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Health Man & Info Sci 2024, 11(2), 43–55

HMIS
Health Management and Information Science

Review Article

The Role of Business Intelligence in Cancer Data Management: A Scoping Review

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Abstract

Introduction: Business intelligence, through its tools and methods, provides a structured approach to managing and optimizing data use. Due to the importance of business intelligence in the collection and integration of treatment data of cancer patients and its management, knowledge of business intelligence tools and their characteristics in the field of cancer is mostly important for managers and health professionals. Therefore, this study aimed to explore the application of business intelligence in cancers.

Method: A comprehensive search of major bibliographic databases, including PubMed, Scopus, Web of Science, and Embase, was conducted without applying time restrictions. A total of 24 studies were ultimately selected, and data extraction was performed using an enhanced version of the Arksey and O'Malley framework.

Results: Research has demonstrated that business intelligence plays a crucial role in managing cancer data. Additionally, the results indicated enhancing patient safety, improving the performance of medical staff in patient monitoring, and supporting decision-makers and administrators in adopting optimal resource allocation policies. Furthermore, business intelligence has been applied to monitor the performance of health service departments for cancer patients, ensure effective resource management, and optimize workflow processes within these departments.

Conclusion: Business intelligence is among the most effective and efficient approaches for optimizing the use of large volumes of data, enabling healthcare providers and other decision-makers to access valuable information for making timely decisions in the field of cancer.

Keywords: Business intelligence, Dashboard, Neoplasm, Cancer

Article History:
Received: 13 December 2023
Accepted: 19 February 2023

Please cite this paper as:
Yazdani S, Baniasadi T, Molavi MA, Khorrami F. The Role of Business Intelligence in Cancer Data Management: A Scoping Review. Health Man & Info Sci. 2024; 11(2): 43-55. doi: 10.30476/jhmi.2024.103708.1236.

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Introduction

The volume of data generated by healthcare services for cancer patients is immense, making it challenging for healthcare managers and providers to access and utilize this information effectively (1). These data are recorded in information systems and are available to decision-makers. Therefore, the huge volume of these data can make hospitals and other health centers face many challenges in the effective management of patients and their treatment (2).

Business intelligence offers a structured approach to managing and optimizing the use of such data. Through its specialized methods, it facilitates the extraction, analysis, and summarization of large-scale health data (2). Utilizing dynamic tools such as dashboards, it plays a pivotal role in enhancing the management of treatment processes within healthcare centers (3). In other words, the electronic display of data summaries in dashboards can be called business intelligence, which by focusing on the most key information causes people to be more informed in making decisions (4). They assist healthcare managers in organizing patient information and provide a comprehensive overview of departmental operations by displaying essential patient and departmental data. By incorporating

key performance indicators through charts and numerical displays, dashboards enable better department management (5, 6). They have been used in many healthcare centers including emergency medicine (7), Intensive Care Units (8), and delivery of healthcare to dialysis patients (9). Also, they help healthcare providers monitor and control important diseases such as cancer by integrating information from various sources (10).

The results of Jansen *et al.'s* study showed that the information collected using dashboards facilitated clinical decision-making and better monitoring of with lymphedema cancer. By integrating data from various sources for specialists, it helps to better identify patients at risk of developing lymphedema cancer and improve their quality of life(1). In addition, another study conducted by Walsh *et al.* showed that the dashboards help doctors apply quick and timely interventions to patients by providing appropriate patient feedback to doctors about choosing the right drug for patients (11).

Cancer is increasingly recognized as a prevalent and dangerous disease worldwide (12), and its management often necessitates continuous patient monitoring and prompt intervention by medical staff to prevent further deterioration (13). Consequently, a tool capable of efficiently collecting and integrating cancer patient data is crucial for healthcare providers. The vast amounts of data generated from services provided to cancer patients must be purposefully processed and refined. Business intelligence tools, particularly dashboards, can support decision-makers and managers in formulating sound policies and making well-informed decisions. Therefore, understanding and identifying the characteristics and potential applications of business intelligence tools in cancer management are essential for healthcare professionals and managers. This study aimed to explore the role and applications of business intelligence in the field of cancer.

Methods

This scoping review was conducted in 2024, following the methodological framework outlined by Arksey and O'Malley (14), with the enhanced version developed by Levac *et al.* (15). All original articles about the application of business intelligence in the field of cancer and their full text where available were examined. We also used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist to report key items for this study (16).

Search Strategy for Relevant Studies

This study was conducted to investigate the applications of business intelligence in the field of cancer. A systematic search was performed across four major bibliographic databases: PubMed, Web of Science, EMBASE, and Scopus. The search utilized a combination of keywords including "Business Intelligence" and "Dashboard" with cancer-related terms such as "Cancer," "Neoplasm," "Tumor," and "Malignancy" (Table 1). The search wasconducted in May 2024, with no time restrictions and based on standardized terms from MeSH and Emtree. In addition, the retrieved records in each database were exported for further evaluation in the form of bibliographic information and abstracts and then entered into the EndNote reference management software.

Study Selection

The selection of related studies from the extracted articles was filtered using four inclusion criteria and five exclusion criteria.

Inclusion Criteria

1) Application of business intelligence in the field of cancer
2) Development of business intelligence dashboards in the field of cancer
3) Use of business intelligence dashboards to

Table 1: Search strategy in databases

Database	Search string	Number
Web of Science	(TS= (cancer OR neoplasms OR tumor OR malignancy)) AND TS=(dashboard OR "business intelligence")	186
PubMed	(((((neoplasm [Title/Abstract]) OR (cancer [Title/Abstract])) OR (tumor [Title/Abstract])) OR (malignancy [Title/Abstract])) AND (dashboard [Title/Abstract])) OR ("business intelligence"[Title/Abstract])	478
Scopus	(TITLE-ABS-KEY (cancer) OR TITLE-ABS-KEY (neoplasm) OR TITLE-ABS-KEY (tumor) OR TITLE-ABS-KEY (malignancy)) AND (TITLE-ABS-KEY (dashboard) OR TITLE-ABS-KEY ("business intelligence"))	269
Embase	(cancer:ti,ab,kw OR neoplasms:ti,ab,kw OR tumor:ti,ab,kw OR malignancy:ti,ab,kw) AND (dashboard:ti,ab,kw OR 'business intelligence':ti,ab,kw)	433
Total		1366

monitor the treatment processes of cancer patients
4) Articles published in Persian and English

Exclusion Criteria

1) Applications or tools under review for collecting and analyzing data from cancer patients
2) Explanation of the challenges and opportunities of dashboard development in the field of cancer
3) Evaluation of the quality of information collected in the oncology department
4) Conference abstracts, review articles, comments, editorials, correspondence, conference posters, and letters to the editor.
5) Full-text articles without any access to them.

Data Extraction

At this stage, the methodological quality of the input studies was critically evaluated using Downs and Black's checklist (17), which is designed to assess both randomized and non-randomized studies. Two researchers separately reviewed each included study for quality using a checklist. The quality scores (26-28), (20-25), (15-19), and =<14 were considered excellent, good, fair, and poor respectively (18). Five studies were reviewed to identify relevant variables for data extraction. Finally, the data extracted from the included studies were classified into two groups: The first one (Table 2.) included the research conducted in the field of cancer using business intelligence, and the second one (Table 3) included the specifications of the business intelligence tools used in the research. To extract the first category of data, we used a variable checklist including the name of the first author, year of study, country, research design, field, study objectives, and key findings. The second category included variables such as the data source used in the business intelligence system, platform for system design, level of data granularity, and key indicators or data elements.

Data Synthesis and Reporting

The full texts of selected articles were independently reviewed by two researchers. Relevant data were extracted, summarized, and organized into a table. Another researcher verified the validity of the extracted data to ensure accuracy and completeness.

Results

Initially,1,366 articles were retrieved from database searches. Following the removal of 800 duplicate records, the title and abstracts of 429 studies were examined. After this review, 371 studies were excluded as they were not relevant to the study objectives. Subsequently, 58 articles were selected for full-text review, and ultimately, 24 studies met the inclusion criteria and were included in this review (Figure 1).

Quality Assessment of the Included Articles

The methodological quality of the selected studies was assessed using the Downs and Black checklist. The quality evaluations of the articles were conducted by the researchers and reported accordingly.

Characteristics of the Included Studies

The frequency of included studies by year is shown in Figure 2.

Studies that Investigated Business Intelligence in Cancer Care

The studies were classified by country into nine categories (Table 2), including The United States of America(USA) (54.2%, S1, S4, S7, S8, S9, S10, S14, S16, S17, S19, S21, S23, and S24), Iran (8.3%, S15 and S18), Australia (8.3%, S5, and S20), Italy (4.2%, S6), Brazil (4.2%, S12), Sweden (4.2%, S3), Canada (4.2 %, S22) and the Netherlands (4.2%, S11). However, two studies (8.3%, S2, and S13) were performed with the collaboration of several countries.

In terms of study design, the included studies were classified into two categories: applied-developmental (75%, S2, S4-S7, S9-S19, S22, and23) and descriptive-applied (25%, S1, S3, S8, S20, S21, and S24) (Table 2).

The studies were further categorized based on the field. Four studies (16.7%, S1, S2, S3, and S4) focused on prostate cancer, three (12.5%, S5, S6, and S7) on breast cancer, three (12.5%, S8, S9, and S10) on radiation therapy, three (12.5%, S11, S12, and S13) on cervical cancer, two (8.3%, S14 and S15) on blood cancer, and two (8.3%, S16 and S17) on chemotherapy. Additionally, one study (4.2%) was conducted on each skin (S19), lung (S20), head and neck (S21), ambulatory (S22), and liver (S23) cancers. In another study, rectal, pancreatic, and lung cancers (S16) were investigated, and one study was found on the management of the oncology department (S18) (Table 2).

Table 2: Research conducted in the field of cancer using business intelligence

Study Num	Author	Country	Research design	Objective	Important results	Field
S1	Hartzler et al(19)	USA	Descriptive-Applied	Designing a dashboard to track the quality of life of patients who had prostate cancer	– Integrating patient-generated data into prostate cancer care	Prostate cancer
S2	Valero et al(20)	International	Applied-Developmental	Creation and development of analytical tools for the progression of cancer in patients	– Investigation of cancer progress in patients – Providing appropriate feedback for Physician	
S3	stattin et al(21)	Sweden	Descriptive-Applied	Reporting prostate cancer treatment indicators using a dashboard for health care providers	– Visualization and reporting of indicators such as waiting time, medical practitioner, treatment result – Providing adherence to diagnostic and treatment instructions	
S4	Izard et al(22)	USA	Applied-Developmental	Integrating of clinical data of patients who have prostate cancer through dashboard development	– Creating a patient-centered tool for timely and appropriate monitoring of the quality of life of patients who have prostate cancer	
S5	Janssen et al(1)	Australia	Applied-Developmental	Development of lymphedema dashboard for breast cancer patients	– Displaying the condition of patients with lymphedema – Display of treatment measures performed for patients	Breast cancer
S6	Basile et al(2)	Italy	Applied-Developmental	Development of decision support system based on business intelligence for management and estimation of treatment costs for women with breast cancer	– Providing therapeutic paths for patients – Providing economic therapeutic path – Reducing the unnecessary waste of money for treating patients	
S7	Tsangaris et al(23)	USA	Applied-Developmental	Supporting the clinical reports of patients who have breast cancer by Creating a platform	– Displaying patients' performance for managers and clinicians to better organize breast cancer – Monitoring the quality of patient care	
S8	Lyatskaya et al(24)	USA	Descriptive-Applied	Investigating the impact of the tracking dashboard on quality assurance in the radiotherapy department	– Monitoring the quality of radiotherapy devices – Improving the quality of medical imaging	Radiation therapy
S9	Munbodh et al(25)	USA	Applied-Developmental	Monitoring resources and clinical workflow of radiotherapy	– Real-time analysis and visualization of resource utilization and clinical workflow – Data-driven decisions in clinical workflow management – Optimizing clinical efficiency Patient Safety	
S10	Nelson et al(26)	USA	Applied-Developmental	Designing a dashboard for visual analysis of anesthetic records of patients undergoing radiation therapy	– Timely access to the key characteristics of anesthetic medicine for patients – Providing a summary of the anesthetic records of children with cancer	
S11	Ebben et al(27)	Netherland	Applied-Developmental	Creating a prototype dashboard to manage and appropriate decision making in cervical cancer	– Providing suitable diagnostic and treatment instructions for decision making in cancer	Cervical cancer
S12	Ahmed et al(28)	Brazil	Applied-Developmental	Development of a tool based on business intelligence to manage the cervical cancer screening program	– Visualization of data related to tests and patients' condition – Monitoring the screening process of patients – Identifying failure factors in the screening process of patients	

Study Num	Author	Country	Research design	Objective	Important results	Field
S13	Ecker et al(29)	International	Applied-Developmental	Development of software for effective monitoring of patients undergoing radiotherapy treatment	– Identifying and highlighting common problems in cervical cancer radiotherapy	
S14	Udalov et al(30)	USA	Applied-Developmental	Creating an automated dashboard to identify mutations in blood tumor genes	– Monitoring tumor progression – Observing the effectiveness of treatment in patients	Blood cancer
S15	Mehdizadeh et al(31)	Iran	Applied-Developmental	Development of a self-management system for cancer management in children	– Improving monitoring of patients' symptoms by doctors and answering patients' questions – Facilitating communication between patients and health care providers	
S16	Walsh et al(11)	USA	Applied-Developmental	Help prescribe the right antiemetic medication for children with cancer	– Modification of antiemetic drugs for patients based on chemotherapy drugs – Measuring the effectiveness of prescription antiemetic drugs	Chemotherapy
S17	Battis et al(32)	USA	Applied-Developmental	Creating a dashboard for drug and treatment orders for chemotherapy	– Improving medical supervision and safety of patients through their follow-up – Identifying and discovering medication errors in patients' prescriptions	
S18	Ahmadi et al(33)	Iran	Applied-Developmental	Management and monitoring of the oncology department	– Gathering information from various systems – Helping to make informed decisions in the direction of managing the oncology ward	Management of the Oncology department
S19	Saqlain et al(34)	USA	Applied-Developmental	Creating a web-based operational tool for monitoring and tracking patients who had skin cancer	– Identifying and monitoring patients through the visualization of their medical and demographic information	Skin cancer
S20	Brown et al(35)	Australia	Descriptive-Applied	Development of clinical quality indicators for lung cancer	– Monitoring of diagnostic indicators, treatment, quality of life and survival of patients	Lung cancer
S21	Strachna et al(36)	USA	Descriptive-Applied	Providing efficient health care in a Head and Neck Oncology	– Visualization and monitoring of data at organizational levels – Visualization of disease subset and patient condition	Head & Neck cancer
S22	Watson et al(37)	Canada	Applied-Developmental	Dashboard development based on patient reported results	– Better identification and understanding of patients' symptoms and problems – Choosing the right methods to meet the needs of patients who had cancer	Ambulatory cancer
S23	Rogal et al(38)	USA	Applied-Developmental	Detect and monitor liver cancer by dashboard development	– Improving in monitor of veteran who have liver cancer – Presentation of patient data in a user-friendly format – Improving in accessibility to patients' data	Liver cancer
S24	Smith et al(39)	USA	Descriptive-Applied	Providing effective end-of-life care for cancer patients	– Effective monitoring of prescribed anticancer drugs to patients – Monitoring the recovery trend and patients' condition	Rectal, pancreatic and lung cancers

Table 3: Specifications of business intelligence systems

Study	Data source		Level of data granularity					Platform	Users	Data elements and Key indicator
	Primary	Secondary	Organi-zational	Urban	County	National	Global			
S1	Patients' reports		*					Web	Health professionals & Patients	– Urinary score of patients – Age group of patients – Interventions – The EPCI index of patients
S2	EHR		*					Web	Health professionals	– Age at diagnosis – Clinical events related to cancer care (event dates and event names) – Drug details by type of treatment – PSA level – Patient ISUP index
S3	Cancer registry					*		Web	Health professionals	– Number of treatment decisions – Comparison of health care performance based on different regions – Waiting time Diagnostic information of patients
S4	Patient's reports				*			Web	Health professionals	– Health-related quality of life index over time – Display of pain scale in patients
S5	EHR		*					Web	Health professionals	– lymphedema index (L-Dex) – Patients' BMI Intervention
S6	HIS				*			Web	Health professionals and Physicians	– Net cost saving per patients – Therapeutic cost per patients
S7	Patient's reports		*					Mobile app	Clinicians & Patients	– Demographic information of patients – Status of referrals to the doctor – Treatments performed – Educational information about cancer
S8	Radiotherapy information system		*					Web	Radiotherapy administrators	- The device radiation dose rate - Mechanical specifications of the device - Records related to the daily quality control of the device
S9	EMR		*					Web	Department administrators & Health professionals	- CT specifications - Linac device specifications - Duties and documents - Diagnosis and interventions
S10	EHR		*					QlikView	Health professionals	- Patient program - Prescribed drugs - Airway devices used - Patient recovery time - Patient restlessness scale based on Watcha score
S11	Cancer Registry					*		Web	Health professionals and Physicians	- Patients' profiles - Comorbidities - Interventions
S12	Information System of Cervical Cancer			*				Pentaho	Administrators of cervical cancer screening	- Pap smear test results of patients - Age group of patients - Basic clinical method Time of the test by year
S13	HIS						*	Web	Health professionals	- The amount of medication dosage - Patient's diagnostic information
S14	LIS			*				Web	Health professionals	- Sample name - Sample sequence output - Pathogenic mutations in the sample - Similar examples - Allele frequency - Gene name

Study	Data source		Level of data granularity					Platform	Users	Data elements and Key indicator
	Primary	Secondary	Organi-zational	Urban	County	National	Global			
S15	Patient's reports		*					Mobile app	Health professionals & Patients	- Symptoms of patients - Patient visit time - Reminders to remember when to see a doctor
S16	EMR		*					Power bi	Clinicians	- Type of chemotherapy - Antiemetic medications
S17	HIS		*					SSRS	Health professionals	- Patient demographic information - Prescription medications - Chemotherapy results
S18	HIS		*					QlikView	Oncology administrators	- Number of patients - Number of days off - Hours of training - Number of personnel - Number of Complaints - Income and expense
S19	EHR		*					Web	Health professionals	- Demographic information of patients - Patients' diagnostic information - Patients' management indicators
S20		Guidelines published in the field of lung cancer & Review of scientific texts		*				Web	Health professionals	- Symptoms and features of the disease - Stage of the disease - Type of treatment
S21	EMR		*					Tableau	Oncologist	- Comorbidities - Patient's demographic data - Patient's clinical data
S22	EMR				*			Web	Clinicians	- Display of patients in priority - Clinical procedures performed - Clinical symptoms of patients - Referrals of patients
S23	EHR					*		Excel	Health professionals	- Demographic information - Patients' MRI Information - Identification of cancer patients - Medication information of patients
S24	Cancer registry					*		Web	Oncologists	- The rate of admission or consultation in the hospital - The percentage of patients admitted to the ICU in the last 30 days of life - The percentage of patients who received anticancer drugs in the last 14 days of their lives

Specifications of Business Intelligence Tools Used in the Research

Most studies (95.8%) utilized primary data sources, including electronic health and medical records of patients, cancer registries, health information systems, and patient reports. Only one study (S20) used secondary data sources, which included guidelines published in the field of lung cancer and a review of scientific literature (Table 3).

The studies were also categorized based on the level of data granularity at the organizational level (50%, S1, S2, S5, S7- S10, S15- S19, and S21), at the urban level (12.5%, S12, S14, and S20), at the county level (12.5%, S4, S6, and S22), at the national level (16.7%, S3, S11, S23, and S24), and at the global level (8.3%, S13) (Table 3).

In addition, the studies were classified based on the design platform of business intelligence systems in the categories of the web (62.5%, S1-S6, S8, S9, S11, S13, S14, S19, S20, S22, S24), mobile application (8.3%, S7, and S15), QlikView (8.3%, S10, and S18), Tableau (4.2%, S21), Power BI (4.2%, S16), SSRS (4.2%, S17), Excel (4.2%, S23), and Pentaho (4.2%, S12) (Table 3).

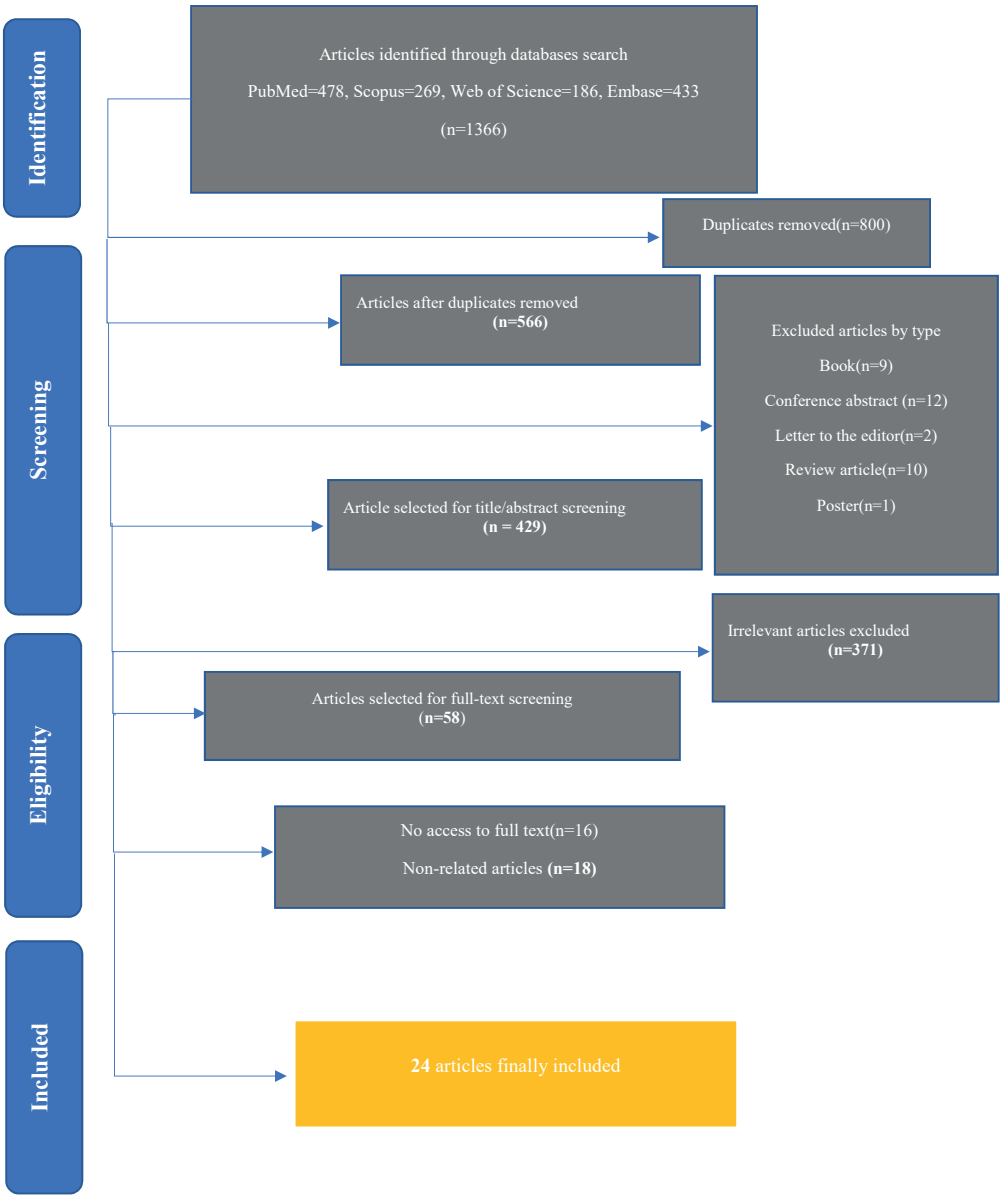

Figure 1: PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart diagram

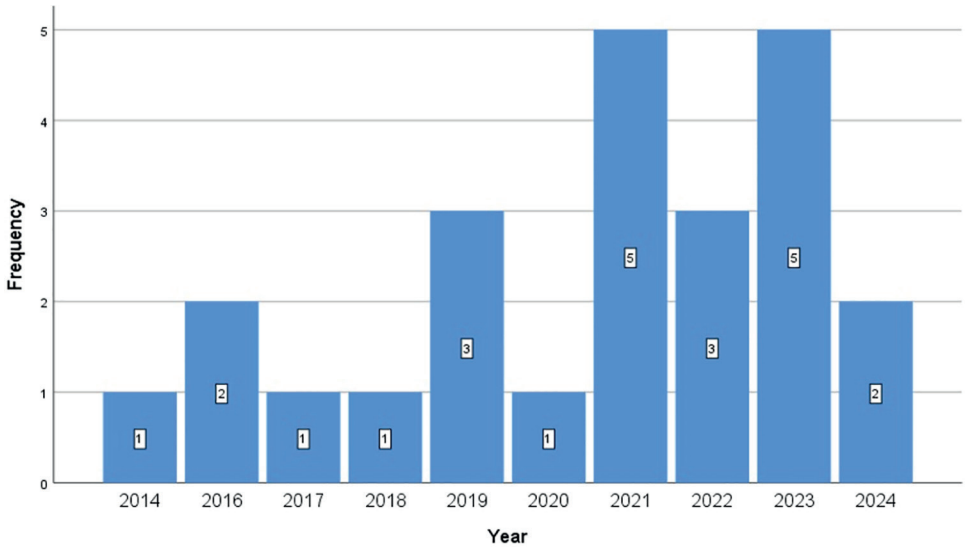

Figure 2: The frequency of included studies is shown based on the year of categorization

Discussion

Studies Investigating Business Intelligence in Cancer

This study investigated the application of business intelligence in cancer management.

Based on the Basile *et al.*'s study results, business intelligence offers a valuable approach to supporting healthcare providers and decision-makers in the effective utilization of patient data for managing care processes. (2). This issue is covered well in the reviewed studies. Each of the business intelligence systems was created for patient safety (S3, S16, S17, S24), improving the performance of medical staff in monitoring and controlling patients (, S21, S1, S2, S4, S5, S6, S7, S10, S12, S14, S15, S19, S20, S22, S23), helping decision-makers and managers to adopt optimal policies in allocating resources to patients (S6, S11), monitoring the performance of health service providers for cancer patients (S13, S18), and proper management of resources and supervision of workflow in these departments (S8, S9).

Bray *et al.* revealed that breast cancer and prostate cancer have a high prevalence in the world (40), highlighting their monitoring importance. Most of the reviewed studies were in the field of managing prostate cancer (S1, S2, S3, S4) and breast cancer (S5, S6, S21) through business intelligence. Thus, the findings from these studies confirm the utility of business intelligence as an effective tool for organizing patient data and offering cost-effective services.

Additionally, based on the geographical distribution, more than half of the studies were conducted in the USA (S1, S4, S7- S10, S14, S16, S17, S19, S21, S23, S24), which were designed for the efficient management of cancer and the care of patients. The results of the Zarowitz *et al.'s* study showed that the use of digital technologies in health care in the USA was expanding (41). This trend aligns with the rising cancer incidence in the USA (42).

Specifications of Business Intelligence Tools Used in the Research

Most of the reviewed studies used primary data sources that were directly provided by medical centers and healthcare organizations, and only one study used secondary data sources (S20). The results of Khodaveisi *et al.'s* study showed that data sources played a crucial role in dashboard development as they form the basis for creating key performance indicators and addressing user needs. Users can use with more confidence the resources that are collected by reliable organizations and centers (43).

Healthcare data can be displayed at various scales, depending on the needs and objectives of the organization, allowing managers to effectively assess patient populations and apply appropriate policies to enhance care quality (2). In this review, most business intelligence systems were implemented at the organizational level (S1, S2, S5, S7- S10, S15, S16, S17, S19, S21).

However, a safe and user-friendly platform for users to access business intelligence systems is important for healthcare organizations. In this review, BI systems were often web-based (S2- S5, S6, S8, S9, S11, S13, S19, S20, S22, S24). The results of the Khodaveisi *et al.'s* study showed that the web-based environment was user-friendly and secure, and making changes to it is easily visible to all users (43). Users are an important part of information systems and play an effective design role. Therefore, understanding users' demands is vital in designing information systems (44, 45). Business intelligence systems are not excluded from this case, and users play a key role in its design (46). Li *et al.'s* study showed that the indicators and data elements should be determined based on the user's needs. Identifying the indicators and data required by users and the methods of transferring them is difficult (47). However, this issue was well mentioned in the reviewed studies. This issue has been well investigated in studies. It was identified that the indicators and data elements of business intelligence systems, including data elements and indicators related to patient referrals, the progress of the patient's treatment, and their symptoms, were what the physicians, oncologists, and other specialists and treatment staff needed (S1, S3, S4, S5, S6, S9, S10, S11, S13, S14, S16, S17, S19, S20 -S24). In addition, information on health services to cancer patients, resource management indicators, equipment, and workflow in these departments has been provided to managers and officials by suitable indicators (S8, S9, S12, S18). Also, in some cases, patients were considered users of the business intelligence systems (S1, S7, S15).

Strengths and Limitations

The use of Arksey and O'Malley's framework,

along with the enhanced methodology proposed by Levac et al., is a notable strength of this study, providing a robust and systematic approach to identifying and extracting relevant data from the included studies. However, a key limitation was the lack of access to the full text of several articles.

Conclusion

In summary, business intelligence, through its practical tools and methods, enables the effective use of patient health data and provides critical insights to healthcare managers and decision-makers. This information facilitates informed decisions and the development of policies which aimed at improving the quality of care for cancer patients. Furthermore, the business intelligence systems have more or less similar characteristics and all of them provide the necessary and important data to decision-makers in the field of cancer. However, few studies examined the performance of oncology departments, the effectiveness of patient services, or financial information through business intelligence systems. Therefore, it is recommended that a systematic review should be conducted focusing on identifying key performance indicators for oncology departments to optimize the use of business intelligence in department management as future work.

Acknowledgment

We extend our sincere gratitude to all those who contributed to this review.

Conflict of Interest

There are no conflicts of interest.

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