extensive and will primarily concern integration with modern technologies and artificial intelligence.

Acknowledgements

Author Contributions: conceptualization: M.CH.; methodology: M.CH.; validation: A.B., investigation: M.CH.; resources: M.CH. and A.B.; writing—original draft preparation: M.CH.; writing—review and editing: A.B.; visualization: M.CH. supervision: A.B.; project administration: A.B.; funding acquisition: A.B. All authors have read and agreed to the published version of the manuscript.
Funding: This research was funded by Statutory Research BK_2024 RG3 of Silesian University of Technology.

References

1. Abouzahr, C.B. (2005). Ties. Health information systems: the foundations of public health. *Bulletin of the World Health Organization*, *83*, 578-583.
2. Arefin, M.S., Hoque, M.R., Bao, Y. (2015). The impact of business intelligence on organization's effectiveness: an empirical study. *Journal of Systems and Information Technology*, *17*, *3*, 263-285.
3. Aws, A.L., Ping, T.A., Al-Okaily, M. (2021). Towards business intelligence success measurement in an organization: a conceptual study. *Journal of System and Management Sciences*, *11*, *2*, 155-170.
4. Bach-Nutman, M. (2020). Understanding the top 10 owasp vulnerabilities. *Arxiv preprint arxiv:2012.09960*.
5. Bahadorestani, A., Naderpajouh, N., Sadiq, R. (2020). Planning for sustainable stakeholder engagement based on the assessment of conflicting interests in projects. *Journal of Cleaner Production*, *242*, 118402.
6. Basile, L.J. et al. (2023). Business intelligence in the healthcare industry: The utilization of a data-driven approach to support clinical decision making. *Technovation*, *120*, 102482.

7. Batko, K., Ślęzak, A. (2022). The use of Big Data Analytics in healthcare. *Journal of Big Data, 9, 1,* 3.
8. Davenport, T.H. (2012). Business intelligence and organizational decisions. In: *Organizational Applications of Business Intelligence Management: Emerging Trends*. IGI Global, pp. 1-12.
9. Eboigbe, E.O. et al. (2023). Business intelligence transformation through AI and data analytics. *Engineering Science & Technology Journal, 4, 5,* 285-307.
10. Ecaremed Śląska Platforma Pacjenta, https://app.ecaremed.pl/, 31.08.2024.
11. Elbanna, S. (2006). Strategic decision- making: Process perspectives. *International Journal of Management reviews, 8, 1,* 1-20.
12. Fan, W., Geerts, F. (2022). *Foundations of data quality management*. Springer Nature.
13. Fischer, M. et al. (2020). Strategy archetypes for digital transformation: Defining meta objectives using business process management. *Information & Management, 57, 5,* 103262.
14. Głód, G. (2014). Zastosowanie systemu klasy Business Intelligence w jednostce ratownictwa medycznego-studium przypadku. *Roczniki Kolegium Analiz Ekonomicznych/Szkoła Główna Handlowa, 35, Technologie informatyczne w służbie zdrowia,* 91-103.
15. Gupta, A., Singh, A. (2023). Healthcare 4.0: recent advancements and futuristic research directions. *Wireless Personal Communications, 129, 2,* 933-952.
16. Hupperz, M.J. et al. (2021). What is a data-driven organization? *AMCIS*.
17. Kravchenko, T., Bogdanova, T., Shevgunov, T. (2022). Ranking requirements using moscow methodology in practice. *Computer Science On-line Conference*. Cham: Springer International Publishing, pp. 188-199.
18. Krishnan, K. (2013). Data warehousing in the age of big data. *Newnes*.
19. Latham, G. (2020). Goal setting: A five-step approach to behavior change. In: *Organizational collaboration*. Routledge, pp. 10-20.
20. Law, E.L.-C. et al. (2009). *Understanding, scoping and defining user experience: a survey approach.* Proceedings of the SIGCHI conference on human factors in computing systems, pp. 719-728.
21. Li, Q., Chen, Y.-L. (2009). Data flow diagram. In: *Modeling and Analysis of Enterprise and Information Systems*. Berlin/Heidelberg: Springer, pp. 85-97.
22. Maaitah, T. (2023). The role of business intelligence tools in the decision making process and performance. *Journal of Intelligence Studies in Business, 13, 1,* 43-52.
23. McGilvray, D. (2021). *Executing data quality projects: Ten steps to quality data and trusted information (TM).* Academic Press.
24. Morgan, K. (2006). *Mining, What Is Data. Data mining: Concepts and techniques*, 10.559-569, 4.
25. Negash, S., Gray, P. (2008). Business intelligence. *Handbook on decision support systems, 2*, 175-193.

26. Niu, Y. et al. (2021). Organizational business intelligence and decision making using big data analytics. *Information Processing & Management, 58, 6,* 102725.
27. Palpanas, T. (2000). Knowledge discovery in data warehouses. *ACM Sigmod Record, 29, 3,* 88-100.
28. Plagg, B. et al. (2021). Primary health care and hospital management during COVID-19: lessons from Lombardy. *Risk Management and Healthcare Policy,* 3987-3992.
29. Rehman, M.U. et al. (2022). Elaborating the Role of Business Intelligence (BI) in Healthcare Management. *Journal of Intelligence Studies in Business, 12, 2,* 26-35.
30. Röglinger, M., Pöppelbuß, J., Becker, J. (2012). Maturity models in business process management. *Business Process Management Journal, 18, 2,* 328-346.
31. Simitsis, A. (2003). Modeling and managing ETL processes. In: *VLDB phd Workshop*.
32. Singu, S. (2021). Business Intelligence on the Quality of Decision Making. *International Journal of Statistical Computation and Simulation, 13, 1*.
33. Słownik Języka Polskiego PWN, https://sjp.pwn.pl/sjp/inteligencja;2561737.html, 31.08.2024.
34. Sołtysik-Piorunkiewicz, A., Furmankiewicz, M., Ziuziański, P. (2015). Kokpit menedżerski jako narzędzie wspomagania decyzji prosumenta w e-zdrowiu. *Prace Naukowe.* Uniwersytet Ekonomiczny w Katowicach, 188-212.
35. Svenson, O. (1979). Process descriptions of decision making. *Organizational behavior and human performance, 23, 1,* 86-112.
36. Tietze, W. et al. (2022). Teaching the ETL process. *Strategic Finance, 104, 2,* 34-41.
37. Vugec, D.S. et al. (2020). Business intelligence and organizational performance. *Business Process Management Journal, 26, 6,* 1709-1730.
38. White, S.A. et al. (2004). Process modeling notations and workflow patterns. *Workflow handbook, 12,* 265-294.
39. Zheng, J.G. (2017). Data visualization in business intelligence. In: *Global business intelligence*. Routledge, pp. 67-81.