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DIGITAL KNOWLEDGE MANAGEMENT IN HEALTHCARE: A SCOPING REVIEW

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DIGITAALNE TEADMUSE HALDAMINE TERVISHOIUS: KIRJANDUSE ANALÜÜS

[Magistritöö]

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Author's declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature, and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

Background: In contemporary healthcare, effective knowledge management is pivotal in determining patient outcomes and the overall quality of healthcare services. Digital knowledge management (DKM), an evolving field, is poised to bring about transformative changes in healthcare. This is by facilitating the efficient creation, organization, dissemination, and utilization of knowledge assets for positive patient outcomes and overall healthcare quality.

Aim: This study seeks to comprehensively assess the impact of DKM on patient outcomes and healthcare quality. The study investigated the current state of knowledge management (KM) practices in healthcare by conducting a comprehensive literature review. Thus, identifying the tools, technologies, and strategies for knowledge organization, dissemination, and utilization within the healthcare systems worldwide.

Method: The Scoping Review (SR) approach ensured a wider scope of selected articles. The aim was to evaluate relevant literature comprehensively and draw conclusions that offer insights into the impact of DKM on patient outcomes and healthcare quality. Conclusions were drawn from existing literature to understand how DKM impacts patient outcomes and healthcare quality from the perspectives of DKM tools (clinical decision support system (CDSS) and open biomedical repository (OBR)), existing DKM strategies, and evidence support for the role of DKM in fostering informed (clinical) decision-making.

Results: There is limited empirical evidence, and the research area is evolving. However, ongoing research provided 15 articles. These were reviewed, and each provided evidence on existing DKM systematic strategies, tools, and evidence-based impact of DKM on patient outcomes and healthcare quality. The study found positive impacts and empirical evidence supporting DKM's impact on positive patient outcomes and healthcare quality. However, findings may not be generalizable, and some results may be region- and treatment-specific.

Conclusion: Leveraging DKM in healthcare facilitates the efficient organization and utilization of medical data and information, leading to more informed decision-making. By ensuring seamless access to up-to-date knowledge, DKM empowers healthcare professionals to deliver personalized, evidence-based care, ultimately enhancing patient outcomes and elevating the overall quality of healthcare services.

Future Research: Explore the effectiveness and implementation challenges and longevity of DKM systems within healthcare. The possible ways of how these can enhance knowledge organization, decision support, and patient outcomes for the continuous improvement of healthcare delivery.

Key Words*: Clinical decision support system, Digital knowledge management, CDSS architecture, Knowledge repositories, CDS tools.*

The thesis is in English and contains 58 pages of text, 5 chapters, 5 figures, 12 tables.

Annotatsioon

Digitaalne teadmuse haldamine tervishoius: Kirjanduse analüüs

Taust: Kaasaegses tervishoius on tõhus teadmusjuhtimine keskse tähtsusega patsientide tulemuste ja tervishoiuteenuste üldise kvaliteedi määramisel. Digitaalne teadmusjuhtimine (DKM) on arenev valdkond, mis võib tuua tervishoius muutusi. See hõlbustab teadmiste varade tõhusat loomist, organiseerimist, levitamist ja kasutamist, et saavutada positiivseid tulemusi patsientidele ja üldist tervishoiu kvaliteeti.

Eesmärk: Käesoleva uuringu eesmärk on hinnata igakülgselt DKMi mõju patsientide tulemustele ja tervishoiu kvaliteedile. Uuringus uuriti teadmiste juhtimise (KM) tavade hetkeseisu tervishoius, viies läbi põhjaliku kirjanduse ülevaate. Seega tuvastati teadmiste korraldamise, levitamise ja kasutamise vahendid, tehnoloogiad ja strateegiad tervishoiusüsteemides kogu maailmas.

Meetod: Scoping Review (SR) lähenemisviis tagas valitud artiklite laiema ulatuse. Eesmärk oli hinnata asjakohast kirjandust põhjalikult ja teha järeldusi, mis annavad ülevaate DKMi mõjust patsiendi tulemustele ja tervishoiu kvaliteedile. Olemasolevast kirjandusest tehti järeldusi, et mõista, kuidas DKM mõjutab patsiendi tulemusi ja tervishoiu kvaliteeti DKMi vahendite (kliinilise otsustamise tugisüsteem (CDSS) ja avatud biomeditsiiniline repositoorium (OBR)), olemasolevate DKMi strateegiate ja DKMi rolli tõenduspõhisuse seisukohast teadliku (kliinilise) otsustamise edendamisel.

Tulemused: Empiirilised tõendid on piiratud ja uurimisvaldkond areneb. Käimasolevad uuringud andsid siiski 15 artiklit. Need vaadati läbi ja igaüks neist andis tõendeid olemasolevate DKMi süstemaatiliste strateegiate, vahendite ja DKMi tõenduspõhise mõju kohta patsiendi tulemustele ja tervishoiu kvaliteedile. Uuringus leiti positiivne mõju ja empiirilised tõendid, mis toetavad DKMi mõju patsientide positiivsetele tulemustele ja tervishoiu kvaliteedile. Siiski ei pruugi tulemused olla üldistatavad ning mõned tulemused võivad olla piirkond- ja ravispetsiifilised.

Järeldused: DKMi kasutamine tervishoius hõlbustab meditsiiniliste andmete ja teabe tõhusat korraldamist ja kasutamist, mis viib teadlikumate otsuste tegemiseni. Tagades tõrgeteta juurdepääsu ajakohastele teadmistele, annab DKM tervishoiutöötajatele võimaluse pakkuda personaliseeritud, tõenduspõhist ravi, parandades lõppkokkuvõttes patsientide tulemusi ja tõstes tervishoiuteenuste üldist kvaliteeti.

Tulevased teadusuuringud: Uurida DKM-süsteemide tõhusust ja rakendamise probleeme ning nende pikaajalisust tervishoiusüsteemides. Võimalikud viisid, kuidas need võivad parandada teadmiste korraldamist, otsuste toetamist ja patsiendi tulemusi tervishoiuteenuste osutamise pidevaks parandamiseks.

Võtmesõnad: Kliiniliste otsuste tugisüsteem, digitaalne teadmusjuhtimine, CDSS arhitektuur, teadmusrepositooriumid, CDS-vahendid.

Lõputöö on kirjutatud Inglise keeles ning sisaldab teksti 58 leheküljel, 5 peatükki, 5 Figuret, 12 tabelit

List of abbreviations and terms

CDSS	Clinical Decision Support System
CQI	Continuous Quality Improvement
DKM	Digital Knowledge Management
eCDSTs	Electronic Clinical Decision Support Tools
EHRs	Electronic Health Records
EMRs	Electronic Medical Record systems
HIE	Health Information Exchange
OBR	Open Biomedical Repository
OECD	Organization for Economic Cooperation and Development
IT	Information Technology
KM	Knowledge Management
KS	Knowledge Sharing
KB-CDSS	Knowledge-Based Clinical Decision Support System
MLD	Medical Literature Databases
RDs	Rare Diseases
RQ	Research Question
SR	Scoping Review
SLR	Systematic Literature Review
WHO	World Health Organization

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> "The goal of healthcare is to create an ecosystem of care that seamlessly integrates technology, information, and human touch to deliver the best possible outcomes for every patient -Bill Oldham" *(Honeyman et al., 2016)*

Introduction

Knowledge Management (KM) is an indispensable and imperative process that encompasses identifying, organizing, storing, and disseminating information within an organization (Lam et al., 2021). To optimize this critical undertaking, Karsikas et al. (2022) opined the strategic implementation of digital knowledge management (DKM) strategies, leveraging cutting-edge digital tools and platforms. This assumes paramount importance in effectively collating, documenting, organizing, and centralizing organizational knowledge. By embracing DKM, Lam et al. (2021) and Karsikas et al. (2022) agree that it produces seamless accessibility of knowledge, catering to both internal and external stakeholders and customers. Thus, reluctance to embrace DKM can engender substantial knowledge deficits, impeding organizational growth and overall success (Karsikas et al., 2022).

Data, information, and KM are distinct but interwoven concepts. Parast and Golmohammadi (2019) opine that data management involves handling raw facts and figures (data points) like patient demographics or test results, e.g., a patient's blood pressure readings. Information management takes these data points, processes them, and adds context (Kovačić et al., 2022). Electronic health records (EHRs) are prime examples, containing a patient's medical history (Uibu et al., 2020), clinical notes, and lab reports, all organized for healthcare professionals' use. KM goes a step further, converting information into actionable insights. According to Abbasi et al. (2018), KM includes clinical guidelines, research findings, and expertise. For instance, best practices for managing diabetes are a form of knowledge, derived from research and expert consensus. Together, these layers facilitate informed decision-making and evidence-based care. Therefore, efficient data management ensures data accuracy, information management aids in clinical diagnosis, and KM disseminates best practices, ultimately improving patient outcomes and healthcare quality (Kovačić et al., 2022; Uibu et al., 2020; Abbasi et al., 2018).

In healthcare, DKM takes a more distinctive role. It systematically captures, organizes, stores, and leverages knowledge by using digital technologies to improve patient care, enhance medical research, and optimize healthcare operations (Fernández-Gutiérrez et al., 2021). According to Wartman and Combs (2019), various digital tools and platforms handle vast amounts of medical data, clinical expertise, research findings, and best practices efficiently and effectively. These are distinctively spread across data, information, and KM. Electronic Health Records (EHRs) (information), Clinical Decision Support Systems (CDSS) (combined data, information, and knowledge), Health Information Exchange (HIE) (information), Medical Literature Databases (MLD) (knowledge management), telemedicine and remote monitoring, clinical pathways and protocols, training and education, data analytics and business intelligence, and security and privacy (Wartman & Combs, 2019; Lam et al., 2021; Fernández-Gutiérrez et al., 2021).

For patient outcomes, the aspects most pertinent to DKM are the effective application of knowledge from existing systematic capture of information (Uibu et al., 2020). For instance, when a physician treats a patient with a complex medical history, DKM tools integrated into the EHR system allow immediate access to comprehensive records. This enables well-informed decisions, preventing potential adverse reactions due to drug interactions (Bertl et al., 2023). According to Colombo et al. (2020), some rural clinics may be able to utilize DKM-powered telemedicine platforms (CDSS). Patients with chronic conditions can remotely transmit vital signs and symptoms via wearable devices, manually input to a DKM system that analyzes this data and alerts healthcare providers to concerning changes, allowing timely interventions to prevent health deterioration.

Since DKM can support patient engagement by providing easy-to-understand educational materials about their conditions and treatment options (Behnke et al., 2021, p. S33), diabetic patients could for instance access a digital knowledge portal that explains dietary guidelines, medication regimens, and self-monitoring techniques which empowers patients to manage their health effectively, leading to improved blood sugar control and overall well-being. Effective DKM implementation in healthcare could also lead to improved patient outcomes, reduced healthcare costs, and streamlined operations (Karsikas et al., 2022). However, it also demands careful attention to data governance, system integration, and training to ensure successful adoption and utilization by healthcare professionals (Wartman & Combs, 2019).

Ultimately, DKM enhances patient outcomes by ensuring healthcare professionals have reliable access to relevant information, facilitating proactive interventions, and engaging patients in their care (Mangalmurti et al., 2020). These practical applications translate into better diagnoses, personalized treatments, and overall improved patient health. Healthcare professionals, including doctors and medical personnel, often find themselves in a challenging situation. While they have access to an abundance of medical information, the sheer volume of data can overwhelm them (Dwivedi et al., 2022). This is especially critical because making the right decisions quickly is vital in healthcare. Doctors frequently see numerous patients daily, and they must base their diagnoses and treatment plans on their knowledge and the limited patient data available during each encounter (Bertl et al., 2023).

To tackle complex cases or unfamiliar symptoms, doctors often engage in discussions with their colleagues to arrive at educated guesses and treatment plans. However, according to Katamoura and Aksoy (2022), the advent of healthcare DKM systems has transformed this landscape. These systems empower doctors to access a wealth of medical knowledge and data, making a significant difference in patient outcomes (Öberg et al., 2018; Katamoura & Aksoy, 2022). With advanced diagnostic algorithms and predictive analytics, DKM can enhance collaboration among practitioners and ensure the availability of essential knowledge throughout the healthcare organization paramount to patients' outcomes. Therefore, DKM plays a crucial role in improving diagnostic accuracy, treatment decisions, and overall patient care (Öberg et al., 2018).

Therefore, the study's objective is to explore prevalent DKM practices in healthcare, drawing insights from credible sources in the field. The study identifies tools, technologies, and strategies for knowledge organization, dissemination, and utilization. Furthermore, the study conducts a comprehensive literature review to explore DKM adoption and its impact on patient outcomes. The results are expected to evaluate DKM's effectiveness, challenges, and potential areas for improvement, including identifying successful models that can be replicated or adapted in other healthcare systems.

The research questions are as follows:

RQ 1: What systematic strategies have been implemented to capture and organize healthcare knowledge effectively in the last five years?

RQ 2: What recent tools have been developed to enhance the digitization of healthcare knowledge?

RQ3: What empirical evidence supports the role of DKM in advancing informed decision-making and fostering positive patient outcomes in healthcare?

This thesis is divided into six main parts. The thesis begins with an Introduction to the research area, existing research problem, and research questions. Next, a review of the existing literature section is divided into sub-sections under, global DKM practices, DKM tools and strategies, and knowledge adoption and utilization. Next is the methodology section which elucidates the method of acquiring and using data to answer research questions. Following this is the results section that depicts the evaluated data. Next is the Discussion of retrieved results. Finally, the conclusion section.

1. Background Literature

1.1 Digital Knowledge Management in Healthcare

Digital knowledge management has become a critical focus within the healthcare sector (Yakovchenko et al., 2021; Colombo et al., 2020; Wartman & Combs, 2019). This trend is primarily driven by substantial investments in information technology (IT) in healthcare, the adoption of advanced information management systems for capturing, recording, and retrieving healthcare knowledge, and the prevailing belief that 'the machine can do it all' (Dwivedi et al., 2022, p. 312) The world of IT often dazzles with its promises and myths, creating an illusion that healthcare challenges can be easily resolved with a click. However, Öberg et al. (2018) argue that healthcare is a profoundly intricate domain characterized by intricate elements such as thoughts, beliefs, culture, rituals, and individual perceptions, which even the most sophisticated IT systems struggle to fully comprehend. While IT plays a crucial role, Thomas and Hailai (2021) opined that a comprehensive approach to DKM in healthcare necessitates a broader consideration of organizational, political, and socio-cultural dimensions. Thus, concentrating solely on IT would lead to an incomplete perspective on DKM within healthcare, disregarding the essential socio-cultural, political, and ethical facets inherent in healthcare organizations (Behnke et al., 2021; Katamoura & Aksoy, 2022).

Recent developments underscore the need to strike a balance between technological advancements and the complex human aspects within the healthcare sector (Colombo et al., 2020). According to Blonigen et al. (2023), organizations that are linked to knowledge creation possess the invaluable ability to enhance their overall performance and effectively leverage intermediate knowledge to foster subsequent innovations. In developed countries, Yakovchenko et al. (2021) and Blonigen et al. (2023) believe the implementation of DKM has garnered significant attention and adoption including multilateral organizations, such as the World Health Organization (WHO) and the United Nations (UN) have played pivotal roles in promoting and facilitating the integration of DKM into healthcare practices globally. Statistics from reputable sources underline the growing significance of DKM in healthcare. For instance, according to the World Bank, the adoption of digitization in healthcare has contributed to a notable increase in research and development investments in these countries, resulting in a remarkable 15% rise in healthcare innovation output over the past decade

(Machado et al., 2022). Additionally, the Organization for Economic Cooperation and Development (OECD) reports that countries with robust DKM infrastructures have experienced an average of 25% higher healthcare quality indices, demonstrating the tangible benefits of DKM in optimizing healthcare delivery and patient outcomes (OECD, 2022).

From an interesting perspective, Paoloni et al. (2022) argue knowledge sharing (KS) is a fundamental aspect of DKM. DKM involves using digital tools and systems to capture, store, organize, and retrieve knowledge within an organization while KS is about people within that organization actively exchanging their expertise, insights, and information through these digital systems (Paoloni et al., 2022). Thus, while DKM focuses on the technology and processes for managing knowledge, knowledge sharing is the human element that ensures valuable insights and information flow efficiently through those systems.

Illustratively, DKM is like having a well-organized library where people can easily find and contribute books (knowledge), but the librarians (knowledge sharing) play a crucial role in helping users navigate and access the right books at the right time. Therefore, knowledge sharing complements and enhances the effectiveness of DKM by ensuring that the knowledge stored digitally is actively used and beneficial to the organization (Ibid). Healthcare professionals can collaborate more efficiently, access up-to-date medical literature and guidelines, and consult with colleagues remotely. Patients can also be empowered to participate in their healthcare decisions by accessing digital resources, sharing their medical histories, and receiving timely information about their conditions (Dwivedi et al., 2022).

1.2 Digital Knowledge Management Process in Healthcare

As described by Jayaraman et al. (2022), the DKM process within the healthcare domain stands as the bedrock upon which a profound comprehension of DKM's multifaceted dimensions. This encompasses its diverse array of tools and their profound implications in the healthcare ecosystem can be constructed. Through this process, digital innovations and strategic implementations can be harnessed to amplify the accessibility, propagation, and application of medical knowledge among healthcare professionals. The DKM process in healthcare involves several key steps to effectively capture, store, organize, and utilize knowledge in a digital format. Marha and Ruiz (2019) suggest a 7-step process and Martin and Lewis (2021) suggest three additional steps. These steps were merged below.

Figure 1- DKM Process in Healthcare

Pereira and Santos (2019) reiterated that knowledge capture is indispensable as it involves the identification, retrieval, and documentation of both tacit and explicit knowledge held by healthcare professionals and experts. This step safeguards against the loss of valuable insights, making it possible to effectively share and utilize this expertise throughout the healthcare system. This can include medical research articles, patient records, clinical guidelines, best practices, and expert insights.

The *data entry and conversion step* involves raw data and information entered in digital formats that can be easily stored and accessed. Marha and Ruiz (2019) believe these involve scanning physical documents, manual data entry, or automated data extraction from sources like EHRs. Simultaneously, the data entry and conversion phase, as emphasized by Martha and Hamon (2020), assumes equal significance. During this phase, unprocessed data from diverse sources are transformed into structured and standardized formats. These standardized datasets serve as the bedrock for knowledge extraction and analysis, facilitating evidence-based decision-making and ultimately enhancing patient care. This symbiotic relationship empowers healthcare organizations to leverage their data repositories for innovation, improved care quality, and efficient resource allocation (Martha & Hamon, 2020).

Storage and Organization. Once data is digitized, Marha and Ruiz (2019) opine it is stored in secure databases or repositories that are organized for data efficiency which makes it easy to search for and retrieve specific information. Taxonomies, metadata, and categorization help in this process. *Indexing and search steps* ensure users (healthcare professionals or researchers) can quickly find the information they need. This often involves implementing robust search engines and using standardized medical terminologies such as SNOMED CT (Systematized Nomenclature of Medicine—Clinical Terms), LOINC (Logical Observation Identifiers Names and Codes), and CMT (Clinical Microsystem Terminology) (Pereira & Santos, 2019).

The *access control and security step* ensures patients' data and sensitive medical information are protected and only authorized personnel can view or edit specific data. This is done with security measures like encryption and authentication. The ten steps in Figure 1, Martin and Lewis (2021) add three additional steps to Marha and Ruiz's (2019) 7-step—knowledge sharing, continuous update and maintenance, and quality control. *The knowledge-sharing step* involves making the knowledge accessible to those who need it. Healthcare professionals can share and collaborate on medical knowledge within a secure digital environment including telemedicine consultations, virtual meetings, and collaborative platforms (Martin & Lewis, 2021).

The *continuous update and maintenance step* involves the updating of existing medical knowledge as it constantly evolves. This means digital knowledge repositories are regularly updated with the latest research findings, clinical guidelines, and best practices, a process for reviewing and incorporating new information (Martin & Lewis, 2021). *Quality Control* ensures quality assurance measures verify the accuracy and reliability of the knowledge stored in digital systems. This includes peer review processes for medical literature and validation of data accuracy (Ibid). The *Knowledge Application step* ensures the knowledge stored digitally must be applied to patient care. Healthcare professionals can access relevant information at the point of care to make informed decisions, diagnose patients, and develop treatment plans (Martha & Hamon, 2020). *Feedback and Improvement* an essential DKM process because the feedback from healthcare professionals and patients can help identify areas for improvement in the system's usability and effectiveness. Therefore, the DKM process aims to leverage technology to improve the accessibility, accuracy, and utility of medical knowledge, ultimately leading to better patient outcomes and more efficient healthcare practices (Pereira & Santos, 2019; Martha & Hamon, 2020).

1.3 Electronic Health Records and Health Information Exchange systems

Electronic Health Records (EHRs) and Health Information Exchange systems (HIEs) have emerged as transformative tools in healthcare quality improvement across various countries. According to Fernández-Gutiérrez et al. (2021), HIE is not typically considered a DKM tool in the same sense as software explicitly designed for knowledge management within an organization. They primarily serve as a platform for the secure exchange of patient health information between different healthcare providers and organizations to improve patient care coordination, reduce duplication of tests, and enhance healthcare delivery by ensuring that relevant medical information is readily available to authorized healthcare professionals (Kovačić et al., 2022). While HIEs do involve the digital sharing of medical information (patient health records), Fernández-Gutiérrez et al. (2021) opine they are specialized systems with a specific focus on patient data exchange rather than comprehensive knowledge management encompassing broader organizational knowledge.

According to Wartman and Combs (2019), their implementation has yielded substantial benefits, enriching patient care, enhancing care coordination, and reducing medical errors. Cervenka and Iber (2020) believe that EHR adoption is widespread in the United States. The Beacon Community Program, supported by the Office of the National Coordinator for Health Information Technology (ONC), serves as an illuminating example. EHR demonstrated that its usage significantly reduced hospital admissions and emergency department visits, particularly among patients with chronic conditions like diabetes (Cervenka & Iber, 2020). This reduction is indicative of the enhanced care coordination and patient management facilitated by EHR systems.

Canada, too, has seen a positive impact on healthcare quality. According to Kitt and Pierre (2020) and Canada Prenatal Nutrition Program research published in the Canadian Medical Association Journal in 2021, EHRs have contributed to a remarkable 37% reduction in prescribing errors and a substantial 68% decrease in potential adverse drug events. Australia's My Health Record system exemplifies the role of EHRs in cost savings (Roseleur et al., 2023). The Netherlands has leveraged EHRs to enhance chronic disease management. This allows patients with conditions such as diabetes now receive personalized care plans and regular monitoring, resulting in better disease control and fewer hospitalizations (Cervenka & Iber, 2020).

Rwanda stands out as an example of how EHRs and HIE systems have positively impacted maternal and child health. These technologies have led to a 7% increase in facility-based deliveries and a remarkable 50% reduction in maternal mortality rates in health facilities using EHRs (Fraser et al., 2022). The improved tracking and management of maternal health data played a pivotal role in these achievements. These examples collectively highlight the substantial contributions of EHRs and HIE systems to healthcare quality. They underscore the importance of these technologies in reducing errors, improving care coordination, enhancing patient engagement, and ultimately achieving better patient outcomes. As the global healthcare landscape evolves, these tools play a pivotal role in driving quality improvements.

1.4 Global Digital Knowledge Management Tools and Practices

Several countries have emerged as leaders in adopting and implementing DKM practices across various sectors, with a particular focus on healthcare. These countries have made significant strides in harnessing the power of DKM to improve knowledge sharing, decision-making, and innovation within their respective domains. In the United States, for instance, Chen et al. (2019) believe the widespread adoption of EHRs and HIE systems has created a robust foundation for knowledge management within the healthcare sector. This has enabled medical professionals to access and share critical information efficiently such as the CommonWell Health Alliance and Carequality (Landi, 2019). Similarly, Canada, South Korea, the Netherlands, Germany Sweden's eHealth initiatives, and China's Smart Healthcare have all made efforts that paved the way for enhanced knowledge sharing, more informed decision-making, and increased innovation within their respective sectors, particularly in healthcare (Slawomirski et al., 2023).

1.4.1 Clinical Decision Support System

Johansson-Pajala et al. (2018) opine a Clinical Decision Support System (CDSS) is a computer-based tool or software application designed to assist healthcare professionals, including doctors, nurses, and other medical staff, in making clinical decisions regarding patient care. Katamoura and Aksoy (2022) add that CDSS systems are built upon medical knowledge and can incorporate various types of information, such as patient data, medical guidelines, research findings, and best practices. However, Neugebauer et al. (2020) argue their significance is underscored by the fact that healthcare is a global concern, and the effective use of CDSS has the potential to address healthcare challenges worldwide. For example, country statistics from the United States (US), United Kingdom (UK), and India have shown an impeccable effect on patient outcomes from initial diagnosis to treatment. In the US, the Journal of the American Medical Informatics Association in 2019 reported that CDSS helped reduce medication errors by 55%. Moreover, the CDC estimated that in the US, healthcare-associated infections affected 1 in 31 hospitalized patients in 2015, and CDSS has been employed to combat these infections (Neugebauer et al., 2020). This is evident in the UK through the National Health Service Report in 2020 employed to aid in early diagnosis and intervention for conditions such as sepsis, contributing to a reduction in sepsis-related deaths (Fritz & Otto, 2021). Despite the shortage of healthcare professionals relative to the population in India, CDSS has been deployed in telemedicine initiatives. These systems help rural and underserved communities access quality healthcare by connecting them with specialists through digital platforms.

Global health initiatives under the World Health Organization recognize the value of CDSS as a combined data, information, and knowledge tool in achieving global health objectives. It can assist in adherence to treatment guidelines for diseases like HIV/AIDS and tuberculosis, which are significant global health concerns (Aayog, 2018). To further understand the significance of a CDSS as a data, information, and knowledge-decision-making tool, the Figure depicts key aspects of a CDSS.

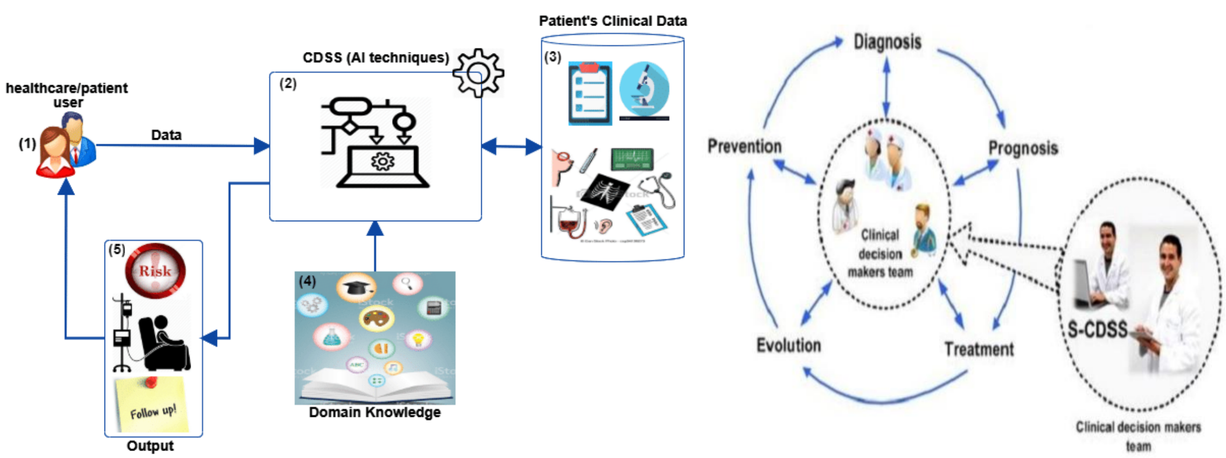

Figure 2- Basic CDSS Set-up and Smart CDSS (Jayaraman et al., 2022; Pournik et al., 2022)

Furthermore, Pournik et al. (2022) argue that CDSS holds immense global significance, offering solutions to a multitude of challenges in healthcare. One of the primary contributions of CDSS on a global scale is the standardization of care (Pournik et al., 2022). Inconsistent healthcare practices are a persistent issue worldwide, often due to clinical knowledge and expertise variations. Uibu et al. (2020) agree that CDSS addresses this by providing healthcare professionals access to the latest medical guidelines and best practices, regardless of their location. Thus, by ensuring that healthcare providers have real-time access to evidence-based recommendations, CDSS helps deliver consistent and high-quality care to patients around the world.

Reducing medical errors is a global imperative (Blonigen et al., 2023). Medical errors not only lead to patient harm but also result in substantial healthcare costs. Katamoura and Aksoy (2022) add that CDSS systems are designed to act as vigilant partners for healthcare providers. They can promptly alert clinicians to potential errors, such as drug interactions or incorrect dosages, thus mitigating the risk of adverse events. In a global context, this translates to safer healthcare practices, reducing patient harm, and substantial savings in healthcare expenditure (Thomas & Hailai, 2021).

In remote or underserved areas, where access to healthcare is limited, CDSS emerges as a lifeline (Cervenka & Iber, 2020). These regions often lack the presence of specialized healthcare professionals, making accurate diagnoses and treatment decisions challenging. Thomas and Hailai, (2021) argue that CDSS can bridge this gap by empowering local healthcare workers with advanced decision-support tools. Thus, they can make more accurate decisions, often with the remote guidance of specialists. This democratization of medical expertise ensures that even the most underserved communities receive quality healthcare, thereby reducing healthcare disparities on a global scale. Therefore, CDSS has far-reaching global implications. It not only standardizes care practices, reducing variations and improving quality but also contributes to the reduction of medical errors, particularly in a world where patient safety is paramount (Uibu et al., 2020). Its ability to support healthcare workers in remote and underserved areas and its role in addressing global health challenges make CDSS an invaluable asset in the pursuit of equitable and effective healthcare worldwide. It is not just a technological advancement but a powerful tool for safeguarding and enhancing human health on a global scale (Cervenka & Iber, 2020; Pournik et al., 2022; Bertl et al., 2023).

1.4.2 Knowledge-Based Clinical Decision Support System

In the fast-evolving healthcare industry, the integration of cutting-edge technology is reshaping the way clinicians make critical decisions (Bashir et al., 2021). The Knowledge-Based Clinical Decision Support System (KB-CDSS) has the potential to transform patient outcomes and redefine the role of clinicians in the modern era (Yang et al., 2016; Martinez-Garcia et al., 2021). According to Martinez-Garcia et al. (2021, p. 5), at its core, a KB-CDSS is an intelligent software system fueled by vast repositories of medical knowledge, clinical guidelines, and patient data.

The primary function of a KB-CDSS is to empower clinicians with actionable insights at the point of care (Bashir et al., 2021; Martinez-Garcia et al., 2021). By synthesizing a wealth of medical knowledge and clinical data, the system assists in diagnostic decision-making, treatment planning, and risk assessment (Bashir et al., 2021). As a digital companion, it offers real-time recommendations based on the latest evidence, thereby enhancing the precision and efficacy of clinical interventions. One key aspect that sets the KB-CDSS apart is its ability to continuously learn and adapt (Martinez-Garcia et al., 2021). As it processes more patient data and incorporates the latest medical research, the system evolves, becoming increasingly adept at recognizing patterns and predicting outcomes. This dynamic learning capability ensures that clinicians are equipped with the most up-to-date information, contributing to more informed decision-making. However, it is not without limitations. The primary challenges include the potential for overreliance, as clinicians might defer excessively to the system, compromising their independent judgment (Beauchemin et al., 2019). Beauchemin et al. (2019) argue that the accuracy of the KB-CDSS relies heavily on the quality and currency of the underlying knowledge base, rendering it susceptible to information gaps and outdated data.

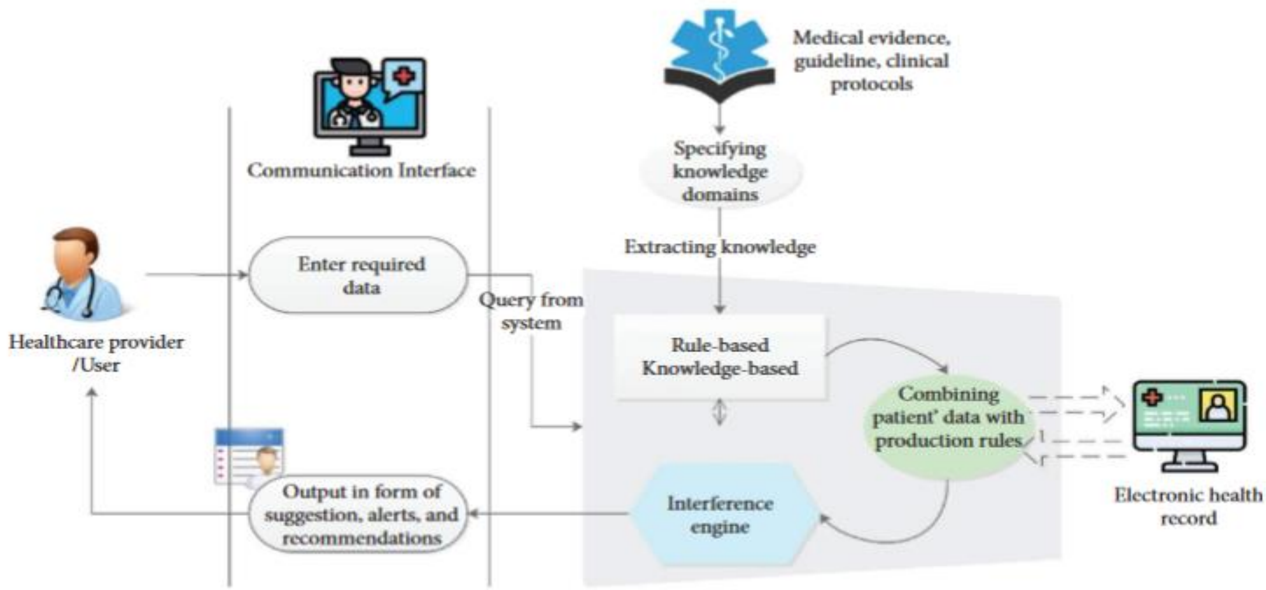

Figure 3-General Model of KB-CDSS *(Gholamzadeh et al., 2023, p. 16)*

The KB-CDSS also serves as a bridge between clinical expertise and the vast expanse of medical knowledge. From figure 3, it acts as a virtual mentor, guiding clinicians through complex cases and providing context-specific information. This not only enhances diagnostic accuracy but also fosters a culture of continuous learning among healthcare professionals. The KB-CDSS integrates seamlessly into existing EHR or electronic medical record systems (EMR), creating a unified platform for clinicians (Gholamzadeh et al., 2023). This allows KB-CDSS to streamline workflows by automating routine tasks, allowing clinicians to focus more on patient interaction and less on administrative burdens (Gholamzadeh et al., 2023).

The contributions of the KB-CDSS to modern treatments are multifaceted (Bashir et al., 2021; Bertl et al., 2023; Yang et al., 2016). Bertl et al. (2023) argue that KB-CDSS helps in minimizing diagnostic errors and improving treatment adherence directly impacts patient outcomes. This is pivotal in resource optimization, reducing unnecessary tests and treatments, and lowering healthcare costs. However, user interface complexities and the need for comprehensive training might impede widespread adoption among healthcare professionals (Johansson-Pajala et al., 2018). Striking a balance between technological reliance and human expertise, addressing data accuracy concerns, and optimizing user-friendly interfaces are imperative for maximizing the benefits of the KB-CDSS. Thus, Bashir et al. (2023) conclude the system is a technological instrument that has dynamic learning capabilities, seamless integration, and contribution to informed decision-making. Therefore, as we progress into the future of healthcare, the KB-CDSS stands out as a potent collaborator, ushering in a novel era marked by the convergence of knowledge and technology for the advancement of patient care.

2. Methods and Methodology

2.1 Scoping Review (SR) Overview

According to Martha (2019), a scoping review (SR) is a qualitative, comprehensive method used in research to map existing knowledge on a specific topic or research question. SRs aim to provide a broad overview and exploration of the available literature, distinguishing themselves from quantitative methodologies that prioritize statistical analysis. Systematic literature reviews (SLRs) synthesize evidence from specific study designs. In contrast, SRs embrace a more flexible methodology, allowing for the inclusion of a diverse range of study types to capture the breadth of the literature (Seidman, 2019).

Unlike SLRs which adhere to strict inclusion criteria and prioritize detailed synthesis, SRs are characterized by their exploratory nature (Machado et al., 2022). They emphasize mapping the landscape of the literature, identifying key concepts, and uncovering gaps in knowledge. The methodology of SRs involves a systematic search, but the criteria for study inclusion may be more adaptable to accommodate various types of evidence, such as reviews, case studies, and other relevant literature (Merriam & Tisdell, 2015).

The output of an SR covers a broad, narrative perspective that highlights main themes, concepts, and gaps in the literature. This approach is particularly advantageous for researchers seeking a comprehensive understanding of a field, as SRs provide a broad perspective and serve as a foundation for identifying areas for further research and exploration (Sporrel et al., 2021). The flexibility and inclusivity of SRs make them valuable tools for researchers aiming to map the existing literature, understand the scope of knowledge, and inform the development of future research questions.

Arksey and O’Malley (2005, p. 28) highlight that SRs play a crucial role in ensuring the validity and reliability of findings by systematically evaluating existing studies. This includes reviewing existing bibliographies and flexibility of included articles. This approach helps prevent the replication of flawed research and reduces dependence on biased or incomplete information. The impact of SRs extends to evidence-based decision-making, benefiting policymakers, healthcare professionals, and practitioners who rely on the reviews to inform interventions, treatments, and policies (Arksey & O'Malley, 2005). The systematic evaluation inherent in SRs contributes to the efficiency of contemporary research by saving valuable time and resources. By eliminating the duplication of studies and providing a comprehensive overview of existing literature, SRs offer a systematic approach to navigating extensive research areas. This aids researchers in identifying pertinent studies and synthesizing their outcomes. Thus, it ultimately enhances the overall quality and effectiveness of the research process (Arksey & O'Malley, 2005).

Serving as an indispensable instrument for knowledge consolidation across diverse healthcare-related domains, SRs provide researchers with the means to remain abreast of cutting-edge developments and seamlessly integrate them into their scholarly pursuits (Karl, 2019). It plays a pivotal role in the identification of pertinent resources for addressing research lacunae by unveiling unexplored realms, accentuating methodological deficiencies in extant studies, and effectively harmonizing seemingly discordant findings. By wielding a profound influence on elevating the quality, pertinence, and methodological rigor of research endeavors, it transcends the boundaries of traditional and contemporary academic fields (Kristof & Alexander, 2019). In this vein, the study embarks on an analysis of the existing scholarly sources and resources, seeking to illuminate the impact of digital knowledge management practices on patient outcomes and healthcare quality.

2.2 Study Design and Search Strategy

Karsikas et al. (2022) and Kokorelias et al. (2019) used SR methodology to address their research gaps. To effectively implement the chosen qualitative research design, this study conducts both electronic and manual literature searches (Uibu et al., 2020).

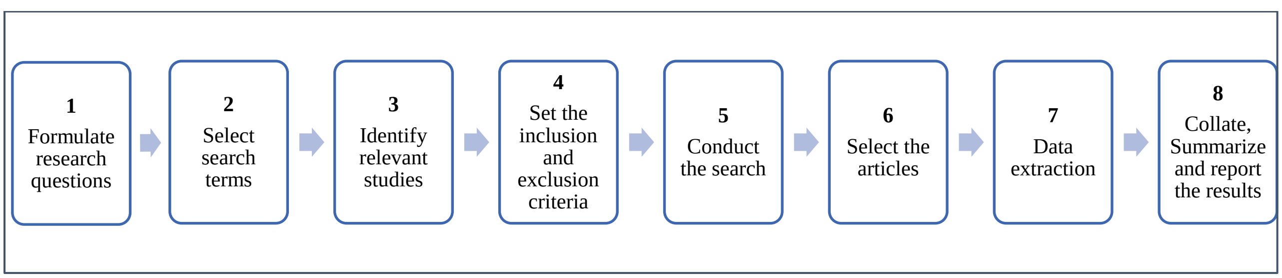

Figure 4- Study Design and Search Strategy *(Arksey & O'Malley, 2005; Karsikas et al., 2022; Kokorelias et al., 2019)*

The SR process has an eight-stage process. Arksey and O'Malley (2005) argue an SR has a five-stage process. However, Kokorelias et al. (2019) and Karsikas et al. (2022) believe that Arksey and O'Malley's (2005) process can be expanded to eight. From the five-stage process, a four-stage process was extracted (1, 3, 6, and 8). These include “identifying the research question, identifying relevant studies, study selection, charting the data, and collating, summarizing and reporting the results” (Arksey & O'Malley, 2005, p. 25). Kokorelias et al. (2019) and Karsikas et al. (2022) added processes 2, 4, 5, and 7.

From Figure 1, Kokorelias et al. (2019) argue the initial stage allows researchers to embark on identifying the research question that will guide the review. This foundational step involves defining the SR's scope, objectives, and parameters to ensure a clear focus. Once the research question is established, the second stage involves systematically identifying relevant studies. This expands to processes 3 and 4 which include conducting a thorough and methodical literature search to capture a broad spectrum of literature related to the research question.

Subsequently, selected search terms are employed to reflect key concepts related to the research questions, facilitating systematic database searches. This includes electronic searches in four databases: Web of Science, PubMed, IEEE Xplore, and Medline (Colombo et al., 2020; Öberg et al., 2018). The search terms, including ‘Digital Knowledge Management,’ ‘Patient Outcomes,’ ‘Healthcare Quality,’ ‘Health Information Systems,’ and ‘Impact Assessment,’ along with their synonyms and combinations, will be used.

For processes 4, 5, and 6, study selection becomes a critical component of the SR process (Kokorelias et al., 2019). Researchers employ predetermined inclusion and exclusion criteria to systematically screen and select studies that align with the review’s objectives. Additionally, the search focuses on scientific, peer-reviewed articles, including primary research articles and reviews, published in English between 2019 and 2023. The timeline between 2019 and 2023 is chosen due to the dynamics of DKM. While older research provides foundational insights and historical context, the dynamic nature of the field suggests considering more recent publications for emerging trends. Therefore, between today and the last five years is appropriate because it provides a suitable and contemporary timeframe that allows the study to capture recent developments, trends, and practices in the field while ensuring that the information gathered remains current and relevant to the research objectives.

With a curated selection of studies, process 7 includes extracting key information from the chosen studies, such as study characteristics, methodologies, and key findings. The systematic organization of this data contributes to a structured synthesis of information. In the final stage of the SR process, researchers focus on collating, summarizing, and reporting the results (Karsikas et al., 2022). This involves the synthesis of findings from the selected studies, and identifying patterns, themes, and gaps in the literature. The results are then presented in a clear and organized manner, providing a comprehensive overview of the current state of knowledge on the chosen topic. These processes ensure a systematic and rigorous approach to conducting scoping reviews, facilitating the generation of valuable insights, and contributing to evidence-informed decision-making in various fields.

Furthermore, manual searches are conducted for the reference lists of included studies from all sources. The study identifies relevant high-quality journals using the same year limitations and inclusion and exclusion criteria. Finally, the review culminates in optional quality checks on selected articles, employing appraisal tools to assess their rigor.

2.3 Study Selection and Criteria

Using the similar study selection process of Machado, Secinaro, Calandra, and Lanzalonga (2022), the study scrutinizes titles, abstracts, and full texts of peer-reviewed papers against pre-established inclusion and exclusion criteria. Specifically, this study selects papers that have reported situations and subsequent actions within hospital settings, focusing on the impact of DKM and knowledge management practices on patient outcomes and healthcare quality. These actions encompassed recommended improvements, feedback stemming from data analysis or recommendations, and the dissemination of knowledge regarding findings and recommendations within an organizational context (Machado et al., 2022).

2.4 Characteristics of Selected Studies

The works of Liberati et al. (2009) and the guidelines presented by Kitchenham and Charters (2007) opine that while a universally fixed minimum number remains absent, a widely endorsed recommendation is to target a cohort of no fewer than 10 to 20 pertinent, and methodologically sound studies. This approach is advocated to establish a substantial and resilient framework for conducting an SR. Therefore, the study uses this as a benchmark in selecting the included studies. The included studies are expected to be across the continent and readily available electronically since the chosen timeline is between 2019 and 2023.

2.5 Data Extraction and Pre-Analysis

The “TITLE-ABS-KEY” typically refers to a search strategy or database field used for conducting comprehensive literature searches (Liberati et al., 2009). Queries can be comprehensive, simplified, or focused (Khan et al., 2022). Therefore, the search for keywords or key terms in the title, abstract, and keywords of research articles identify relevant studies under the four identified databases. This search method helps researchers find articles where the specified terms appear prominently, increasing the likelihood of finding relevant literature (Ibid).

To ease data extraction, pertinent information such as the article title, the source database, and the criteria upon which the evaluation was grounded is retrieved and recorded within an Excel spreadsheet. This systematic approach facilitates subsequent in-depth analysis and comprehensive documentation.

Research Question 1- identifying implemented systematic strategies that capture and organize healthcare knowledge effectively in the last five years (2018-2023) (September 14, 2018, to September 14, 2023)

Keywords such as “systematic strategies,” “systematic approach,” “systematic strategy to practice,” “practical healthcare data capture,” “organize healthcare data,” “capture healthcare information” and “effective healthcare data capture” will be used as base searches. Using the TITLE-ABS-KEY method, (“systematic strategies” OR “methodologies” OR “approaches”) AND (“capture and organize” OR “manage” OR “organize effectively”) AND (“healthcare information” OR “medical data” OR “patient records”) AND (“last five years” OR “recent” OR “up to date”)).

The included articles (title, abstract, and content) will be based on:

i. The availability of full text and covered in the last five years
ii. It is written or translated into English
iii. The title and abstract summarize successfully implemented strategies within the last five years that capture healthcare data and information and organize it effectively.
iv. The articles’ content addresses how healthcare data is collected, stored, and structured for usability and accessibility.

v. The articles addressed research questions using qualitative, quantitative, or mixed methods.

Research Question 2- recent tools developed to enhance the digitization of healthcare knowledge

Keywords such as "recent tools," "new DKM tools," "digital healthcare knowledge," "digitization healthcare knowledge," "digital healthcare knowledge," and "digital healthcare tools," will be used as base searches.

Using the TITLE-ABS-KEY, ("recent tools" AND "digitization" AND "healthcare knowledge"), ("recent tools" AND "healthcare knowledge management" AND "digital transformation"), and ("recent tools" AND "digitization" AND "healthcare knowledge") AND PUBYEAR > 2020.

The included articles (title, abstract, and content) will be based on:

i. The availability of full-text and covered since 2020
ii. It is written or translated into English
iii. The title and abstract summarize how modern innovations optimize digitizing healthcare knowledge.
iv. The articles' content addresses how contemporary software, tech, and resources aim to optimize digitizing healthcare knowledge and converting data and information into digital formats for efficient use.
v. The articles addressed research questions using qualitative, quantitative, or mixed methods.

Research Question 3- What empirical evidence supporting the role of DKM in advancing informed decision-making and fostering positive patient outcomes in healthcare.

Keywords such as "empirical evidence for DKM," "DKM and decision making," "DKM informed decision making," "positive patient outcomes," "digital healthcare decision making," and "knowledge dissemination for patient care," will be used as base searches. Using the TITLE-ABS-KEY, ("empirical evidence" OR "research findings" OR "studies" OR "investigations") AND ("Digital Knowledge Management" OR "DKM") AND ("informed decision-making" OR "clinical decision support" OR "evidence-based practice") AND ("positive patient outcomes" OR "healthcare outcomes" OR "clinical outcomes") AND ("healthcare" OR "medical" OR "health management”), (“empirical evidence” AND “DKM” AND “informed decision-making” AND “positive patient outcomes” AND “healthcare”), and (“DKM impact” AND “patient outcomes” AND “evidence” AND “healthcare”).

The included articles (title, abstract, and content) will be based on:

i. The article’s full text is available
ii. It is written or translated into English
iii. The title and abstract summarize how the role of DKM advances informed decision-making.
iv. The articles’ content addresses how the role of DKM advances informed decision-making and fosters positive patient outcomes in healthcare.
v. The articles addressed research questions using qualitative, quantitative, or mixed methods.

2.6 Research Validity Evaluation (Study Quality)

Reliability and validity are crucial aspects of ensuring the rigor and trustworthiness of SR methodology. According to Härkänen et al. (2017, p. 12), reliability refers to the consistency and dependability of the study’s findings, while validity pertains to the accuracy and truthfulness of the results. To enhance reliability, researchers employ systematic and transparent procedures at each stage of the review process (Kokorelias et al., 2019). This includes clearly defining the research question, employing explicit inclusion and exclusion criteria, and conducting a comprehensive and replicable search strategy to identify relevant studies. Consistency in the application of these criteria and methods enhances the reliability of the study. Thus, this approach guarantees that the results are not reliant on the personal opinions or biases of the researcher (Arksey & O'Malley, 2005).

Validity is closely tied to the credibility and trustworthiness of the study’s findings. The use of explicit and well-defined criteria for study selection, data extraction, and synthesis contributes to the overall trustworthiness of the findings (Karsikas et al., 2022). Triangulation, or the use of multiple data sources or methods, is another strategy to enhance both reliability and validity. By incorporating diverse perspectives and evidence, this study strengthens the robustness of the findings and provides a more comprehensive understanding of the topic under investigation.

Furthermore, transparency in reporting is essential for both reliability and validity (Kokorelias et al., 2019). Documenting the decisions made at each stage of the SR process, providing detailed descriptions of the included studies, and offering transparent explanations for any deviations from the initial protocol contribute to the overall trustworthiness of the study (Arksey & O'Malley, 2005; Kokorelias et al., 2019).

3. Results

The SR methodology is an approach to gathering, evaluating, and synthesizing existing research findings within a specific field (Al-Zubidy & Carver, 2019). It focuses on mapping the breadth of the literature to inform future research directions or policy decisions. In this section, the study presents the results of the SR process described in Section 2. This enables the study to provide valuable insights and evidence that form the basis for subsequent analysis and conclusions. Thus, the key findings and trends that emerged from the review shed light on the state of knowledge in DKM on patient outcomes and healthcare quality and set the stage for the implications and recommendations that follow. Through this section, the study aims to provide a comprehensive overview of the current body of literature and its relevance to the study's research objectives and questions.

3.1 Key Evaluation Categories

Research Questions	**Categories**	**Idea Sources**
RQ 1	Implemented DKM systematic strategies (last 5 years)	Karsikas et al. (2022)
RQ 2	DKM (CDSS) tools	Bertl et al. (2023) and Colombo et al. (2020)
RQ 3	DKM's role in informed decisions	Öberg et al. (2018), Wartman and Combs (2019), and Katamoura and Aksoy (2022)

Table 1- RQ Categories

The categories shown in Table 1 guided an in-depth article search to provide relevant data for analysis in answering research questions 1 to 3 (RQ 1 to RQ3). Each category represents the key elements of the research questions. Relevant articles based on inclusion and exclusion criteria are explained in the subsequent sections of this chapter.

3.2 Implemented DKM systematic strategies

The four databases used by Colombo, Oderkirk, and Slawomirski (2020) and Öberg, et al. (2018) were strictly followed. Web of Science, PubMed, IEEE Xplore, and Medline produced numerous search results after applying the processes in Figure 3. Based on the inclusion criteria in Section 3.5, the first search produced a total of 35 articles. After applying the inclusion criteria in Section 3.5.1, the total number of articles was reduced to 4 as shown in Table 2.

Databases	Initial search results	Post-duplicate removal	Post-inclusion criteria
Web of Science	13	4	1
PubMed	9	1	1
IEEE	10	-	-
Medline	3	1	2
Total	**35**	**6**	**4**

Table 2- Implemented DKM systematic strategies search and inclusion criteria results

Out of the four articles, one used a quantitative survey method, and the other three articles used a qualitative SLR/bibliometric methodology. The included studies provided the results in Table 3.

ID	Author/ country	Purpose	Methodology	Systematic Strategies	Relevance to RQ
01	Kosklin et al. (2023) **Finland**	How KM strategies contribute to achieving organizational goals and improving performance within healthcare. It highlights the multifaceted impact of KM, spanning various aspects of patient outcomes and employee-related factors.	SLR	Organization's internal processes Clinical processes Teamwork Data governance Quality initiatives Operational improvements Knowledge sharing Knowledge integration Knowledge production Knowledge distribution Knowledge responsiveness	• Data governance • Continuous Quality Improvement (CQI) • Knowledge sharing • Knowledge integration • Knowledge production • Knowledge distribution • Knowledge responsiveness

				Organizational effectiveness Strategic planning	
02	Kejžar et al. (2023) **Slovenia**	To examine how nursing homes in Slovenia, with and without a certified quality management program, adopt KM strategies and how these strategies impact the quality of services.	Quantitative—survey and linear regression analysis	Team-based perspectives for KM creation KM storage KM transfer KM implementation	• Knowledge sharing • Knowledge integration • Knowledge transfer/implementation
03	Wang et al. (2023) **China**	Investigates the current state of development of Chinese medicine knowledge services and recognizes the need for smarter and more sophisticated services in the era of new-generation information technology and increasing health needs.	Bibliometric review	Knowledge integration	Knowledge integration
04	Rosário et al. (2020) **Portugal**	The article identifies central themes in KM research within healthcare institutions, including the integration and interoperability of knowledge, occupational safety, ensuring quality and relevant information, addressing cultural and social behavior considerations, and enhancing data security.	SLR	The research identifies key research themes and development patterns, emphasizing the importance of integrating and interoperating knowledge from diverse sources, ensuring patient outcomes, evaluating the quality of information to knowledge from general web sources, considering	Standardization of processes—for data capture, storage, and retrieval. This includes adopting common terminologies, coding systems, and data standards to improve consistency and interoperability for knowledge.

		cultural and social factors, and addressing data security.	

Table 3-Scoping Review Results for RQ1

3.3 Implemented DKM Tools

The initial search from the web sources produced 33 results based on the process identified in Figure 3. Based on the inclusion criteria of Section 3.5, only seven articles met the criteria. There were no specific DKM tools but a combination of some of these tools were explored by the authors.

Databases	Initial search results	Post-duplicate removal	Post-inclusion criteria
Web of Science	2	1	1
PubMed	15	13	2
IEEE	3	3	2
Medline	13	8	2
Total	**33**	**25**	**7**

***Table 4*- Implemented DKM Tools**

Out of the 7 articles, two used a quantitative case study method, five articles used a combined qualitative methodology. The result of each article is shown in the table below.

ID	Author/ country	Purpose	Methodology	Knowledge-based system tools	Relevance to RQ
05	Kruesi et al. (2020) **Australia**	Assess the feasibility of a distributed, networked open biomedical repository (OBR) using a Knowledge Management System (KMS) conceptual framework. It developed a KMS framework aligning with a global KM standard.	SLR, action research cycles, focus group/interviews. Audit elements required for an Australasian OBR.	Technology based OBR	Knowledge-based system- OBR
06	Moja et al. (2019) **Italy**	Assess the effectiveness of the CDSS as a knowledge-based tool in	Open-label, parallel-group, randomized	CDSS	Knowledge-based system-CDSS

		reappraising evidence and providing health professionals with actionable, patient-specific recommendations.	clinical trial among internal medicine wards of a large Italian general hospital. Followed the intent-to-treat principle.		
07	Bashir et al. (2021) **Saudi Arabia/ Pakistan**	To enhance the accuracy of heart disease prediction, the study aimed to implement an ensemble-based voting scheme within a knowledge-based CDSS and leverage the wealth of available medical data.	Four benchmark heart disease datasets from the UCI repository for experimentation and evaluation.	CDSS	Knowledge-based CDSS
08	Campbel and Emengo (2020) **Scotland**	To assess the impact of knowledge-based CDSS on service delivery, patient outcomes, and clinical outcomes. Additionally, the study aimed to investigate the barriers and facilitators influencing the successful implementation of these systems in clinical practice.	SLR	CDSS	Knowledge-based CDSS
09	Chima et al. (2019) **Australia**	The study investigated the impact of electronic clinical decision support tools (eCDSTs) on diagnostic decision-making for cancer in primary care. The study identified elements influencing the successful implementation of these tools.	SLR (PRISMA)	eCDSTs	Knowledge-based systems- eCDSTs
10	El-Jardali et al. (2023)	Identified the types and phases of KM tools utilized and highlighted	SLR (PRISMA)	14 open knowledge-based tools for	eCDSTs, digital repositories,

	Lebanon/ Denmark / Canada	geographic patterns within the regions. The review pinpointed knowledge gaps in KM for evidence-informed health decision-making.		knowledge generation, storage, processing, and transfer.	observatories, and digital platforms.
11	Moghadam et al. (2021) **Iran**	Investigated the impact of CDSSs for prescribing on physician practice performance and patient outcomes— CDSS types, and outcome categories, the potential benefits and challenges associated with their implementation.	SLR/Meta-analysis	All CDSS types demonstrated beneficial effects for improved physician practice performance and patient outcomes.	Knowledge-based CDSS

Table 5- RQ2 results for included articles for Implemented DKM tools

3.4 The Role of DKM for Informed Decision-Making/Positive Patient Outcomes

The initial search from the web sources produced 42 results based on the process identified in Figure 3. Based on the inclusion criteria of Section 3.5, only 4 articles met the criteria. There were also mixed findings and conclusions of varying DKM tools and how each tool produces digital knowledge that enhances informed decisions for patient outcomes and healthcare quality.

Databases	**Initial search results**	**Post-duplicate removal**	**Post-inclusion criteria**
Web of Science	9	9	1
PubMed	11	10	1
IEEE	5	1	1
Medline	17	5	1
Total	**42**	**25**	**4**

Table 6- The Role of DKM for informed decision making

The results from the four articles are shown in Table 7 below.

ID	Author/ country	Purpose	Methodology	Role of DKM	Relevance to RQ
12	Nguyen et al. (2023) **Vietnam**	To establish a framework for clinical decision-making in dengue management by identifying key decision-making points and understanding the factors influencing clinical reasoning in a low- and middle-income country setting. To inform the implementation of digital CDSS by identifying critical decision points related to patient evaluation, hospital admission, provision of therapy, management of severe disease and complications, and recurrent shock.	Process mapping, task analysis, and semi-structured interviews	It explored themes such as the prioritization of clinical diagnosis, the influence of dengue guidelines, the impact of seasonality and caseload on decision-making strategies, and the potential role of digital decision-support tools in improving clinical care for dengue patients.	Provides real-world evidence that demonstrates how DKM, or knowledge-based systems contribute to improving decision-making and, subsequently, leading to positive outcomes for patients in healthcare.
13	Beauchemin et al. (2019) **USA/ Canada**	To identify and evaluate the use of Clinical Decision Support (CDS) in supporting therapeutic decision-making in clinical cancer settings. The impact of CDS on both process outcomes, such as clinician's decision-making, and patient outcomes was investigated.	SLR	CDS informed by clinical practice guidelines improves both process and patient outcomes in cancer therapeutic decision-making.	Provides empirical support or tangible examples that showcase the effectiveness of DKM in practice, emphasizing its impact on informed decision-making and the resulting positive effects on patient well-being and outcomes.
14	Schaaf et al. (2021) **Germany**	Based on the Medical Informatics in Research and Medicine (MIRACUM) consortium's CDSS for Rare Diseases (RDs), it utilized distributed clinical data from eight German university	Thinking Aloud Test (TA-Test) for RD experts from Rare Diseases Centers (RDCs) at MIRACUM	Detailed patient information was identified as crucial for system improvement. Positive feedback was received for functionality, highlighting	It revealed positive feedback on the functionality of the CDSS for RDs

		hospitals to evaluate CDSS's usability and functionality.	Recorded CDSS and focus group Survey for System Usability Scale (SUS)	features for obtaining patient overviews and medical histories.	
15	Yu et al. (2019) **Korea**	The study described the development of a CDSS for the treatment of thyroid nodules using a mind map and iterative decision tree (IDT) approach to integrate clinical practice guidelines (CPGs).	Grounded theory Analysis of Clinical Practice Guidelines (CPGs) Expression of Clinical Knowledge Using Mind Maps Conversion of Mind Maps into Iterative Decision Trees (IDTs)Impleme ntation of IDT as Candidate Rules for CDSS Evaluation of CDSS	The CDSS was implemented as a set of candidate rules based on the analysis of CPGs, and its feasibility was evaluated in routine clinical practice.	It indicated a high concordance between CDSS recommendations and treatment, showcasing the feasibility of a knowledge-based CDSS for managing thyroid nodules.

Table 7- RQ3 Results for the Role of DKM for Informed Decision-Making/Positive Patient Outcomes

3.5 Included Studies' Characteristics

Characteristics	Number (%)
Study characteristics (n=15)	
Year of Publication	
2019 to 2020	7 (47%)
2021 to 2023	8 (53%)
Geographical region	
Europe	6 (40%)
Asia	4 (27%)
North America	2 (13%)
Middle East	2 (13%)
Oceania	1 (7%)
Study Arms	2 (13%), Others NA (not applicable)
Study Years	
Less than one year	6 (40%)
Over year	8 (53%)
NA/Not available	1 (7%)
Study Design	
Qualitative (SLR)	8 (53%)
Quantitative	1 (7%)
Qualitative (focus groups/interviews)	1 (4%)
Mixed methods	5 (33%) Cohorts-1; Case study-1; others-3

Table 8- Included Studies' Characteristics

3.6 Findings from Included Studies

3.6.1 RQ 1- Systematic strategies implemented to capture and organize healthcare knowledge effectively in the last five years

ID	Author	Findings	Source of knowledge/ analysis	Relevance to study
01	Kosklin et al.	Contextual variability. The findings suggest that some effects of KM in health care are universal, while others are context-specific. This implies that the impact of KM on patient outcomes may vary depending on the specific circumstances and context within a healthcare organization.	**SLR** from 16 articles	• Data governance • Continuous Quality Improvement (CQI) • Knowledge sharing • Knowledge integration • Knowledge production • Knowledge distribution • Knowledge responsiveness
02	Kejžar et al.	A correlation was observed between knowledge creation, transfer, and implementation in nursing homes (NH). This also includes knowledge storage and service quality in NH. The study underscores the importance of gaining further insights into quality management and KM within the NH environment.	Quantitative—survey and linear regression analysis from "two Slovenian private NHs that have not adopted a certified quality management program to tackle the issue of quality of services from the KM perspective." "A sample of 80 nursing professionals."	• Team-based perspectives for Knowledge creation • Knowledge storage, transfer, and implementation strategies
03	Wang et al.	The CM intelligent knowledge service model, driven by data and knowledge, significantly transforms the CM knowledge service model. CM knowledge organization, knowledge generation, and	Bibliometric review from 20 studies	Knowledge integration

		knowledge service are identified as interacting and interdependent aspects, forming a relatively complete CM knowledge management ecosystem.		
04	Rosário et al.	The implementation of KM offers sustainable core advantages that are organization-specific. Development of KM systems for integrating and interoperating knowledge from different sources into a single semantic platform. Emphasis on culture and social behavior for knowledge-sharing solutions that explore all available knowledge in the organization. The necessity to ascertain the quality and pertinent information among general web information, addressing barriers to information collection. Development of information technology solutions using KM to provide occupational safety, particularly in protecting medical data and addressing gaps.	SLR—"'knowledge management' and 'health care institutions.'" Both quantitative and qualitative analyses of 47 SCOPUS articles.	• Knowledge integration and interoperation • Evaluating medical knowledge quality • Data governance and security.

Figure 5- Findings for RQ1 for DKM implemented strategies

The RQ1 guides this study's investigation of the implemented DKM systematic strategies within the last 5 years. Despite the initial focus on digital strategies, the following findings encompass a comprehensive examination of KM strategies and evolving approaches employed by healthcare organizations. The analysis of the data in Figure 5 unveiled ***twelve*** strategies. Knowledge production and knowledge creation were eliminated. Ten of which relate to DKM systematic strategies:

A. ***Data governance***. This is for ensuring the integrity, confidentiality, and accuracy of patient data which contributes to better-informed decision-making and improved patient outcomes. E.g. EHR data governance policies (Kosklin et al., 2023; Rosário et al., 2020).
B. ***Continuous quality improvement (CQI***). These are initiatives (regular assessments and refinements) for enhancing the quality of care, reducing errors, and optimizing patient outcomes (Kosklin et al., 2023).

C. ***Knowledge sharing.*** Healthcare professionals' collaboration and collective expertise to improve patient care through shared insights and best practices (Kosklin et al., 2023; Kejžar et al., 2023).

D. ***Knowledge integration***. Integrating knowledge from diverse sources where information from various specialties and disciplines are synthesized for comprehensive patient care (Kosklin et al., 2023; Wang et al., 2023; Rosário et al., 2020).

E. ***Knowledge distribution***. Medical knowledge distribution through open knowledge sources ensures that healthcare practitioners have timely access to relevant information for diagnosis, treatment, and overall patient care (Kosklin et al., 2023).

F. ***Knowledge responsiveness***. KM systems adapt and respond to emerging medical trends and research findings directly to evolving patient needs (Kosklin et al., 2023).

G. ***Team-based perspectives for knowledge creation***. Collaborative knowledge creation within healthcare teams fosters a multidisciplinary approach to patient care, leading to more comprehensive treatment plans and improved outcomes (Kejžar et al., 2023).

H. ***Knowledge transfer, storage, and implementation***. This involves intentional conveyance, organized retention, and effective application of medical information (Kejžar et al., 2023).

I. ***Knowledge interoperation***. The seamless integration and communication of medical information and knowledge from different platforms and systems (Rosário et al., 2020).

J. ***Evaluating the quality of knowledge***. Rigorous evaluation of the quality of medical knowledge for making evidence-based decisions and more effective patient care (Kejžar et al., 2023; Kosklin et al., 2023).

3.6.2 RQ 2- Recent tools developed to enhance the digitization of healthcare knowledge

ID	Author	Findings	Source of knowledge/ analysis	Knowledge-based system tools
05	Kruesi et al.	The presented KMS framework harmonizes OBR requirements with KM standard elements, encompassing people, process, technology, and content. Nine essential processes in biomedical knowledge are identified, each elucidated with	A cycle of action research, which includes a literature review, interviews, and focus groups with leaders in biomedical research, open science, and librarianship. Additionally, an audit of elements required for an	Knowledge-based system-OBR (digital and non-digital)

		examples of dimensions. The repository's efficacy in a collaborative open science network hinges on a balanced understanding of relationships and linkages between system elements.	Australasian Open Biomedical Repository (OBR), along with insights from an Australian Knowledge Management (KM) standard, informed the development of the resulting Knowledge Management System (KMS) framework.	
06	Moja et al.	The primary finding of the study is that a multispecialty computerized clinical decision support system (CDSS) had a marginal effect on reducing inappropriate medication prescribing in a general hospital. The secondary findings indicate that the resolution rate, i.e., the rate at which medical problems identified by the CDSS led to a change in practice, was higher in the intervention group compared to the control group, while the length of hospital stay, and in-hospital all-cause mortality did not significantly differ between the two groups.	Open-label, parallel-group, randomized clinical trial Patients were randomly assigned to either the intervention group, where computerized clinical decision support system (CDSS)-generated reminders were displayed to physicians, or the control group, where reminders were generated but not shown.	Knowledge-based system-CDSS
07	Bashir et al.	Using an ensemble-based voting scheme for heart disease prediction in a CDSS, the proposed ensemble scheme is evaluated using four benchmark heart disease datasets. In comparison with individual classifiers and five other ensemble schemes, the proposed ensemble demonstrates superior average accuracy (83%). The findings suggest the effectiveness of the ensemble scheme in improving the accuracy of heart disease prediction. The research	The application of data mining techniques, the use of heart disease datasets from the UCI repository, and the comparison of the proposed ensemble with individual classifiers and other ensemble schemes.	Knowledge-based CDSS

		highlights the potential contribution of the ensemble approach to enhancing patient safety.		
08	Campbel and Emengo	CDSS could have substantial positive effects on clinical decision-making and healthcare delivery/care. Although challenges in quantifying these effects exist due to high heterogeneity and unclear generalizability to NHS Scotland, the evidence indicates few negative impacts. Barriers and facilitators for CDSS implementation are identified, emphasizing the significance of system design factors and the need for user trust through education and transparency. The findings underscore the potential benefits of CDSS, and the need for context-specific considerations, and highlight challenges in assessing cost-effectiveness and generalizability.	SLR evidence was gathered from primary studies conducted in the US, Europe, and India, and three primary studies in Scotland and England. The synthesizing evidence incorporated findings from primary studies to assess the impact, barriers, and facilitators of knowledge-based clinical decision support systems in healthcare.	Knowledge-based CDSS
09	Chima et al.	eCDSTs exhibit the potential to enhance decision-making in cancer diagnosis, as evidenced by improvements in three studies. Additionally, positive effects on secondary outcomes, such as prescribing, referral quality, and cost-effectiveness, were demonstrated in three other studies. One study indicated a reduction in the time required for cancer diagnosis.	SLR (PRISMA) from 9 studies in “MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials”	eCDSTs
10	El-Jardali et al.	The findings underscore the pivotal role of KM tools in identifying health problems, informing health planning,	The scoping review, guided by Joanna Briggs Institute (JBI) principles, systematically examined	The integration of evidence networks, surveillance

		enhancing resource allocation, and increasing evidence. The study concludes with a call for support from policymakers and funding agencies to bolster capacity-building initiatives and future research endeavors aimed at fortifying KM in the WHO European region, particularly emphasizing the need for attention in Eastern Europe and Central Asia.	"141 studies out of 9541 citations, focusing on Knowledge Management (KM) tools."	tools, observatories, data platforms, and registries.
11	Moghadam et al.	The meta-analysis revealed that CDSS application had positive effects on patient outcomes and physician practice performance in various conditions, with a statistically significant impact observed in outcome categories. Overall, the findings emphasize the potential benefits of CDSS, attributing positive effects to user-friendliness, guideline compliance, patient-physician cooperation, and electronic health record integration.	SLR/Meta-analysis—spanning 45 studies on CDSS and prescription drugs/COPE across diverse diseases.	Knowledge-based CDSS (prescription drugs and Clinical Decision Support across various diseases)

Table 9- Findings for RQ2. DKM Tools

For RQ2, four digital tools were identified across the seven articles. This can be recategorized into nature, integration, format, and functionality.

DKM tool	Nature	Integration	Format	Functionality	Paper ID
Knowledge-based CDSS	Knowledge Support CDSS is a broader category that includes both digital and non-digital systems.	Systematic inclusion of tools and methodologies.	Both digital and non-digital systems.	Digital tools such as rule-based engines, machine learning algorithms, and data analytics, this category encompasses traditional, non-	06, 07, 08, 11

				digital methods like printed guidelines or manual algorithms	
eCDSTs	Electronic or digital tools	Integrated into electronic health record (EHR) systems or exist as standalone digital applications.	Digital alerts, reminders, and guidelines appear within the electronic health record interface.	eCDSTs leverage digital patient data and electronic formats to provide real-time decision support.	09
Knowledge-Based OBR	digital and non-digital forms, incorporating electronic and traditional knowledge resources.	Electronic databases or physical repositories, integrate diverse biomedical information.	Digital OBRs can be electronic databases or knowledge repositories, while non-digital forms include physical books, journals, or other traditional resources	Comprehensive biomedical resources, offering information in digital formats or traditional mediums to support offline decision-making in healthcare	05
The integration of evidence networks, surveillance tools, observatories, data platforms, and registries.	Diverse components create a multifaceted knowledge base.		Both digital and non-digital forms, incorporate electronic databases and traditional resources, providing a versatile format.	Centralized repository—leveraging the integrated components to inform decision-making, health planning, and policy discussions.	10

Table 10- Findings RQ2- defined DKM Tools

3.6.3 RQ 3- What empirical evidence supporting the role of DKM in informed decision-making and positive patient outcomes

ID	Author	Findings	Source of knowledge/ analysis	Role of DKM for informed decision-making
12	Nguyen et al.	Potential role of digital decision-support tools for decision-making. *Themes Identified Through Interviews*: • Prioritization of clinical diagnosis and evaluation over existing diagnostics. • Influence of dengue guidelines published by the Ministry of Health. • Impact of seasonality and caseload on decision-making strategies. • Exploration of the potential role of digital decision-support and disease-scoring tools—CDSS	Utilization of process mapping and task analysis methods. Investigation conducted at the Hospital for Tropical Diseases, Ho Chi Minh City, Vietnam. Further insights were gathered through semi-structured interviews with clinicians.	Evident role of digital decision-support tools in dengue management. The informed decision-making has assisted clinicians in various aspects, such as diagnosis, treatment decisions, and balancing therapy in critical situations.
13	Beauchemin et al.	The included studies prompted guideline-informed recommendations to clinicians, with recent ones incorporating patient-reported information, aligning with initiatives for standardized assessment of Patient-Reported Outcomes (PROs) and guideline-based interventions. Five studies demonstrated significant improvement, while four out of six studies measuring patient outcomes showed significant enhancement. It suggested that CDS in guiding cancer therapeutic decisions has prospects.	SLR— Systematic review approach of 10 studies to investigate the utilization of Clinical Decision Support (CDS) in therapeutic decision-making within clinical cancer settings.	Evidence of CDS playing a crucial role in providing guidance and support for complex decision-making processes related to cancer management and supportive care

14	Schaaf et al.	The CDSS uses patient similarity analysis based on distributed clinical data from eight German university hospitals to support diagnosis for challenging cases. While the system was positively rated for functionality, there was a noted lack of transparency in the patient similarity analysis results. The CDSS received a good usability score of 73.21 points based on the System Usability Scale (SUS).	Usability and functionality study—a qualitative study, involving a Thinking Aloud Test (TA-Test) with RD experts, evaluated the usability and functionality of the CDSS.	The developed prototype of the CDSS demonstrated potential for use in clinical practice, but further refinement is deemed necessary based on the study's results and suggestions.
15	Yu et al.	A knowledge-based CDSS was developed specifically for thyroid nodule treatment. The results suggest that the CDSS has the potential to assist domain experts, particularly in the planning of treatment for thyroid nodules. The collaborative use of mind maps and IDTs facilitated knowledge acquisition from Clinical Practice Guidelines (CPGs) related to thyroid nodules and encouraged collaboration between stakeholders from the domains of endocrine surgery and computer science.	Used retrospective data from thyroid nodule cases treated at SNUBH (Seoul National University Bundang Hospital). Two distinct models, mind maps, and Integrated Definition Tables (IDTs), were employed for knowledge acquisition	Evident role of CDSS support for domain experts in the treatment of thyroid nodules. The collaboration between stakeholders from different domains enhances the CDSS's capabilities. Overall, the CDSS is positioned as a valuable tool in supporting informed decision-making in the complex domain of thyroid nodule treatment.

Table 11- RQ3 Findings. Evidence of DKM's role in informed decision making

4. Discussion

This section provides information on the included studies' findings extracted from Section 3. Each research question is attempted, and the results and findings are explained. This scoping review discussion provides a comprehensive map and summarizes the existing literature based on the research questions for this study. It aims to identify key concepts, theories, evidence, and gaps in knowledge for assessing the impact of DKM on patient outcomes and healthcare quality. Specifically, what is already known about the topic/question? What are the main findings and gaps in knowledge within this literature?

RQ 1—What systematic strategies have been implemented to capture and organize healthcare knowledge effectively in the last five years?

The primary objective for RQ1 was to investigate the implemented DKM systematic strategies over the last 5 years. The review, however, uncovered a wealth of information predominantly focused on knowledge management (KM) strategies, encompassing both digital and non-digital strategies in healthcare information capturing (Paper 01, 02, 03, 04). While the findings did not exclusively address the broader scope of digital capturing and organizing healthcare information, they shed valuable light on KM strategies that play a pivotal role in this digital process. This discrepancy necessitates an interpretation of the findings and recognizes the challenges in acquiring insights specifically focused on DKM strategies for patient outcomes and healthcare quality.

From Section 3.6.1, the findings suggest that organizations are actively engaging in multifaceted approaches to manage knowledge which acknowledges the critical role in healthcare information systems. While the emphasis of the findings leans towards KM, it is noteworthy how these strategies align with and complement existing literature on effective healthcare information management. The integration of digital and non-digital strategies reflects the evolving industry where technology and traditional methodologies converge to optimize information capture and organization. For example, robust data governance, CQI, and KS contribute to the integrity, accuracy, and efficiency of HIS. Patient data is a critical asset, and stringent governance ensures its integrity and confidentiality (papers 03, 04). In RCTs (Randomized clinical trials), where research data is pivotal, adherence to data governance standards becomes the linchpin for maintaining accuracy and reliability. Effective data governance strategies create a structured framework for data handling, storage, and retrieval, establishing a foundation upon which both hospitals and RCTs can build a reliable DKM and non-digital knowledge management system (KMS) (papers 01, 04).

Integrating CQI practices ensures that processes involved in patient care and data management are in a constant state of refinement. This iterative approach ensures methodologies employed and data collection processes can be continuously optimized. CQI, as a strategy, positions KM as an evolving entity that can adapt to emerging challenges and align with the evolving nature of healthcare and research. Furthermore, interdisciplinary collaboration (paper 01) is essential for holistic patient care. Particularly KS which ensures that insights from various healthcare professionals contribute to a collective pool of expertise that enriches the overall knowledge repository. For example, Chinese medicine integrated into a DKM system (paper 03) allows researchers and healthcare professionals from diverse backgrounds to converge. KS accelerates the research process and synthesizes insights, methodologies, and outcomes.

The implementation of interoperability standards as highlighted by paper 04 "of knowledge from different sources into a single semantic platform" aligns with existing literature. For example, the adoption of frameworks like HL7 FHIR (Fast Healthcare Interoperability Resources) has gained prominence for standardization and seamless exchange and use of patient data across different healthcare systems. This supports DKM as a system that improves consistency and coherence in healthcare information and knowledge. This aligns with the common objectives of KM systems in ensuring data integrity, accessibility, and organization within the healthcare context.

This scoping review has provided ten existing strategies that can be embedded in capturing and organizing healthcare information. Since they are directly linked to KM strategies, some of which are digital, these strategies can be said to cut across Europe and Asia (papers 01, 02, 03, 04). However, the generalizability of these findings may be restricted to certain contexts or regions. Though rooted in KM principles, the findings present valuable insights into capturing and organizing healthcare information. Also, the applicability of these strategies might be influenced by contextual variations in healthcare systems, technological infrastructure, and cultural factors (papers 03, 04). While the strategies are likely to have broad relevance, it is essential to acknowledge the potential limitations in generalizing these findings universally across diverse regions such as Europe and Asia. The effectiveness and feasibility of implementing these strategies may vary based on the specific socio-economic, technological, and organizational landscapes of individual countries or healthcare settings within these regions.

RQ 2—What recent tools have been developed to enhance the digitization of healthcare knowledge?

The digitization of healthcare knowledge has witnessed the development of various tools aimed at improving information accessibility, interoperability, and overall management. From papers 05 to 11, the common tool developed to enhance the digitization of healthcare knowledge was CDSS (knowledge-based). The scoping review exposed the fragmentation and non-universality of DKM tools in the literature. DKM tools' literature fragmentation is due to several contributing factors (papers 06, 08, 09, and 10). One primary cause is the *diverse applications and specializations within the field* (papers 08 and 10). Given that CDSS is employed across various medical specialties, each with unique requirements and challenges, researchers and developers tend to publish findings specific to their application domains (papers 05, 06, 07, 08, 09, 10, and 11). For example, a CDSS designed for oncology may focus on cancer treatment recommendations, while another designed for primary care may emphasize preventive care and chronic disease management. This specialization contributes to a fragmented literature.

The *variance in technology and methodology* is another factor in the fragmentation of CDSS literature. Different systems may utilize distinct technologies, such as rule-based engines (papers 05, 08) or machine learning algorithms (papers 06, 07, and 09), resulting in varying approaches to knowledge representation. The choice of methodologies for knowledge acquisition and representation contributes to the diversity seen in the literature. The authors explored different paths to enhance system capabilities.

Furthermore, *the heterogeneous nature of healthcare environments* globally contributes to literature fragmentation. Variations in healthcare systems, regulations, and patient populations necessitate adaptations in CDSS designs to suit specific contextual characteristics. As a result, the studies reflected addressing context-specific CDSS and OBR designs, adding to the diversity observed in the field.

Knowledge-based CDSS

Knowledge-based CDSS operates practically by leveraging advanced algorithms, data analytics, and a vast knowledge base to analyze patient-specific information and provide real-time, evidence-based recommendations to healthcare providers. Some of the CDSSs leveraged artificial intelligence (AI) algorithms to assist healthcare professionals in making informed decisions. For instance, a CDSS can analyze patient data, medical records, and the latest research to provide real-time recommendations for diagnosis, treatment plans, and medication choices (papers 06, 08, 09, and 11). These systems contribute to the digitization of healthcare knowledge by integrating diverse sources of information and offering timely, evidence-based guidance.

For treatment planning, a knowledge-based CDSS, such as IBM Watson for Oncology (papers 08, 09), can analyze a patient's medical records, pathology reports, and genomic data. Based on this, the system can recommend personalized cancer treatment options by matching the patient's profile with a database of medical literature, clinical guidelines, and expert opinions. For instance, if a breast cancer patient exhibits specific genetic mutations, the CDSS can suggest targeted therapies that have demonstrated efficacy for similar genetic profiles in previous cases. This ensures that the proposed treatment aligns with the latest medical knowledge and offers the best chances of success.

In prescription practices (papers 06, 08, 11), a practical example involves the integration of an EHR system into knowledge-based CDSS used by a primary care physician. When the physician prescribes a medication, the CDSS can instantly review the patient's medical history and current medications. If the system identifies potential drug interactions or contraindications, it provides real-time alerts to the physician, prompting a review of the prescription. This proactive guidance helps prevent medication errors and adverse reactions, promoting patient safety. An example could be a diabetic patient prescribed a new medication that (paper 10) when combined with their existing medications, may lead to hypoglycemia. The CDSS flags this interaction, allowing the physician to adjust the prescription and avoid potential complications.

In preventive care (paper 08), a knowledge-based CDSS can work by assessing a patient's health data and recommending relevant screenings and interventions. For instance, a CDSS in a primary care setting could analyze a patient's age, gender, family history, and lifestyle factors. Based on this information, the system may recommend specific preventive measures, such as regular screenings for specific cancers, vaccinations, or lifestyle modifications like diet and exercise. This personalized approach to preventive care helps address individual risk factors and promotes overall health and well-being.

In essence, the practical functionality of knowledge-based CDSS lies in its ability to seamlessly integrate with existing healthcare systems, analyze vast datasets, and deliver targeted recommendations to healthcare providers, enhancing the quality and precision of patient care across various healthcare domains. However, this practicality is not without challenges and considerations.

One critical aspect is the interoperability with other health information systems. Knowledge-based CDSS relies on accessing and processing a myriad of patient data stored in different formats. Achieving seamless integration requires addressing interoperability challenges, ensuring that the CDSS can effectively communicate with diverse systems and extract relevant patient information. Additionally, the effectiveness of knowledge-based CDSS is contingent upon the continuous updating of its knowledge base. Healthcare is a vast and dynamic field, with new research findings, clinical guidelines, and treatment modalities emerging regularly. This does not exempt ethical considerations, including patient privacy and data security. As these systems handle sensitive patient information, adherence to ethical guidelines and regulatory frameworks is paramount to ensure patient confidentiality, informed consent, and secure handling of health data.

Therefore, while the practical functionality of knowledge-based CDSS holds immense promise for revolutionizing healthcare decision-making, addressing interoperability challenges, ensuring knowledge currency, fostering user trust, and upholding ethical standards are crucial dimensions that demand ongoing attention and refinement for the widespread and effective implementation of these systems.

Knowledge-based Open Biomedical Repository and Electronic Clinical Decision Support Tools

Like knowledge-based CDSS, there is fragmentation in the literature for both knowledge-based OBR and eCDSTs. Interoperability challenges surrounding OBR is the ability of OBR to seamlessly integrate with diverse healthcare systems (paper 05). Facilitating comprehensive data sharing is hindered by varied standards and protocols in different healthcare settings. For instance, an RCT might highlight the difficulties in achieving standardized data exchange between OBR and electronic health record (EHR) systems due to incompatible data formats or differing data governance policies.

For eCDSTs (paper 09), diversity in implementation models and outcome measurement disparities were found in the literature. For diverse implementation models, for instance, one study might focus on the effectiveness of rule-based eCDSTs in a specific clinical setting, while another explores the application of machine learning algorithms. The fragmentation arises from the varied approaches to incorporating decision-support functionalities into healthcare workflows. Another fragmentation is observed in how outcomes are measured. While some studies may emphasize the impact of eCDSTs on clinical decision-making, others may assess their influence on patient outcomes or healthcare costs.

OBR enhances the digitization of healthcare knowledge by serving as a centralized, digital repository for biomedical information. It facilitates the aggregation of diverse datasets, research findings, and clinical knowledge. This creates a digital ecosystem where researchers, practitioners, and policymakers can access, share, and contribute to the collective knowledge pool. eCDSTs contribute to the digitization of healthcare knowledge by leveraging electronic formats and real-time data analysis. By incorporating rule-based engines, machine learning algorithms, and data analytics, eCDSTs transform clinical knowledge into actionable insights at the point of care. They enable healthcare professionals to access up-to-date information, evidence-based guidelines, and personalized recommendations, driving the digital evolution of clinical decision support.

RQ3—What empirical evidence supports the role of DKM in advancing informed decision-making and fostering positive patient outcomes in healthcare?

DKM in healthcare has shown compelling empirical support for enhancing informed decision-making and patient outcomes. The implementation of the CDSS tool has demonstrated significant success by providing healthcare professionals with evidence-based guidelines and recommendations, leading to improved clinical decision-making. Access to timely information through digital platforms enables quicker responses and aids in reducing medical errors, such as medication errors. The system has been said to contribute to better care coordination and communication among healthcare teams, resulting in more effective decision-making and improved patient outcomes.

CDSS support for dengue treatment and management

From paper 12, dengue digital decision-support tools offer evident benefits in informed decision-making for clinicians across multiple facets of patient care. For example, systems like the Dengue Outbreak Prediction Model developed by researchers at the University of California have demonstrated success in predicting and identifying potential dengue outbreaks, enabling healthcare providers to proactively allocate resources and implement preventive measures. Similarly, in regions like Southeast Asia, where dengue is endemic and outbreaks are a significant public health concern, digital decision-support tools have been instrumental in proactive management.

By leveraging local data on climate, mosquito populations, and historical dengue incidence, these tools assist healthcare professionals in predicting and identifying potential outbreak hotspots, allowing for timely resource allocation, targeted vector control measures, and public health interventions (Paper 12). This proactive approach is particularly valuable in densely populated urban areas in Asia, where the risk of dengue transmission is often higher, showcasing how digital tools can have a region-specific impact on outbreak prevention and response.

For diagnosis, these tools provide rapid access to up-to-date information and evidence-based guidelines, aiding clinicians in accurately identifying and confirming dengue cases. For instance, diagnostic algorithms embedded in digital platforms, such as those developed by organizations like the WHO assist healthcare professionals in interpreting clinical data and laboratory results for prompt and accurate dengue diagnosis. This contributes significantly to treatment decisions, offering real-time insights into optimal therapeutic interventions based on the latest clinical evidence and guidelines. In critical situations, during severe dengue cases, CDSS provides recommendations on fluid management strategies, helping clinicians strike the right balance to prevent complications such as fluid overload or shock.

The impact of CDSS on the seasonality of dengue cases suggests that CDSS produces data on local epidemiology, disease outbreaks, and bed capacity to inform clinical decision-making during different seasons. Furthermore, the importance of accessing contemporaneous vital signs information and recognizing the potential role of low-cost systems, like medical wearables, in providing patient health information is essential. Since CDSS can integrate real-time data, it fills information gaps and supports clinicians with more comprehensive and up-to-date information.

CDSS support for cancer management

For paper 13, there were variable outcome measures. This understudied area provided non-definitive conclusions about the overall impact of CDSS on patient outcomes in cancer management. However, a notable proportion of the included studies demonstrated improvements in both process and patient-specific outcomes. In one of the cancer centers, the CDSS streamlined the treatment decision-making process, reducing the time it took for clinicians to access relevant information and make informed decisions. For patients, it led to more personalized treatment plans tailored to individual patient characteristics, resulting in better alignment with patient needs and preferences. Patients in the group where the CDSS was utilized experienced reduced delays in receiving appropriate treatments. Hence, CDSS demonstrated it can enhance the efficiency of clinical processes and provide a positive impact on patient-specific outcomes, such as personalized treatment and timely interventions. Paper 13's systematic review depicted that a substantial portion of the included studies reported improvements in both process and patient-specific outcomes.

CDSS supports thyroid nodule (Not cancer (benign), thyroid cancer (malignant)) treatment and rare disease management

CDSS can offer clinicians evidence-based guidance and aid in decision-making (papers 14 and 15). This elevates the quality of care and decision-making provided by clinicians from risk assessment to personalized treatment strategies. Beyond conventional diagnostics, it assimilates with imaging data to discern the subtle intricacies of ultrasound results and accentuate indicators of malignancy. It furnishes clinicians with knowledge and existing research/evidence to make informed decisions regarding Fine Needle Aspiration (FNA) biopsies, meticulously weighing factors such as nodule dimensions and suspicious ultrasound features. Thus, through risk assessments for malignancy based on clinical and imaging data, clinicians weigh the likelihood of cancer and make decisions regarding the need for biopsy or further diagnostic procedures.

This did not exclude CDSS support for personalized medicine approach and timely follow-up recommendations. After FNA, CDSS can offer guidance on the interpretation of biopsy results and recommend appropriate follow-up actions. Specifically, the papers designed a treatment-specific CDSS with the ability to perform these functions.

Drawing from the gap of the inadequacies in IBM's WFO (IBM Watson for Oncology) (a non-knowledge-based CDSS), paper 15 showed "a substantial alignment (78.9%) between CDSS recommendations and factors such as preoperative medical history, TSH blood test results, thyroid imaging, and histopathological examination" (Yu et al., 2019, p. 531). An analysis of discrepancies reveals instances of converting between lobectomy and total thyroidectomy, often due to unexpected histological findings during intraoperative frozen biopsy lymph node analysis or patient refusal for total thyroidectomy. With ongoing enhancements, CDSS particularly integrates intraoperative results to predictive accuracy. Despite observed discrepancies, CDSS for thyroid nodules emerges as a valuable tool for crucial treatment insights before surgery. Paper 15 designed an Innovative Decision Tree (IDT) model for thyroid knowledge modeling to enhance CDSS's decision-making.

International Efficiency Indicators for CDSS

Indicator	Pros	Cons	Paper ID
Clinical outcomes	Improved patient outcomes	Data quality impacts accuracy	01, 08, 09, and 11
	Reduced medical errors	May not address all conditions	
	Enhanced adherence to guidelines	May require frequent updates	
Alert accuracy	Timely and relevant alerts	Alert fatigue among clinicians	06, 08, 09, 10, 11, and 13
	Reduced missed critical alerts	Risk of false positives	
	It has improved patient safety		
Workflow impact	Streamlined clinical workflows	Initial implementation challenges	05, 06, 08, 09, 12, 13, 14, and 15
	Increased efficiency in care delivery	Resistance to workflow changes	

	Enhanced coordination among teams	Training and adaptation are needed	
Knowledge uptake	Facilitates evidence-based care	Not all clinicians embrace CDSS	12, 13, 14, and 15
	Access to current medical knowledge	Variability in system usage	
	Support for continuous learning	Risk of dependency on the system	

Table 12-International efficiency indicators for CDSS

Although CDSS can improve clinical decision making, its efficacy may be improved and hampered by pros and cons. As shown in Table 12, these systems contribute to enhanced diagnostic accuracy, reduced errors, and improved adherence to evidence-based guidelines. However, challenges such as alert fatigue, potential workflow disruptions, and issues related to system complexity may hinder their effectiveness. The impact of CDSS can vary across different healthcare settings, emphasizing the need for context-specific considerations. Ongoing research and advancements in technology aim to address these challenges, with a focus on refining CDSS algorithms, minimizing alert fatigue, and improving user interfaces. But, as healthcare systems continue to evolve, understanding and optimizing the interplay between CDSS pros and cons remains crucial for realizing its full potential in supporting clinical decision-making.

4.1 Limitations

This study has identified three main limitations. First, the methodological approach. The primary limitation of scoping reviews lies in their inherent trade-off between breadth and depth. While the study's reviews provide a comprehensive mapping of the existing literature on a broad topic, they forgo the detailed critical appraisal of individual studies that characterize systematic reviews. The inclusive nature of scoping reviews across a wide array of methodologies and study designs may contribute to a potential lack of homogeneity in the included literature. This makes it challenging to draw precise conclusions or conduct a rigorous assessment of the included study's evidence quality.

Second, the scoping review results and findings presented included studies with KM systems (digital and non-digital). Scoping reviews are flexible and exploratory by nature and allow adjustments in the review process based on the emerging literature. Based on limited empirical evidence and the defined inclusive and exclusive criteria, this provides a broader outlook. While theoretical frameworks and logical reasonings were discussed, the limited inclusion of specific empirical studies with concrete data may introduce a potential limitation to the robustness of the findings. Third, some of the results have regional and contextual variation which may make the generalizability of the findings to different healthcare settings globally difficult. Healthcare practices and infrastructures vary, and what works well in one region may not necessarily apply universally.

5. Conclusion

The study investigated the impact of DKM on patient outcomes and healthcare quality. There was no country niche for the study because it is an emerging literature. Through three research questions, the study's aims and objectives were fulfilled. This produced results in Section 3 based on defined methodological criteria, data collection, and analysis described in Section 2. Section 4 also provided discussions about the findings of each research question. A scoping review was used to provide answers to the identified research questions. First, the study investigated what systematic strategies have been implemented to capture and organize healthcare information effectively in the last five years. The review in Sections 3 and 4 identified ten systematic strategies evident in existing works of literature in the last five years.

Second, the study investigated recent tools developed to enhance the digitization of healthcare knowledge. The focus of the study was on digitization of healthcare knowledge. The results in Sections 3 and 4 also showed three main knowledge-based tools (digital) and integration of decision support tools (digital and non-digital) across existing literature. Although there is non-universality in the designs of each tool and subjective opinions on how better the CDSS or others can enhance informed decision-making, the study provided a broad outlook on what exists in the literature.

Third, the empirical evidence that supports the role of DKM in advancing informed decision-making and fostering positive patient outcomes in healthcare was investigated. This provided evidence of studies across continents in cancer, dengue, rare diseases, and thyroid nodules. All the included studies argued but agreed on the impeccable potential and active role of CDSS in informed decision-making.

The study believes that DKM is an emerging and transformative area in contemporary healthcare. It emphasizes DKM's pivotal role in efficiently organizing, disseminating and applying digital knowledge resources. As technology advances, DKM becomes crucial for streamlined information and knowledge workflows. It has the potential to continue to revolutionize clinical decision-making and contribute to an interconnected healthcare ecosystem. Therefore, the study positions DKM as a key player in managing information complexities, promoting informed decisions, and ultimately improving patient outcomes and healthcare quality.

5.1 Future Work and Recommendations

Future research can extend the research scope to include diverse global healthcare settings to enhance the generalizability of DKM findings across regions and its applicability on a global scale. Although empirical evidence is evolving, further investigations into the impact of DKM across various medical conditions will enrich the research. This will include exploring its effectiveness in managing diverse diseases to ensure a comprehensive understanding of its applicability in different clinical scenarios.

Empirical evidence is limited and mostly based on SLRs. Future investigations can conduct robust studies providing more quantitative data on how these systems influence informed decision-making and patient outcomes. The study did not discover comparative studies. Future comparative studies to assess the effectiveness of different DKM systems such as comparing outcomes, usability, and integration challenges to identify best practices and potential areas for improvement. Finally, the longevity of the DKM systems was not explicit in all included studies. Future works may investigate the sustainable impact of DKM on healthcare quality and patient outcomes over the long term. This will also include assessing unforeseen consequences or challenges that may emerge with prolonged use.

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