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# Unraveling the Nexus: Exploring the Qualitative Dimensions of the Internet of Things, Impact on Knowledge Management in Healthcare System through a Systematic Literature Review

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**Abstract:** The advent of the Internet of Things (IoT) has ushered in a transformative era for knowledge management in healthcare systems, promising enhanced integration, efficiency, and decision-making capabilities. We investigates the intersection of Internet of Things (IoT) technology and knowledge management within the healthcare system. It aims to elucidate the qualitative aspects of IoT that influence the identification, utilization, and dissemination of knowledge in healthcare organizations. To achieve its objectives, this study employs a systematic literature review methodology, meticulously selecting and analyzing relevant qualitative research from databases and journals. The implications of this research are multifold, serving as a guide for healthcare practitioners and decision-makers in implementing IoT-driven knowledge management strategies. It highlights the importance of considering organizational culture and tailoring IoT initiatives to the specific needs and contexts of healthcare entities, suggesting that careful alignment with these factors which consist Leadership Support, Collaboration and Communication, Learning and Development, Trust and Transparency, Adaptability and Flexibility, Recognition and Incentives, Ethical Consideration and Risk taking and experimentation can lead to successful adoption and utilization of IoT technologies.

**Keywords:** IoT in Healthcare, Knowledge Management, Healthcare System, Systematic Literature Review, Organizational Culture, Tacit Knowledge.

## 1. Introduction

As technology develops from year to year, many organizations are starting to carry out digital transformation in their business processes because the need for innovative communication and knowledge management is increasing [1]. Companies or organizations that implement technology-based solutions to corporate needs such as new products, habits, and good systems increase the company's innovation capacity, enabling them to meet changing market needs [1]. The Healthcare industry is one of those that is intensively developing technology. This is because health is something that modern society values highly especially during the COVID-19 epidemic [2]. Apart from that, health is also a strength that helps each individual move and work to become a part that can form a community [3]. So this makes the healthcare industry an important part of human life.

The healthcare industry has an increasing demand and a vast service system that is complicated and expensive due to the complex human body and the various possibilities available to citizens. [3] Inevitably they must think about the organization's ability to adapt to these conditions and rapidly developing technology. [4]. Such as the effectiveness of decision making, operational skills, adaptability, and employee involvement in the organization [4]. Several of these factors are closely related to important technological entities in system implementation, one of which is the knowledge management system [4].

Knowledge management adopts technology to create stronger operational process capacity [5]. On the other hand, an effective organizational information management system requires digital technology infrastructure [5]. Automating data retrieval is one of the things that IoT can do [5]. IoT can be very useful in knowledge management

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systems, especially in the healthcare industry [6]. In this modern era, the use of IoT in knowledge management has many variations, such as remote monitoring, clinical devices management, distant medicine and others [6].

However, the use of IoT can be a boomerang for business processes which can have a direct impact on users, namely patients, doctors and nurses in the healthcare industry [6]. Lack of real-time data collection is often a problem because the current knowledge management system is not used optimally/effectively in decision making [7]. IoT has an Essential part when integrated with knowledge management systems in collecting real time data, especially in the healthcare industry [6]. The data collected by IoT will continue to be updated as new data continues to come in. The advantage gained by implementing this system, apart from continuously updating data, is that the data collected can be used as a reference for making decisions by medical personnel to treat patients [6]. Therefore, this paper will discuss whether by implementing IoT in knowledge management, what impacts will be felt by users so that they can optimize decision making for taking action on patients.

## 2. THEORITICAL BACKGROUND

According to Bukowitz & Williams(2009), KM has a direct relationship to tactical and strategic needs. With a focus on using and improving knowledge-based assets so that organizations can make the right decisions for a problem [8]. Based on this view the answer to "what is knowledge management?" will be very broad. Knowledge management plays the role of managing organizational knowledge through a systematic and organizationally specific process for organizing, acquiring, applying, maintaining, sharing and updating tacit and explicit employee knowledge to improve organizational performance and create a value [8].

Meanwhile, IoT is a technological entity that can be applied in knowledge management to increase its benefits [1]. The IoT itself refers to a network of devices that are interconnected throughout the world. These devices can be uniquely identified and communicate using standard communication protocols [10]. In other words, IoT includes connections and interactions between various devices that can communicate with each other at a global level, enabling more efficient exchange of information and control [1].

A healthcare system refers to the organized structure and network of institutions, resources, and professionals involved in providing healthcare services to a population[13]. It encompasses the financing, provision, and regulation of healthcare services, including the mechanisms for funding, the delivery of medical care, and the oversight and control of healthcare activities [13].

## 3. REVIEW METHODOLOGY

In this paper, the author uses a systematic literature review method with the aim of finding and combining related research thoroughly using organized and transparent procedures [10] and [11]. To carry out SLR, there are 3 step categories, namely planning the research, conducting a review and making a report [10].

### A. *Planning the Review*

This stage is the initial stage in the SLR which consists of a research question. Planning the Review is a stage in the SLR method that contains research questions.

#### 1) *Research Question*

The study's research questions are crafted to delineate the problem's boundaries. Here :

- RQ1: What qualitative evidence exists regarding the ways in which IoT technologies contribute to the identification and leveraging of tacit knowledge, and how are these insights reflected in healthcare practices?
- RQ2: In what ways do qualitative studies shed light on the challenges and opportunities associated with the integration of IoT into knowledge management systems, and how do healthcare system navigate these complexities?
- RQ3: How do qualitative investigations highlight the role of organizational culture and contextual factors in shaping the effectiveness of IoT-driven knowledge management initiatives, and what lessons can be drawn for successful implementation in healthcare?

### B. *Conduct the Review*

The following is an explanation of the implementation of the SLR stage which includes search terms (Search Terms), selecting articles in the database (Selection of Article Database), filtering based on criteria (Inclusion and Exclusion), selecting the type of study (Study Selection), data extraction (Data Extraction) and synthesis (Data Synthesis).

#### 1) *Search Terms*

A search for articles or literature using certain keywords is carried out to find related articles that can answer the research question. Apart from using keywords, Boolean operators are used in formulating research questions. The sentences used in the search in this study were (IoT Healthcare AND Knowledge Management), (Healthcare System or Knowledge-Based Systems).

#### 2) *Selection of Article Database*

The databases used in this research come from sources such as Scopus, Google Scholar, Taylor & Francis, Springer, Emerald.com, and Science Direct, while queries for Taylor & Francis, Springer, Emerald.com, and Science Direct are exported manually using the feature official export, while queries for Google Scholar and Scopus are performed automatically using the Publish or Perish tools [13].

### 3) *Inclusion and Exclusion*

Selection parameters were used to minimize potential bias in the study [18]. This parameter consists of inclusion and exclusion criteria. Details of inclusion and exclusion criteria are outlined in Table 1.

| ***Inclusion Criteria*** | ***Exclusion Criteria*** |
|---|---|
| Publish article between 2020- 2023 | Publish article under 2020 |
| Article written in English | Article written not in English |
| IoT in knowledge management healthcare | Not related to IoT in knowledge management healthcare |
| The title and abstract research that provides possible answers to the research question. | The title and abstract research that does not provides possible answers to the research question. |
| Can be open access in full text | Cannot be open access in full text |

### 4) *Study Selection*

The prism method is the method used in conducting this research, as follows

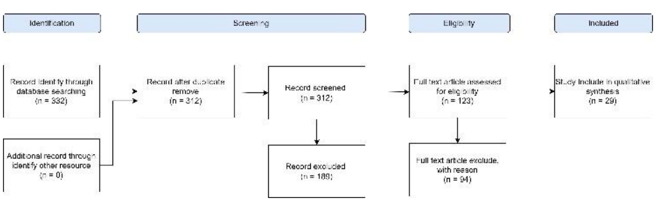


Figure 1. Study selection

The action taken after obtaining the initial database with the number of 332 through the search string is to eliminate duplication in the data, thereby producing 20 articles in this first stage. The next stage is filtering the articles through the title and abstract with the result being 189 articles are deleted and leaving 312 articles. In the final stage, articles were filtered using inclusion and exclusion criteria on the articles, so that in the end we left behind articles that were relevant to this research.

### 5) *Data Extraction*

A data extraction process is used to gather all the information necessary to answer a review request [11]. Important details of the articles, such as title, author, year of publication, publisher, and main findings, are included in the extracted data.

### 6) *Data Synthesis*

The data synthesis process requires collecting and summarizing important findings from research [11]. Results and discussion related to RQ data are presented in Section 4.

## 4. Result and Discussion

### A. *What qualitative evidence exists regarding the ways in which IoT technologies contribute to the identification and leveraging of tacit knowledge, and how are these insights reflected in healthcare practices?*

Of the 29 papers reviewed, there are 2 classifications of users who utilize IoT in knowledge management in the healthcare sector, namely IoT for Patients and IoT for Medical Staff:

TABLE I. User in IoT Knowledge management Medical System

| ***User*** | ***Papers*** |
|---|---|
| IoT for Patient | P01; P02; P03; P04; P06; P08; P10; P13; P14; P15; P18; P20; P21; P22 |
| IoT for Medical Staff | P05; P07; P11; P18; P20; P09 |

### 1) *IoT for Patient*

The human body is a complex entity so the diseases that each individual contracts can be different. Therefore, the handling is different [P02][P03][P18]. Generally, patients provide information about their illness to medical personnel in the traditional way, namely by word of mouth [P06]. However, this is less effective because medical personnel do not get accurate information about the disease the patient is suffering from [P06]. For example, in patients with non-communicable diseases (NCDs) such as diabetes, cancer and cardiovascular disease which generally occur in older people and are prone to death [P02] [P14]. In addition, Patients feel the Discomfort and stress that sick and exhausted patients face when they have to visit several locations to carry out different health tests[P14][P22].

IoT is one solution in this case, namely by using IoT devices and wearable technology. IoT can help save money and time for patients and healthcare providers by eliminating the need for multiple visits and reducing travel by combining 6 health testing tools including an ECG, pulse oximeter, thermometer, glucometer, blood pressure monitor, and heartbeat sensor[P04 ][P15]. The system includes an android application with a server that can access cloud data [P02]. This cloud data can be accessed by health workers to become the basis for taking decisions in action to patients [P19][P20].

Particularly real-time health monitoring systems can potentially contribute to the identification of tacit knowledge related to patient health and well-being [P10]. For example, continuous monitoring of vital signs and body motion through IoT sensors can provide healthcare practitioners with valuable insights into patients' health conditions, allowing for early detection of potential health issues and personalized treatment plans[P08]. Additionally, to improve healthcare practices, the data collected from IoT sensors can be leveraged by enabling evidence-based decision-making, personalized care, and proactive health management [P13]. This allows for personalized care, continuous health monitoring, and early detection of disease[P01].

Another example is the use of biosensors and IoT devices to gather patient mobility data, which is then integrated into the SmartHealth context-aware 5G cloud platform [P21]. This integration allows for the continuous adaptation of the platform with experts feedback, enhancing the accuracy and reliability of medical diagnostics [P21]. The SmartHealth system is designed to provide personalized diagnostic solutions for chronic diseases, such as liver cirrhosis and diabetes, through the integration of machine learning algorithms and big data analytics [P21].

*2) IoT for Medical Staff*

IoT for medical staff includes the use of knowledge management by medical personnel for the purposes of taking action decisions for patients and their performance. Health workers, especially doctors, have an important role in making decisions about patient healing [P05]. IoT in knowledge management can help health workers make decisions quickly by displaying real-time data and almost accurate data [P07][P18]. Additionally, the Internet of Things (IoT) can convert raw, unprocessed data into a format that machines can understand and analyze, allowing them to generate useful insights through the application of semantic technologies. [P11]. Semantic technology works through a smart semantic gateway whose output is then sent to the semantic engine, which consists of modules for semantic knowledge representation and reasoning[P11]. Semantic engines utilize automated reasoning to generate actionable knowledge from ontologies and knowledge bases, while intelligent semantic gateways handle the pre-processing, encryption, and standardization of medical data formats, using APIs to enable cloud services and support collaboration between healthcare and public health systems. [11].

*B. In what ways do qualitative studies shed light on the challenges and opportunities associated with the integration of IoT into knowledge management systems, and how do healthcare system navigate these complexities?*

Based on the literature review, there are several challenges in integrating IoT into knowledge management

TABLE II. CHALLENGE IN INTEGRATION OF IOT INTO KNOWLEDGE MANAGEMENT

| ***Challenge*** | ***Papers*** |
|---|---|
| Data security and privacy concern | P03; P05; P06; P14; P16; P19; P20; P21; P25; P26 |
| Data Management (real time data processing heteroginity) | P06; P10; P11; P18; P19; |
| User Adoption | P01; P05; P23; P27; P28; 29 |

*1) Data Security and Privacy Concern*

Data security is a very complex challenge in the integration of IoT in knowledge management; especially in the healthcare industry [P03] [P05] [P16]. Patient medical records are important information to protect [P03]. The current healthcare information systems are vulnerable to security breaches; leading to the leakage of patients' private information[P03] [P21] [P25]. Potential cyberattacks have increased as a result of the increased use of interconnected devices and systems; such as Internet of Things (IoT) devices; and the digitization of healthcare data [P14][P19]. The sensitive and valuable nature of healthcare data; including personal and medical information; makes it an attractive target for cybercriminals [P20]. Additionally; the security vulnerabilities of healthcare information systems have been exacerbated by the increasing difficulty of detecting and combating malware; leading to potential data breaches [P26]. Implementation of Security algorithms such as DNA encryption; decryption on the cloud and fully homomorphic encryption [P25].

The Privacy-Preserving Medical Record Searching Scheme (PMRSS) is an architecture crafted to facilitate secure and intelligent diagnostic processes within IoT healthcare frameworks [P03]. It allows patients to search their past medical records securely while protecting patient privacy and case databases [P03]. In the PMRSS framework; the patient interacts through a local host while the intelligent doctor; utilizing the iDoctor-database; collaborates to provide medical guidance [P03]. This scheme operates in several phases:

1. Query Phase: The patient selects the uncomfortable part of the body and enters the physical symptoms into his PLH. This information is sent to iDoctor.
2. Parameter Identification: Upon receiving relevant information; the intelligent doctor (iDoctor) determines the disease type and notifies the patient of the diagnostic parameters needed.
3. Data Collection: Patients use medical equipment at home to measure the values of required parameter items and create query vectors.
4. Encrypt and Upload: PLH encrypts patient health data and uploads the encrypted data to iDoctor.
5. Matching Phase: iDoctor compares the encrypted abstract of the current patient data with previous records in iDD using ElGamal Blind Signature. If

the abstract matches; the patient can obtain a diagnosis report.

6. Result Acquisition: The patient is provided with a diagnosis report that is securely encrypted using the ElGamal blind signature algorithm. The report; matching the patient's health status; is accessible without needing to decode the data from the iDD.

The PMRSS scheme ensures the privacy of both patients and the iDoctor case database is secure; whether their data matches or not. By changing the amount of zeros in a sequence of binary digits (bits); we can strengthen or weaken the security to protect against forceful; systematic hacking attempts[P03].

*2) Data Management*

Data management is very important in IoT knowledge management because of the large amount of data generated by IoT devices [P06]. IoT devices create vast amounts of data quickly; which varies depending on where it's gathered and can differ in accuracy or detail. [P10]. The goal of IoT is to capture and analyze this data to provide more effective services to operators[P10]. The collected data needs to be analyzed in great detail; and big data algorithms are used for this purpose. Additionally; due to the unreliable nature of network connections; some of the data collected may be incomplete; requiring sophisticated machine learning algorithms to extrapolate the data [P10]. In the context of healthcare; managing big data is essential for real-time monitoring; personalized healthcare; and improving patient care [P10]. It also plays an important role in medical emergency management; drug storage management; and blood data management[P11]. Additionally; data collected from IoT devices in healthcare environments is continuously updated; and information exchange can occur simultaneously among hundreds or thousands of devices[P10]. Therefore; effective data management is essential to ensure the accuracy; security; and timely processing of data for healthcare decision making and patient care[P19].

Organizations can simplify their data management by using a combined local and cloud-based system that understands and organizes information smartly; guided by a set of knowledge rules. [P11]. This architecture consists of three hierarchical levels: the subject; edge; and cloud layers [P11]. Semantic edge-cloud; which operates at the edge of the network closer to the data source; facilitates pre-processing; local data processing and real-time notification to relevant health professionals and emergency medical services[P11]. In addition; the use of semantic technology enables the integration of heterogeneous IoT systems independently and seamlessly; converting raw data into a form that can be clearly interpreted by machines [P18]. This approach enables the processing and interpretation of data by machines to generate meaningful knowledge; ultimately improving the quality of healthcare services and supporting crisis management efforts [P19].

*3) User Adoption*

The literature suggests that perceived difficulties in learning; using; and maintaining technology can act as a significant obstacle. It might be perceived by stakeholders as challenging to learn; use; or maintain; which could impede its adoption [P05]. For example; Older adults often adopt new technologies like computers and smartphones more slowly; leading to a tech gap with service providers. [P23]. Individuals with dementia often struggle with wearable devices due to memory loss; disorientation; and physical discomforts like itching and sweating; highlighting the need for more elderly-friendly technology solutions [P27].

Organization understand that using a mix of different methods helps to better understand the challenges people face when starting to use new technology [P28]. This approach merges statistical data analysis with personal narratives from interviews or open-ended surveys to create a detailed picture of user adoption barriers [P01] [P23] [p28]. Research suggests that age; gender; and technological proficiency markedly influence the degree to which different factors affect technology adoption [P28]. Therefore; when implementing technology adoption strategies; organizations need to consider these demographic and experiential differences.

*C. How do qualitative investigations highlight the role of organizational culture and contextual factors in shaping the effectiveness of IoT-driven knowledge management initiatives; and what lessons can be drawn for successful implementation?*

The role of organizational culture in IoT knowledge management is important for shaping the effectiveness of IoT-driven knowledge management[P08]. Organizational culture influences how knowledge is shared; utilized; and valued within the organization[P25]. A supportive and collaborative culture can facilitate the sharing and integration of IoT-driven knowledge across different departments and teams [18].

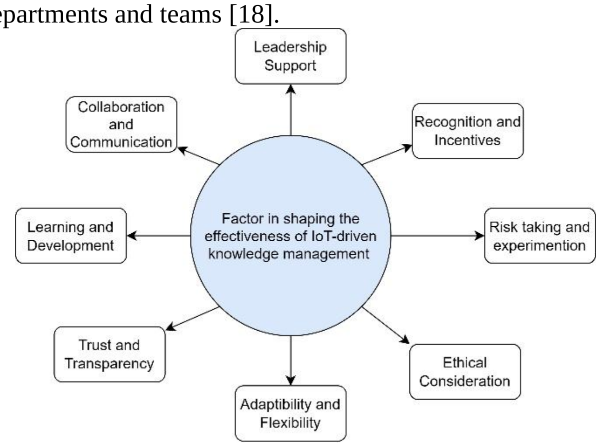

Figure 2. Factor in shaping the effectiveness of IoT-driven knowledge management

Factors that shape the effectiveness of IoT-driven knowledge management within organizational culture include:

TABLE III. FACTORS IN SHAPING THE EFFECTIVENESS OF IOT-DRIVEN KNOWLEDGE MANAGEMENT

| ***Contextual Factor*** | ***Papers*** |
|---|---|
| Leadership Support | P08; P10; P12; P25; P18; P11; P05; P23 |
| Collaboration and Communication | P08; P10; P12; P25; P18; P11; P05; P23 |
| Learning and Development | P08; P10; P12; P18; P05; P23 |
| Trust and Transparency | P08; P23 |
| Adaptability and Flexibility | P08; P10; P12; P25; P11 |
| Recognition and Incentives | P08; P05 |
| Ethical Consideration | P10; P12; P03 |
| Risk taking and experimention | P25; P11; P23 |

Organizational leadership plays a crucial role in shaping the culture and effectiveness of healthcare systems; particularly in the context of implementing IoT-driven knowledge management initiatives [P8][P25]. Effective leadership is essential for fostering a culture of innovation; collaboration; and continuous learning within healthcare organizations [P23][P11]. It involves setting a clear vision for the integration of IoT technologies; promoting the adoption of new knowledge management practices; and ensuring that employees are engaged and supported in embracing these changes [P10][P12][P18]. In the context of IoT-driven knowledge management; organizational leadership is responsible for guiding the strategic implementation of IoT technologies in healthcare [P05].

Collaboration and communication play pivotal roles in the successful implementation of IoT-driven knowledge management initiatives in healthcare [P08][P12][P18]. These aspects are essential for fostering a culture of teamwork; knowledge sharing; and effective coordination among healthcare professionals and stakeholders[P10]. Collaboration involves the joint effort of various healthcare professionals; including doctors; nurses; specialists; and administrators; to leverage IoT technologies for knowledge management [P11][P23]. Effective communication is essential for sharing knowledge; exchanging information; and coordinating activities within healthcare organizations. In the context of IoT-driven knowledge management; clear and efficient communication channels are necessary for transmitting data collected from IoT sensors; sharing medical knowledge; and coordinating patient care [P25]. For instance; in telemedicine and mobile medical care; effective communication channels are vital for remote consultations; patient monitoring; and timely exchange of medical information[23]

Learning and development refer to the continuous acquisition of knowledge; skills; and competencies by healthcare professionals to adapt to technological advancements and improve patient care[P12]. This includes staying updated on the latest advancements in medical technology; understanding the functionalities of IoT devices and sensors; and acquiring the necessary skills to interpret and utilize data collected from IoT devices for patient care and treatment[P08]. Organizations that invest in employee training and development related to IoT technologies and knowledge management foster a culture of continuous learning and adaptation to new IoT-driven knowledge[P23].

Trust refers to the confidence and reliance that patients; healthcare providers; and stakeholders have in the accuracy; security; and ethical use of IoT technologies in healthcare [P08]. Transparency; on the other hand; involves the openness and clarity in the operation and data management of IoT systems; ensuring that all stakeholders have access to relevant information and understand the processes involved[P08]. A culture of trust and transparency encourages employees to share their IoT-driven knowledge without fear of judgment or reprisal[P23]. This openness can lead to more effective knowledge management practices [P23].

In the rapidly evolving landscape of healthcare technology; adaptability refers to the ability of healthcare systems to adjust and respond to changes; new technologies; and emerging patient needs[P11]. Flexibility; on the other hand; involves the capacity of healthcare systems to accommodate diverse requirements; integrate new solutions; and modify existing processes to meet evolving demands [P12]. An organizational culture that values adaptability and flexibility is better equipped to integrate new IoT-driven knowledge into existing processes and systems [P10].

Recognition refers to acknowledging the efforts and achievements of healthcare professionals in leveraging IoT technologies for knowledge management; patient care; and treatment[P08]. This recognition can take various forms; such as acknowledging innovative solutions; successful patient outcomes; or contributions to improving healthcare processes through the use of IoT technologies[P08][P05]. Incentives; on the other hand; involve providing tangible rewards or benefits to healthcare professionals for their active participation and successful utilization of IoT- driven knowledge management initiatives[P08]. These incentives can include financial rewards; professional development opportunities; career advancement; or other forms of recognition for their contributions to improving healthcare services through the effective use of IoT technologies[P08][P05].

Ethical considerations in IoT-driven healthcare systems encompass patient privacy; data security; informed consent; equitable access; transparency; and accountability [P10][P12]. Upholding ethical standards in the implementation and utilization of IoT technologies is essential for ensuring patient trust; data integrity; and equitable healthcare delivery [P03].

Risk-taking and experimentation are fundamental for driving innovation; adapting to change; and improving the effectiveness of IoT-driven knowledge management initiatives in healthcare and public health collaborations [P11][P25]. Embracing experimentation allows organizations to address the complexities of IoT integration; semantic interoperability; and the dynamic nature of healthcare systems; ultimately leading to improved healthcare outcomes and crisis management[P25]. Cultures that support risk-taking and experimentation provide a conducive environment for piloting and implementing IoT-driven knowledge management systems[P23]. Employees are more likely to explore new ways of leveraging IoT technologies to manage and utilize knowledge effectively[P23].

Successful implementation of IoT in healthcare requires collaboration; integration of IoT and big data; addressing technical challenges; ethical considerations; data security; and overcoming barriers. By considering these lessons; healthcare organizations can effectively leverage IoT technologies to enhance knowledge management and improve patient care.

## 5. Conclusion

With the development of technology; organizations are starting to widely adopt digital solutions in developing their business; which is driven by the need for innovative Knowledge Management Systems. Especially in application to the health sector; especially during the COVID-19 pandemic. The application of KM in the health sector can strengthen operational processes by using the integration of the Internet of Things into the KM system. So that the data collection process can run optimally. KM can also be applied to remote monitoring systems; clinical device management and remote medicine. The challenge that can occur in implementing this system is that when the management is not good; the resulting data can also be a problem for users. To face these problems; it is necessary to utilize the system optimally and in real time so that the data obtained can be used to make optimal decisions.

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## Appendix Literature Sample (n=29)

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