Health Management System: A comparative study

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**Abstract**: The healthcare landscape is undergoing a transformative shift towards digitization, driven by the need for efficient healthcare data management and improved patient services (northoasss 2022). This research project presents the design and development of a Health Management System (HMS) aimed at addressing critical challenges faced by healthcare organizations, patients, and medical practitioners. The HMS features three core components: appointment setting, data storage, and virtual sessions. Leveraging a user-centric design approach and modern technologies, including Python Flask, Angular, and MongoDB, the system offers a comprehensive solution for healthcare management. Our research successfully modernizes healthcare data management by transitioning from traditional paper-based records to a secure and accessible digital platform (Jones, 2019). The use of MongoDB ensures structured data storage and aligns with industry best practices (tutorialspoint 2023). Furthermore, the system enhances accessibility and user experience, allowing healthcare professionals to efficiently manage patient data and facilitate virtual consultations (HIMSS 2015).

Adherence to industry norms and rigorous evaluation during the development process ensures the system's trustworthiness and potential for real-world applications (Davis & Martin, 2019; Wilson, 2020). The HMS contributes to the ongoing digitization of healthcare services, offering a scalable and user-friendly solution ((HIMSS 2015). While acknowledging limitations in handling emergency situations and resource constraints, this research project presents a valuable artifact and insights into iterative development processes, data privacy considerations, and user-centred design principles (AWS 2023). As the healthcare sector continues its digital transformation journey, the HMS serves as a promising contribution to the advancement of healthcare services and technology.

Table of Contents

[1. RESEARCH PROPOSAL 1](#_Toc149583328)

[1.1 Introduction 1](#_Toc149583329)

[1.2 Concepts Central to study 1](#_Toc149583330)

[1.3 Problem description and Objectives 2](#_Toc149583331)

[1.3.1 Problem description 2](#_Toc149583332)

[1.3.2 Research aim 3](#_Toc149583333)

[1.3.3 Research objectives 3](#_Toc149583334)

[1.4 Paradigmatic perspective 4](#_Toc149583335)

[1.4.1 Critical Social theory 4](#_Toc149583336)

[1.5 Methodological assumptions 5](#_Toc149583337)

[1.6 Research methodology 5](#_Toc149583338)

[1.6.1 The cycle of relevance 6](#_Toc149583339)

[1.6.2 The cycle of design 6](#_Toc149583340)

[1.6.3 The cycle of rigor 6](#_Toc149583341)

[1.7 Study context 7](#_Toc149583342)

[1.8 Data collection 7](#_Toc149583343)

[1.9 Study design 7](#_Toc149583344)

[1.10 Approach to project management and project plan 8](#_Toc149583345)

[1.11 Scope 10](#_Toc149583346)

[1.12 Limitations of the project 11](#_Toc149583347)

[1.12.1 No central system for managing data captured. 11](#_Toc149583348)

[1.12.2 Aging workforce is resistant to change. 12](#_Toc149583349)

[1.12.3 Lack of decision support tools 12](#_Toc149583350)

[1.13 Risks of the project 12](#_Toc149583351)

[1.13.1 General technology risks which may occur once the project is done: 12](#_Toc149583352)

[1.13.2 Risks which may occur during this study and development of the artefact: 13](#_Toc149583353)

[1.14 Description of development platform, resources, and environments 13](#_Toc149583354)

[1.14.1 Development platform 14](#_Toc149583355)

[1.14.2 Resources 14](#_Toc149583356)

[1.14.3 Environment 14](#_Toc149583357)

[1.15 Ethical considerations 15](#_Toc149583358)

[1.15.1 Confidentiality 15](#_Toc149583359)

[1.15.2 Executive Summary 15](#_Toc149583360)

[2. Research Methodology 17](#_Toc149583361)

[2.1 Introduction 17](#_Toc149583362)

[2.2 Paradigms 18](#_Toc149583363)

[2.2.1 Positivism 18](#_Toc149583364)

[2.2.2 Interpretivism 18](#_Toc149583365)

[2.2.3 Post positivism 19](#_Toc149583366)

[2.2.4 Critical Social theory 20](#_Toc149583367)

[2.3 Research Methodology 21](#_Toc149583368)

[2.3.1 The cycle of relevance 22](#_Toc149583369)

[2.3.2 The cycle of design 22](#_Toc149583370)

[2.3.3 The cycle of rigor 22](#_Toc149583371)

[2.4 Research problems in Design Science Research 24](#_Toc149583372)

[2.5 Qualitative study 24](#_Toc149583373)

[2.6 Testing the artefact as part of ensuring rigor and validity 25](#_Toc149583374)

[2.7 Research Methods 25](#_Toc149583375)

[2.8 Case Study 26](#_Toc149583376)

[2.9 Action Research 27](#_Toc149583377)

[2.10 Survey 28](#_Toc149583378)

[2.11 Modelling 28](#_Toc149583379)

[2.12 Prototyping 28](#_Toc149583380)

[2.13 Research design 29](#_Toc149583381)

[3. Literature Review 31](#_Toc149583382)

[3.1 Introduction 31](#_Toc149583383)

[3.2 Background 32](#_Toc149583384)

[3.3 User Interface 33](#_Toc149583385)

[3.4 Data Storage Format 34](#_Toc149583386)

[3.4.1 SQL 34](#_Toc149583387)

[3.4.2 Why SQL? 35](#_Toc149583388)

[3.5 No SQL 35](#_Toc149583389)

[3.5.1 Why NoSQL? 36](#_Toc149583390)

[3.6 Data Sharing 37](#_Toc149583391)

[3.6.1 Distributed database system 38](#_Toc149583392)

[3.6.2 Centralised database system 40](#_Toc149583393)

[3.6.3 Hybrid database design combination of blockchain and central database 41](#_Toc149583394)

[3.7 Critique 43](#_Toc149583395)

[4. Empirical Study 45](#_Toc149583396)

[4.1 Introduction 45](#_Toc149583397)

[4.2 Description of the Artefact 46](#_Toc149583398)

[4.3 Appointment setting 46](#_Toc149583399)

[4.4 Storage of data 47](#_Toc149583400)

[4.5 Virtual session 49](#_Toc149583401)

[4.6 Implementation Technologies 50](#_Toc149583402)

[4.6.1 Virtual Platform Technologies 50](#_Toc149583403)

[4.6.2 Website Technologies 50](#_Toc149583404)

[4.7 Description of the development according to the DSR methodology 51](#_Toc149583405)

[4.7.1 Relevance cycle 51](#_Toc149583406)

[4.7.2 Design Cycle 52](#_Toc149583407)

[4.7.3 Rigor Cycle 53](#_Toc149583408)

[4.7.4 Iterative development cycles 54](#_Toc149583409)

[4.8 Findings 55](#_Toc149583410)

[4.8.1 User engagement and usability 55](#_Toc149583411)

[4.8.2 Data Management Efficiency 55](#_Toc149583412)

[4.8.3 Virtual Consultations Feasibility 55](#_Toc149583413)

[4.8.4 Frontend Development Challenges 56](#_Toc149583414)

[4.8.5 Security and Compliance 56](#_Toc149583415)

[4.8.6 Feedback and Continuous Improvement 56](#_Toc149583416)

[4.8.7 Future Potential 56](#_Toc149583417)

[4.8.8 User acceptability test 56](#_Toc149583418)

[4.8.9 User-Friendliness 57](#_Toc149583419)

[4.8.10 Satisfaction with Features and Performance 57](#_Toc149583420)

[4.8.11 Suggestions for Improvement 57](#_Toc149583421)

[5. Conclusion 59](#_Toc149583422)

[5.1 Overview of the research 60](#_Toc149583423)

[5.2 Phases and Cycles 60](#_Toc149583424)

[5.3 Contributions of the Research 61](#_Toc149583425)

[5.3.1 Outcomes 61](#_Toc149583426)

[5.3.2 Recommendations 61](#_Toc149583427)

[5.4 Limitations to the Study and Future Research 62](#_Toc149583428)

[5.4.1 Limitations of the Study 62](#_Toc149583429)

[5.4.2 Prospects for Future Research 62](#_Toc149583430)

[5.5 Evaluation of the Study 63](#_Toc149583431)

[5.5.1 Validity and Reliability of Research Tools 63](#_Toc149583432)

[5.5.2 Adherence to Prescribed Principles 64](#_Toc149583433)

[5.6 Reflection on the Study 64](#_Toc149583434)

[5.6.1 Lessons Learned 65](#_Toc149583435)

[5.6.2 Strengths 65](#_Toc149583436)

[5.6.3 Weaknesses: 66](#_Toc149583437)

[5.6.4 Achievement of Objectives 66](#_Toc149583438)

[5.6.5 Project Management and Timeline 66](#_Toc149583439)

[5.7 Conclusion of the Study 66](#_Toc149583440)

[6. References 68](#_Toc149583441)

[Figure 1 9](#_Toc149575467)

[Figure 2 9](#_Toc149575468)

[Figure 3 10](#_Toc149575469)

[Figure 4 10](#_Toc149575470)

[Figure 5 10](#_Toc149575471)

[Figure 6: Relevance and Cycle of Rigor in Design Science Research (Dresch et al. 2015). 23](#_Toc149575472)

[Figure 7: Criteria for conducting Design Science Research (Henver et al. 2004). 24](#_Toc149575473)

[Figure 8: Design Science iterates over two problem solving activities (Wieringa 2014). 25](#_Toc149575474)

[Figure 9:Activities in a case study (Miguel 2007). 27](#_Toc149575475)

[Figure 10: Study design. 30](#_Toc149575476)

[Figure 11: SQL Architecture (tutorialspoint 2023) 34](#_Toc149575477)

[Figure 12: Database vs NoSQL 36](#_Toc149575478)

[Figure 13:A distributed database environment (Ozsu and Valduriez 1991). 38](#_Toc149575479)

[Figure 14: Centralized database system 40](#_Toc149575480)

[Figure 15: Hybrid Database Design Combination of Blockchain and centralized database (Şafak et al. 2019) 42](#_Toc149575481)

[Figure 16: Appointment Making Kanban view. 47](#_Toc149575482)

[Figure 17: Appointment Making table view. 47](#_Toc149575483)

[Figure 18: MongoDB Storage. 48](#_Toc149575484)

[Figure 19: MongoDB Saved doctor's information. 48](#_Toc149575485)

[Figure 20: MongoDB Saved Patient's data. 48](#_Toc149575486)

[Figure 21: Virtual Platform. 49](#_Toc149575487)

[Figure 22: Criteria for conducting Design Science Research (Henver et al. 2004). 51](#_Toc149575488)

[Figure 23: Iterative phases. 54](#_Toc149575489)

[Figure 24: User acceptability statistics 57](#_Toc149575490)

# RESEARCH PROPOSAL

## Introduction

Health management systems have become an essential tool for healthcare organizations in managing patient care and improving healthcare delivery. With the rapid advancement of technology, health management systems have evolved to provide more efficient and effective ways to manage patient data, track clinical outcomes, and support decision-making processes in healthcare organizations.

Despite the potential benefits of health management systems, there are still significant challenges facing their implementation and adoption in healthcare organizations. These challenges include issues related to data privacy and security, interoperability and data exchange, user adoption and training, and cost-effectiveness. Therefore, this study aims to investigate the implementation and adoption of health management systems in healthcare organizations. The study will explore the challenges and opportunities facing healthcare organizations in adopting health management systems, the impact of these systems on patient care and outcomes, and the factors that influence their adoption and use.

By understanding the challenges and opportunities facing the implementation and adoption of health management systems, this study aims to provide insights and recommendations that can guide healthcare organizations in their decision-making processes and improve the quality of patient care and outcomes in healthcare.

## Concepts Central to study

In the past the healthcare industry was using a paper-based approach because it was not linked to any Health management systems. During the 1990s, there was a growing trend in the healthcare industry to embrace new information technologies and software applications, thus the industry recognized the potential benefits of these technologies, including increased efficiency and higher-quality care (Ranjit 2003).

A Health Management System (HMS) is a specialized type of learning management system designed to manage and deliver educational content related to healthcare. A HMS can be used by healthcare organizations, medical schools, and other institutions to train healthcare professionals, provide continuing education for existing healthcare workers, and deliver health-related courses to patients and the public HMSs can provide a range of features, including online course creation and delivery, course management, and learner tracking and assessment. They may also include features specific to healthcare education, such as simulation tools, virtual patient cases, and clinical practice guidelines. Some HLMSs may be tailored for specific healthcare fields, such as nursing or pharmacy, while others may offer more general healthcare content. Some HMSs may also incorporate social learning features, allowing healthcare professionals to collaborate and share knowledge and expertise with each other. Overall, HMSs can be powerful tools for improving healthcare education and training, helping healthcare professionals to stay up to date with the latest knowledge and best practices, and improving patient outcomes.

As technology grew the healthcare industry became more digital and is rapidly evolving. Due to the Health learning management systems, the healthcare industry is evolving faster than ever thus increasing the global healthcare market. The value of the worldwide healthcare industry exceeds $4 trillion currently and it is projected to increase to approximately $7 trillion by the year 2025 ('northoasss' 2022a). Despite the progress made in the use of information technology (IT) in healthcare, there are still several significant challenges that the industry is facing. These challenges include dealing with the complexity of medical data, the lack of a standardized electronic health care record (EHCR) system that is recognized across the industry, difficulties with data entry, concerns around security and confidentiality, integration issues within clinical practice, and a general lack of understanding about the benefits and risks of IT in healthcare (Bose 2003).

## Problem description and Objectives

In the following subsection, the study aims to give a comprehensive description of the problem description and the objectives of this research.

### Problem description

The healthcare industry faces significant challenges in managing patient health information efficiently and securely. In the past, the adoption of IT in healthcare has been siloed within individual organizations or units. As a result, there has been limited recognition of the clinical advantages that could be gained by sharing information between different organizations (Bose 2003). In many healthcare settings, patient data is still being stored in paper-based records, making it difficult to access, share, and update patient health information. For example, every time when one goes to the hospital or clinic, we usually carry our appointment card and then when you get there, the nurse will take your physical file to your doctor before you can be called to see your doctor, same applies to when you had taken blood tests, you must physically come back to get your test results, which most people don’t do. This can lead to errors in clinical decision-making, duplication of tests and procedures, and delays in patient care. Additionally, the absence of a standardized electronic HMS across the industry has resulted in a lack of interoperability and compatibility among different healthcare systems. Currently, a significant challenge facing the healthcare industry in its efforts to improve efficiency and cost-effectiveness is the lack of ability or difficulty in sharing information between different systems and care organizations (Bose 2003). As a result, patient data is often fragmented and difficult to integrate, leading to suboptimal patient outcomes and increased healthcare costs. Therefore, there is a pressing need to develop and implement an efficient and secure electronic health management system that can integrate with existing healthcare systems to improve patient care and outcomes.

### Research aim

This study aims to provide insights and recommendations that can guide healthcare organizations in their decision-making processes and improve the quality of patient care and outcomes in healthcare.

### Research objectives

* **Objective 1**: Perform a literature study on what an HMS should do and how it can improve the quality of patient care. The literature study of health management system entails an in-depth review of existing research and publications on various aspects of health management systems, including their design, implementation, and evaluation. This includes a review of academic journals, books, reports, and other relevant sources to gain an understanding of the key issues, challenges, and best practices in health management systems.
* **Objective 2**: From the literature study provide of a list of the features that the artefact will have to achieve the aim of these research.
* **Objective 3**: Develop an artefact. This artefact will store and manage patient medical records including patient history, test results and treatment plans, allows patients to access their health information, and use technology to facilitate remote consultations to reduce traffic at hospitals.
* **Objective 4**: Provide a documentation of the artefact. Documentation refers to the process of creating, organizing, storing, and maintaining written or electronic records of the artefact's activities, processes, and procedures. This can include several types of documents, such as policies, manuals, reports, specifications, and user guides. The purpose of documentation is to provide a clear and comprehensive understanding of the artefact's operations. Well-documented processes and procedures can help to ensure consistency, accuracy, and efficiency, and can also support compliance with regulations and standards.

## Paradigmatic perspective

This perspective is often associated with the philosophy of science and is used to describe the way that scientific communities establish and maintain a particular way of understanding the world. It involves a shared understanding among scholars or practitioners of a particular discipline about what constitutes legitimate knowledge, how that knowledge is acquired, and what methods and techniques should be used to advance the field.

### Critical Social theory

Critical theory emerged from the writings of a group of authors in the 20th century who were associated with the Institute of Social Research at the University of Frankfurt, and this is why they are commonly referred to as the Frankfurt School (Adil Abdul Rehman 2016). Critical social theory is a philosophical approach that focuses on the critique of society and its structures to bring about social change. It is an interdisciplinary field that draws from various social sciences, including sociology, philosophy, and political science. Critical theorists adopt a position of historical realism when it comes to their ontological perspective because The assumption is made that a concrete reality exists, but it is moulded by a combination of cultural, political, ethnic, gender, and religious influences that interplay with each other to produce a complex societal system (Adil Abdul Rehman 2016). Critical theory has a subjective epistemological approach, as it assumes that the researcher cannot investigate an object without influencing it thus Critical educational researchers aim to be aware of their own underlying assumptions about knowledge and its acquisition, and to articulate these assumptions clearly when conducting their investigations (Adil Abdul Rehman 2016). This ensures that everyone involved in the research is aware of the researchers' epistemological and political perspectives and prevents any confusion or misunderstandings about the researchers' biases or values. The primary goal of critical educational research is not limited to providing an explanation or comprehension of the workings of society but rather to effect change in it (Adil Abdul Rehman 2016). In other words, critical educational research aims to go beyond a passive understanding of society and instead strives to actively transform it. Rather than producing knowledge that merely describes and reinforces the current state of society, critical researchers aim to uncover the underlying beliefs and behaviours that restrict individual freedom (Adil Abdul Rehman 2016). The interpretive and positivist approaches to research are criticized because they are seen as being deeply embedded in the prevailing ideology, without any interest in transforming society, and lacking any intention to promote liberation (Adil Abdul Rehman 2016). The critical methodology involves a back-and-forth conversation that aims to promote change in the perspective of the subjects regarding the social systems that deprive them of their intellectual and social needs. The investigator engages in dialogue with the subjects to achieve this objective (Adil Abdul Rehman 2016). This paradigm will be appropriate for this research because Critical social theory can be helpful in identifying the underlying power structures and social inequalities that affect access to and quality of healthcare which is what the aim of this research is aside from developing an artefact.

## Methodological assumptions

During this research study Design Science Research (DSR) will be considered or as a methodology and not a paradigm because it is focused on the practical application of knowledge to solve real-world problems, rather than on developing a particular worldview or theoretical framework. Design science research is based on the ontological assumption that there are multiple realities that exist in different contexts, this means that reality is not singular and universal but varies depending on the situation or environment (V. K Vaishnavi 2004). The epistemological assumption of design science research states that creating artefacts is necessary to acquire knowledge (Salvatore T March 1995). In other words, knowledge can only be gained through the process of designing and building things.

## Research methodology

DSR will be used for this research because DSR methodology provides a structured approach to developing an artefact that is grounded in empirical evidence and focused on addressing a specific problem or need which in this case is the quality of patient care and outcomes in healthcare. And since critical social theory will be used as a paradigm, combining these two approaches create an opportunity to develop a health learning management system that is grounded in empirical evidence and best practices, while also being informed by a critical perspective that considers the broader social context in which the system will be used. This can help to ensure that the system is effective in achieving its goals, while also being sensitive to the needs and preferences of stakeholders. The concept of DSR involves solving problems and improving human understanding by creating innovative artefacts (Jan vom Brocke 2020). A design science research project is primarily concerned with the creation and evaluation of a modern design rather than the generation of new knowledge (Gregory 2010). In other words, the focus of a design science research project is on the practical application and testing of a modern design, rather than the theoretical exploration and discovery of new knowledge. In a design research project, there are typically three cycles of DSR: the cycle of relevance, the cycle of design, and the cycle of rigor (Alan Henver 2010). This means that throughout the project, researchers engage in a process of identifying the relevant problem or issue, designing potential solutions, and rigorously evaluating the effectiveness of those solutions. Each cycle informs and builds upon the others, leading to a more refined and effective outcome.

### The cycle of relevance

The underlying motivation is to introduce innovative solutions that can improve the existing situation thus the relevance cycle is the starting point for design science research, which begins with an application context. This context not only provides the necessary requirements for the research, such as identifying a problem that needs to be addressed, but it also outlines the criteria for evaluating the research results to determine if they meet the desired outcomes (Hevner 200).

### The cycle of design

The fundamental component of any DSR project is the internal design cycle, which is integral to the entire process of designing, creating, or enhancing something. This cycle of designing involves creating multiple options and then assessing each one to determine which one meets the necessary standards or expectations (Hevner 200). This cycle continues until a design is found that meets all the necessary requirements and is deemed satisfactory. According to (Hevner 200) it is crucial to maintain an equilibrium between the resources utilized in creating and assessing the developing design during the design cycle.

### The cycle of rigor

The rigor cycle involves incorporating existing knowledge into a research project to ensure its originality and novelty (Hevner 200). Researchers must put in the effort to produce designs that make a unique and significant contribution to the field, rather than simply relying on established processes thus In design science research, the rigor of the research is dependent on the researcher's ability to choose and use suitable theories and methods to create and assess the artefact (Hevner 200).

In general, the process of DSR comprises three stages: identifying a problem that is applicable and significant, creating an IT artefact to address the issue, and assessing its value before and after implementation with the intension to achieve the primary objective of DSR which is to identify and solve real-world problems that are practical and relevant (Alan Henver 2010).

## Study context

The health care industry has increasingly embraced information technologies and software applications in the past few decades, as it seeks opportunities for efficiency and higher-quality care. One area where these technologies have shown significant promise is in the development of health learning management systems. These systems are designed to help healthcare providers manage patient data, track health outcomes, and monitor performance metrics.

## Data collection

The artefact that will be developed during this research will be able to generate its own data therefore there will not be any data collection involved.

## Study design

The design of a research study refers to the structure or system of techniques and approaches employed to gather and analyse data related to specific variables identified in a research question (Priya Ranganathan 2018). The design cycle consists of the following stages:

1. **Define the problem:** The lack of standardized electronic health learning management system across the industry has resulted in the lack of interoperability and compatibility among different healthcare systems, leading to suboptimal patient outcomes and increased healthcare costs. An efficient and secure electronic health learning management system is needed to integrate with existing healthcare systems to improve patient care and outcomes.
2. **Conduct research**: A literature review will be conducted to gather more information about the existing Health learning management systems and observing how they work.
3. **Brainstorm**: From the information gathered from the previous stage, brainstorming of solutions to breach the gap of the existing Health Management System that will solve the research problem will be done.
4. **Prototype**: The best Ideas or solutions from the Ideate stages will be used to develop an artefact or prototype
5. **Test**: Test if whether the artefact can solve the research problem efficiently and identify areas of improvement
6. **Iterate**: Based on the results from testing, the design is refined, and the cycle begins again with the revised design being evaluated and further refined until a satisfactory solution is achieved.

## Approach to project management and project plan

|  |  |  |
| --- | --- | --- |
|  | Start date | End date |
| Research on Health learning management system | 15 March | 17 March |
| Write project proposal | 18 March | 05 April |
| Review and corrections | 06 April | 09 April |
| Research proposal hand in (feedback) |  | 10 April |
| Research proposal re-hand in |  | 17 April |
| Literature study submission |  | 11 May |
| Research methodology submission |  | 02 May |
| Feedback: Research methodology |  | 09 May |
| Resubmission: Research methodology |  | 15 May |
| Literature study resubmission |  | 17 May |
| Learn Angular | 07 April | 10 April |
| Learn HTML | 11 April | 12 April |
| Learn JavaScript | 13 April | 15 April |
| Learn API’S | 16 April | 20 April |
| Artefact development | 21 April | 19 September |
| Testing | 20 April | 20 April |
| Project demonstration |  | 21 September |
| Demonstration of project |  | 12 October |
| Submission: Full documentation |  | 16 October |
| Feedback: Complete documentation |  | 23 October |
| Resubmission: Full documentation |  | 30 October |
| Final Assessment completed |  | 20 November |

Table 1: Project plan

**

Figure 1

**

Figure 2

*Graphical user interface

Description automatically generated*

Figure 3

Background pattern

Description automatically generated

Figure 4

Graphical user interface, website

Description automatically generated

Figure 5

## Scope

Project scope definition is a crucial process that involves outlining the boundaries and parameters of a project to prepare it for execution (Kerzner 2017). This process is essential in determining whether the project should proceed or not. Incomplete scope definition in the initial stages of a project's life cycle is a common issue that can cause difficulties in the development of construction projects (Mohammed K. Fageha 2013). A clear and comprehensive project scope is crucial for effective project management and to avoid scope creep, which is the addition of unapproved work to a project's scope (Lock 2007). Therefore, it is crucial to define the project scope comprehensively and accurately to ensure a smooth and successful project execution. The scope for this research entails the following:

* This research aims to address the challenges faced by healthcare organizations in managing patient health information efficiently and securely.
* The focus of this research is on the adoption of information technology (IT) in healthcare and the need for a standardized electronic health management system (HMS) that can integrate with existing healthcare systems to improve patient care and outcomes.
* This research will investigate the current state of healthcare information management systems, including the use of paper-based records, siloed IT systems, and the lack of interoperability and compatibility among different healthcare systems.
* This research will explore the clinical advantages that could be gained by sharing information between different organizations and propose recommendations for healthcare organizations to improve the quality of patient care and outcomes.
* This research will also consider the cost-effectiveness of implementing an efficient and secure electronic health management system, including the potential for reducing errors in clinical decision-making, duplication of tests and procedures, and delays in patient care.
* This research will be focused on the healthcare industry in general, without any specific geographic or organizational limitations.

## Limitations of the project

The limitations of a study typically involve weaknesses that are often beyond the researcher's control and are intricately linked to the chosen research methodology, restrictions of the statistical model, limitations of funding, or other similar factors. The limitations of this study include:

### No central system for managing data captured.

Since the artefact that will result from this study is still new, there is no unified system in place to store and manage all the data that is being collected and generated by various sources within the system. This absence of a centralized system can lead to various problems, including difficulties in accessing data in a timely and efficient manner, inconsistencies in data due to duplication or errors, and challenges in data analysis and reporting. For example, if patient data is captured in multiple systems and there is no centralized database, healthcare providers may have to manually search for patient records across various systems, resulting in delays in delivering care. Similarly, without a centralized system, it can be challenging to monitor the performance of health facilities, identify trends, and make informed decisions based on data analysis.

Implementing a centralized system for managing data can help ensure data accuracy, accessibility, and efficiency, thereby enhancing the overall performance of the health management system.

### Aging workforce is resistant to change.

There is a common belief that older workers tend to be less adaptable, more set in their ways, and focused on immediate results, which makes them less open to embracing new ways of doing things (Florian Kunze 2013). Another thing is that old workers are not familiar with technology hence the resistance to change.

### Lack of decision support tools

The absence or insufficiency of technology-based resources that can help healthcare providers make informed decisions regarding patient care. These tools may include electronic medical record systems, clinical decision support software, and other digital resources that can provide real-time patient data, evidence-based treatment guidelines, and other relevant information to support clinical decision-making. Without these tools, healthcare providers may struggle to diagnose and treat patients, leading to potential negative health outcomes efficiently and accurately.

## Risks of the project

The concept of risk refers to how the presence of uncertainty can impact the achievement of objectives (Adel Badri 2012).

### General technology risks which may occur once the project is done:

The subsequent subsection discuss the technology risks that may occur during the project.

#### Malware

People’s computers do not have the same security, thus for some computers it may be easy for them to receive malicious software which will disrupt the computer operation and as result not have access to the HMS for some time.

#### Human error

In the HMS, data will still be capture by a human being thus there is still a chance that a mistake of wrong data being capture may happen.

#### Natural disasters

When natural disasters such as floods and storms occur, they tend to disrupt the network services in nearby areas thus making patients or even health practitioners to not have access to the HMS.

#### Hardware and software failures

Since the artefact of HMS is still new, chances of the hardware or software failing regularly are high.

### Risks which may occur during this study and development of the artefact:

The subsequent subsections describes the risks that may occur during the research and development of the artefact.

#### Load shedding

Not having electricity may delay the progress of this project which may result in late submissions. To prevent this, load shedding schedule will be checked so that a proper project schedule can be derived as result work can be done ahead of schedule.

#### Failure of hardware

A computer might become unresponsive due to long hours of working and for unexplained reasons, which results in project delays and progress loss. To prevent this, I will be using GitHub to save my progress there, that way I have backups of my project.

#### Late submissions

Work might not be finished in time which results in missing deadlines. To prevent this, I will follow the schedule given to us at the beginning of the semester.

## Description of development platform, resources, and environments

In the subsections that follow, the study dives deeper into the platform that will be used to during the development of the artefact, the resources needed as well as the environment.

### Development platform

Operating System: Windows 11

Programming language: Python

Frameworks: CSS, Angular

Database: MongoDB

### Resources

In this context, there will be a need for a computer or a laptop that works properly and enough storage to install the necessary applications.

### Environment

Incudes phases of the software development life cycle (SDLC) which is the act of creating or maintaining software systems (Yu Beng Leau 2012).

1. **Planning phase**

This is the phase where the upcoming project is planned for by defining the problems and scope of the system as well as the objectives of the system.

1. **Feasibility or Requirements of Analysis Stage**

Includes performing research to determine the needs of the users and evaluating alternatives of existing protypes. During the analysis stage, the process of collecting all necessary information for a new system takes place, while also exploring initial concepts for prototypes.

1. **Design and Prototyping**

Includes outlining the details for the entire system along with specific aspects such as user interphases, system interfaces, databases, and access level.

1. **Software Development phase**

In this phase code is starting to be written and the actual system is being build according to the earlier design documents and outlined specifications.

1. **Software testing phase**

After the overall system has been built, the system must then be assessed to make sure that they are not bugs and that the system is user friendly so that the end-user experience is not negatively affected at any point.

1. **Implementation and Integration**

The overall design will come together into its environment and eventually installed thus making it ready for use.

1. **Operations and maintenance phase**

Based on the feedback from end users, in this phase we practice activities to manage issues reported from the end users.

## Ethical considerations

The subsequent subsection provides a clear description of ethics that will be considered during the development of the artefact.

### Confidentiality

Since the artefact will dealing or storing sensitive data about patients’ health, the artefact will adhere to POPIA act. POPIA (Protection of Personal Information Act) is a South African data protection law that was signed into law in 2013 and became effective on July 1, 2020. The purpose of the act is to protect the personal information of individuals, and to regulate the processing of personal information by public and private bodies.

### Executive Summary

The HMS is a comprehensive software solution designed to improve the efficiency and effectiveness of healthcare management. The system aims to streamline various healthcare management processes, including patient care, clinical decision-making, and economic management. HMS includes modules for electronic health records (EHRs), patient management, clinical decision support, and economic management. The EHR module allows healthcare providers to securely store and access patient health records electronically, while the patient management module enables providers to track patient appointments, test results, and treatment plans.

The clinical decision support module provides healthcare providers with real-time access to patient data and evidence-based guidelines, enabling them to make informed decisions about patient care. The economic management module helps healthcare organizations to manage billing, insurance claims, and revenue cycle management. HMS offers several benefits to healthcare organizations, including improved patient outcomes, increased efficiency, and reduced costs. By streamlining healthcare management processes, HMS enables providers to deliver more effective and timely care, resulting in better patient outcomes. The system also helps healthcare organizations to optimize their resources, reducing costs and improving their financial sustainability.

In conclusion, the HMS is a powerful tool that can help healthcare organizations to improve the quality of care they provide while reducing costs and increasing efficiency. By leveraging the latest technology and evidence-based guidelines, HMS can help healthcare providers to deliver the best possible care to their patients. The next chapter will dive deeper into the description of the methodology used throughout this research journey.

# Research Methodology

## Introduction

The focus of the research is the implementation and adoption of HMSs in healthcare organizations. The study aims to investigate the challenges and opportunities facing healthcare organizations in adopting HMSs, the impact of these systems on patient care and outcomes, and the factors that influence their adoption and use. The research aims to provide insights and recommendations that can guide healthcare organizations in their decision-making processes and improve the quality of patient care and outcomes in healthcare. The problem statement highlights the challenges faced in managing patient health information efficiently and securely in the healthcare industry and the need for an efficient and secure HMS that can integrate with existing healthcare systems to improve patient care and outcomes. The HMS will consist of the following features: appointment setting, storage of data and the ability to share data amongst health organisations. We will address this in this chapter by conducting research and choosing the appropriate paradigm for this research, the suitable methodology the aligns with the paradigm chosen, the appropriate research methods and the research design for this research.

This chapter will cover several key components of research, including paradigms, research methods, research methodology, research methods, and research design. It will explore different paradigms or worldviews that underlie research, including positivism, interpretivism, and critical theory. The chapter will also delve into the different research methods available, such as surveys, case studies, experiments, and ethnography, and explain their advantages and disadvantages. The research methodology will be discussed, including how to formulate research questions, collect and analyse data, and interpret the results. Finally, the chapter will explore research design, including how to select the appropriate design for a study, such as cross-sectional, longitudinal, or mixed-methods design.

At the end of this chapter, we will have a better understanding of the different paradigms, research methods, research methodology, research methods, and research design used in research studies. The chapter will provide an overview of each concept and how they relate to each other in the research process. Additionally, the chapter will discuss the importance of choosing the appropriate paradigm, methodology, methods, and design for a specific research study and how they can impact the findings and outcomes of the study. By the end of the chapter, the reader should have a clearer understanding of these concepts and be able to apply them to their own research studies.

## Paradigms

In the following subsections, different types of paradigms will be discussed briefly.

### Positivism

Positivism is a philosophical school that gained prominence in the early 19th century thanks to the writings of Auguste Comte, a French philosopher (Rehman and Alharthi 2016). Positivism posits that the objective reality exists independently of human observation or perception. In terms of ontology, positivists adopt a realist stance because positivists seek to comprehend the social realm using methods and principles that resemble those used in the study of the natural realm (Rehman and Alharthi 2016). The epistemological viewpoint of positivists is grounded in objectivism because researchers strive to maintain objectivity and neutrality as they investigate phenomena that exist independently of their own existence and activities, without altering or interfering with what they are observing. This paradigm emphasizes the use of scientific methods and the collection of empirical data to establish objective knowledge. Positivism holds that reality can be objectively measured and understood using quantitative methods, and that the goal of research is to discover the objective truths that underlie the phenomena being studied. The methodology of positivism places a significant emphasis on experimentation, where the researcher formulates hypotheses in the form of propositions or questions that aim to establish causal relationships between different phenomena (Rehman and Alharthi 2016).

This paradigm is not appropriate for this research because the positivism paradigm is focused on quantitative data and objective measurement, which may not be sufficient for understanding complex healthcare systems and the interactions between stakeholders such as healthcare providers and patients.

### Interpretivism

Interpretivism is a perspective that emerged as an alternative to the dominant approach of positivism (Rehman and Alharthi 2016). Interpretivism posits that there is no single objective reality that exists independently of our perceptions and experiences (Rehman and Alharthi 2016), and therefore rejects the idea that there is a universally verifiable truth that can be discovered through scientific inquiry. Instead, interpretivism emphasizes the importance of subjective meanings and interpretations in shaping our understanding of the world. An interpretive ontology rejects the idea of a foundation for knowledge or reality because it rejects the idea of having a set of permanent and universally accepted standards for establishing truth (Rehman and Alharthi 2016). Interpretivists believe that social reality is shaped by the meanings, values, and beliefs of individuals and groups, and that these meanings must be understood in their own context. Interpretive epistemology is based on subjectivity because observers cannot have direct access to external reality without their own perspectives, ideas, and experiences affecting their perception (Rehman and Alharthi 2016). Therefore, any observation of the world is influenced by the observer's own worldview, concepts, and background knowledge. The aim of interpretive research is not to uncover objective, impartial knowledge or absolute truths that are applicable across all contexts, but rather to comprehend how individuals interpret and make sense of the social phenomena they encounter. The interpretive paradigm has faced criticism for several reasons. One criticism is that it is perceived as "soft," lacking the ability to generate theories that can be applied to broader populations, more over the involvement of the researcher with study participants can compromise objectivity, leading to potential bias (Rehman and Alharthi 2016). Interpretive methodology emphasizes the importance of understanding social phenomena from the perspective of the participants themselves, rather than solely relying on the researcher's interpretation (Rehman and Alharthi 2016). In other words, the focus is on gaining insight into how individuals experience and interpret their social world, rather than imposing preconceived notions or assumptions onto their experiences.

This paradigm will work for this research because this paradigm is useful for understanding the social context in which an artifact will be used and the artefact that will be developed is for medical purposes and there will not be a need to conduct interviews nor observations for the development of the artefact. Health management systems involve intricate social, cultural, and organizational dynamics. Interpretivism allows for the exploration and understanding of the complex and contextual nature of these systems. It enables this study to delve into the meanings, experiences, and perspectives of individuals involved in the use and implementation of health management systems.

### Post positivism

The critique of the positivist paradigm resulted in the development of post-positivism, which combines elements of both positivist and interpretivist paradigms thus post-positivism is a response to the limitations of the positivist paradigm, which aims to overcome its weaknesses (Rehman and Alharthi 2016). Post-positivism holds a critical realist ontological position, which means that it assumes the existence of an objective reality that is independent of the observer, however, due to the intricate nature of social phenomena, this reality can only be imperfectly understood (Rehman and Alharthi 2016). Additionally, post-positivism acknowledges that the researcher's own beliefs and values may influence the observations made (Rehman and Alharthi 2016). Post-positivism shares some of the basic assumptions of positivism, such as the importance of empirical evidence and scientific methods. a hypothesis is put forward and its validity is then assessed through statistical analysis. The outcome of the statistical analysis determines whether the hypothesis is accepted or rejected. the aim of scientific inquiry is to achieve various goals, such as quantifying and regulating phenomena, making predictions about future outcomes, establishing general principles or laws, and identifying causal relationships between variables (Rehman and Alharthi 2016). The act of using numerical measures to depict and examine aspects of social existence aligns with a positivist approach to knowledge (epistemology) because this approach presumes that these aspects remain consistent over time and contexts, that specific features can be isolated and viewed as variables - entities that can take on different values (Rehman and Alharthi 2016). It recognizes the limitations and subjectivity of these methods.

This paradigm will not work for this research because it does not provide clear guidance for the development process of the Health Learning Management System artefact, and it is more focused on the subjective experiences and social constructions of the Health Learning Management System rather than on creating an artefact that can reliably be used in a clinical setting.

### Critical Social theory

Critical theory emerged from the writings of a group of authors in the 20th century who were associated with the Institute of Social Research at the University of Frankfurt, and this is why they are commonly referred to as the Frankfurt School (Rehman and Alharthi 2016). Critical social theory is a philosophical approach that focuses on the critique of society and its structures to bring about social change. It is an interdisciplinary field that draws from various social sciences, including sociology, philosophy, and political science. Critical theorists adopt a position of historical realism when it comes to their ontological perspective because The assumption is made that a concrete reality exists, but it is moulded by a combination of cultural, political, ethnic, gender, and religious influences that interplay with each other to produce a complex societal system (Rehman and Alharthi 2016). Critical theory has a subjective epistemological approach, as it assumes that the researcher cannot investigate an object without influencing it thus Critical educational researchers aim to be aware of their own underlying assumptions about knowledge and its acquisition, and to articulate these assumptions clearly when conducting their investigations (Rehman and Alharthi 2016). This ensures that everyone involved in the research is aware of the researchers' epistemological and political perspectives and prevents any confusion or misunderstandings about the researchers' biases or values. The primary goal of critical educational research is not limited to providing an explanation or comprehension of the workings of society but rather to effect change in it (Rehman and Alharthi 2016). In other words, critical educational research aims to go beyond a passive understanding of society and instead strives to actively transform it. Rather than producing knowledge that merely describes and reinforces the current state of society, critical researchers aim to uncover the underlying beliefs and behaviours that restrict individual freedom (Rehman and Alharthi 2016). The interpretive and positivist approaches to research are criticized because they are seen as being deeply embedded in the prevailing ideology, without any interest in transforming society, and lacking any intention to promote liberation (Rehman and Alharthi 2016). The critical methodology involves a back-and-forth conversation that aims to promote change in the perspective of the subjects regarding the social systems that deprive them of their intellectual and social needs. The investigator engages in dialogue with the subjects to achieve this objective (Rehman and Alharthi 2016).

This paradigm will not be appropriate for this study because the focus of this study is more practical and technical and may not require an in-depth analysis of power dynamics and social justice issues.

## Research Methodology

DSR will be used for this research because DSR methodology provides a structured approach to developing an artefact that is grounded in empirical evidence and focused on addressing a specific problem or need which in this case is the quality of patient care and outcomes in healthcare. And since critical social theory will be used as a paradigm, combining these two approaches create an opportunity to develop an HMS that is grounded in empirical evidence and best practices, while also being informed by a critical perspective that considers the broader social context in which the system will be used. This can help to ensure that the system is effective in achieving its goals, while also being sensitive to the needs and preferences of stakeholders. The concept of DSR involves solving problems and improving human understanding by creating innovative artefacts (Brocke et al. 2020). DSR involves constructing or evaluating artifacts, which can be classified as constructs, models, methods, and instantiations (March and Smith 1995). The resulting artifacts may lead to the improvement of theories (Henver and Chatterjee 2010). These artifacts are the output of DSR. A DSR project is primarily concerned with the creation and evaluation of a modern design rather than the generation of new knowledge (Gregory 2010). In other words, the focus of a DSR project is on the practical application and testing of a modern design, rather than the theoretical exploration and discovery of new knowledge. In a DSR, there are typically three cycles of DSR: the cycle of relevance, the cycle of design, and the cycle of rigor (Henver and Chatterjee 2010). This means that throughout the project, researchers engage in a process of identifying the relevant problem or issue, designing potential solutions, and rigorously evaluating the effectiveness of those solutions. Each cycle informs and builds upon the others, leading to a more refined and effective outcome.

### The cycle of relevance

The underlying motivation is to introduce innovative solutions that can improve the existing situation thus the relevance cycle is the starting point for design science research, which begins with an application context. This context not only provides the necessary requirements for the research, such as identifying a problem that needs to be addressed, but it also outlines the criteria for evaluating the research results to determine if they meet the desired outcomes (Henver 2007).

### The cycle of design

The fundamental component of any design science research project is the internal design cycle, which is integral to the entire process of designing, creating, or enhancing something. This cycle of designing involves creating multiple options and then assessing each one to determine which one meets the necessary standards or expectations (Henver 2007). This cycle continues until a design is found that meets all the necessary requirements and is deemed satisfactory. According to (Henver 2007) it is crucial to maintain an equilibrium between the resources utilized in creating and assessing the developing design during the design cycle.

### The cycle of rigor

The rigor cycle involves incorporating existing knowledge into a research project to ensure its originality and novelty (Henver 2007). Researchers must put in the effort to produce designs that make a unique and significant contribution to the field, rather than simply relying on established processes thus In design science research, the rigor of the research is dependent on the researcher's ability to choose and use suitable theories and methods to create and assess the artefact (Henver 2007).

In general, the process of design science research comprises three stages: identifying a problem that is applicable and significant, creating an IT artefact to address the issue, and assessing its value before and after implementation with the intension to achieve the primary objective of design science research which is to identify and solve real-world problems that are practical and relevant (Henver and Chatterjee 2010).

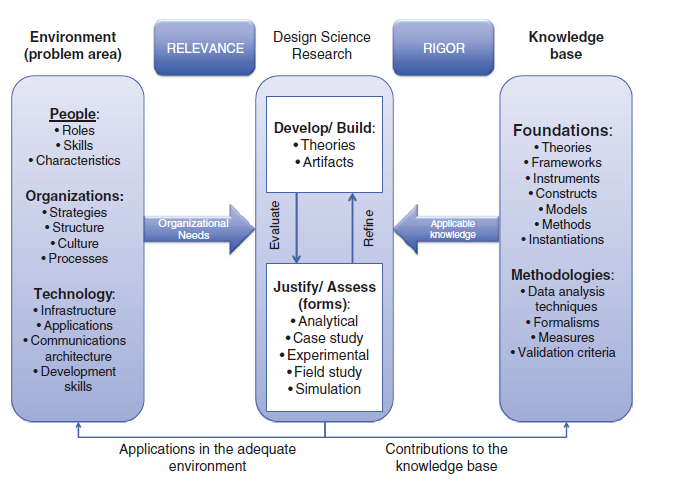


Figure 6: Relevance and Cycle of Rigor in Design Science Research (Dresch et al. 2015).

The term "environment" in Figure 6 pertains to the specific setting where the researcher can observe and obtain the phenomenon of interest related to the problem being studied (Henver et al. 2004).

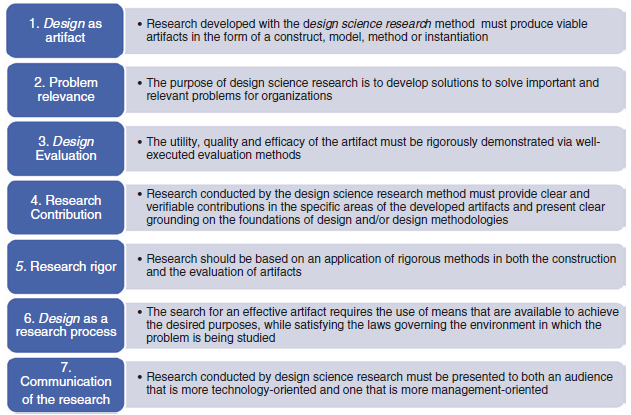


Figure 7: Criteria for conducting Design Science Research (Henver et al. 2004).

The criteria used in design science research are crucial because this type of research involves creating a new artifact (criterion 1) that addresses a specific problem (criterion 2) (Henver et al. 2004). The usefulness of the artifact should be explained, and it must be adequately evaluated (criterion 3) (Henver et al. 2004). It is important to clarify the research contributions for both professionals who aim to solve organizational problems and the academic community that seeks to advance knowledge in the field (criterion 4) (Henver et al. 2004). In order to ensure the validity and reliability of the research, investigations should be conducted with enough rigor to demonstrate that the constructed artifact is appropriate for its intended use and that it meets the criteria for its development (criterion 5) (Henver et al. 2004). The researcher must also conduct research to understand the problem and explore potential problem-solving methods in order to construct or evaluate the artifact (criterion 6) (Henver et al. 2004). Finally, the research results should be effectively communicated to all interested parties (criterion 7) (Henver et al. 2004).

## Research problems in Design Science Research

In design science, there are two components: design and investigation, which address two distinct types of research problems. The first component, design, deals with design problems, while the second component, investigation, deals with knowledge questions in design science (Wieringa 2014).

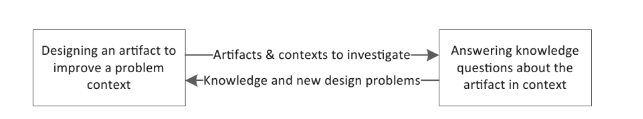


Figure 8: Design Science iterates over two problem solving activities (Wieringa 2014).

When faced with design problems, it is necessary to bring about a change in the real world, this requires an examination of the goals of stakeholders, whether they are hypothetical or actual (Wieringa 2014). In contrast to design problems, knowledge questions do not necessitate a modification in the world but rather seek information about the existing state of the world and the answer to a knowledge question takes the form of a proposition, and it is assumed that there is only one correct answer when attempting to address a knowledge question (Wieringa 2014).

## Qualitative study

As part of my methodology, a qualitative study will be conducted to address the following questions:

* What is the relationship between the implementation of an HMS and patient outcomes?
* How do different HMSs compare in terms of efficiency and cost-effectiveness?
* What are the factors that influence the adoption and implementation of HMS systems in healthcare organizations?
* What is the impact of HMSs on healthcare provider job satisfaction and burnout?

## Testing the artefact as part of ensuring rigor and validity

Rigor in testing involves conducting comprehensive and well-designed testing procedures to ensure that the system performs as intended. Validity in testing refers to the extent to which the testing process measures what it is intended to measure and produces accurate and dependable results. The following are ways that I will use to test my HMS artifact:

* **Functional testing**: This involves testing the system's features and functionalities to ensure that they work as intended. This can be done by creating test scenarios and scripts and executing them to verify that the system meets the requirements.
* **Performance testing**: This involves testing the system's ability to handle many users and data without compromising its performance. This can be done by simulating a high workload and monitoring the system's response time and resource utilization.
* **Security testing**: This involves testing the system's security features to ensure that patient data is protected from unauthorized access, modification, or theft. This can be done by conducting vulnerability assessments, penetration testing, and other security testing techniques.
* **Usability testing**: This involves testing the system's user interface and user experience to ensure that it is user-friendly and easy to use. This can be done by conducting user surveys, interviews, and usability tests to gather feedback from users and identify areas for improvement.
* **Compliance testing**: This involves testing the system's compliance with regulatory standards and requirements, such as POPI Act.

## Research Methods

Defining and justifying the research method is crucial because it ensures that the investigation will address the research problem effectively, moreover, using an appropriate research method enhances the credibility of the investigation among the scientific community, indicating that the research work is trustworthy and valuable for the field (Dresch et al. 2015). In other words, selecting an appropriate research method is significant in providing a reliable and valid answer to the research problem, which, in turn, increases the likelihood of the research work being accepted and recognized by the scientific community. Out of numerous methods available, five have been chosen as the most significant, and these methods will now be explained (Dresch et al. 2015).

## Case Study

According to (Yin 2013) a case study is an empirical investigation that aims to enhance our comprehension of a complex and contemporary phenomenon in its genuine context. The case study research method is well-suited for examining intricate issues within their specific context because it is particularly effective for exploring problems that are multifaceted and occur in real-world settings (Dubé and Paré 2003). Case studies are typically conducted using various data-gathering techniques such as interviews, questionnaires, observations, and other methods (Eisenhardt 1989). These methods are used to collect evidence that supports the researcher's investigation, and the evidence gathered may be either quantitative or qualitative in nature. The primary objectives of conducting a case study, which include: (I) providing a detailed account of a particular phenomenon; (II) testing an existing theory; and (III) developing a novel theory were identified by (Eisenhardt 1989). The connection between case studies and the scientific method can be attributed to two main factors, firstly, case studies typically commence with the observation and analysis of real-life phenomena and secondly, the scientific method involves the creation of theories, which is also a primary objective of case studies (Eisenhardt 1989).

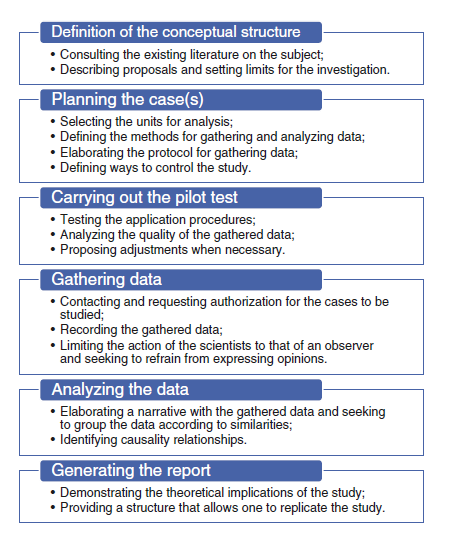


Figure 9:Activities in a case study (Miguel 2007).

## Action Research

Action research aims to identify and resolve problems within a specific system by producing knowledge that can be applied both in practice and theory (Dresch et al. 2015). The goal of action research is to provide practical solutions to issues that arise within a system while also generating theoretical insights that can inform future research (Dresch et al. 2015). Through the cyclical process of problem identification, solution design, implementation, and evaluation, action research seeks to improve the overall functioning of a system by producing actionable insights that can be used to make informed decisions (Dresch et al. 2015). If the method of analysis used involves a participatory approach, it presupposes that the researcher works closely with the members of the system being studied and that there is mutual collaboration and engagement between them (Morandi et al. 2013). In Action Research, the researcher may have dual rules, firstly, the researcher may be involved as participants in implementing a system and secondly, the researcher may also seek to evaluate an intervention technique while simultaneously serving as a participant (Benbasat et al. 1987). Action Research is a research method based on empirical evidence and requires a qualitative approach (Dresch et al. 2015). This approach involves working collaboratively with stakeholders to identify problems, design solutions, and evaluate their effectiveness (Dresch et al. 2015). At the end of the study, the results of the research should be compared with the existing theories (Dresch et al. 2015). It is also necessary to implement the proposed solutions to assess their effectiveness (Dresch et al. 2015). In contrast to a study case or action research, survey research uses a quantitative approach (Dresch et al. 2015).

## Survey

A survey-based study aims to generate knowledge in a particular area by collecting data or information to evaluate the behaviour of individuals and/or their surroundings (Aline Dresch 2015). The investigation is focused on obtaining information to analyse the behaviour of people and the environment they interact with (Miguel 2007). Additionally, surveys are often utilized to collect dependable data that can withstand rigorous statistical analysis (Dresch et al. 2015). The objective of such studies is to produce trustworthy and accurate results that can be used to make informed decisions (Dresch et al. 2015).

## Modelling

The use of modelling as a research method can help researchers to gain a deeper understanding of complex problems (Dresch et al. 2015). A model is a simplified version of reality that enables investigators to more easily grasp and analyse the phenomena they are studying (Neto and Pureza 2012). By creating and analysing these models, researchers can improve their understanding of the environment and the various factors that influence it (Neto and Pureza 2012). Ultimately, modelling can be a valuable tool for researchers seeking to explore and address complex problems.

## Prototyping

Prototyping involves a methodical approach to developing and evaluating a new product design concept (Camburn et al. 2015). The goal is to determine the feasibility of the concept and improve the design details of pre-production models through testing and feedback (Camburn et al. 2015). Research has shown that the way in which prototyping is approached can have a significant effect on the outcomes, both in the short and long term (Camburn et al. 2015). This suggests that the choice of prototyping approach can be an important factor in determining the success of a project.

To effectively address the research questions and develop a viable solution for the research problem, this study will utilize action research and prototyping research methods. The choice of these research methods is informed using qualitative data in answering the research questions and in the development of an artifact as a solution to the research problem. The combination of these methods will enable a comprehensive analysis of the research problem, informed decision-making, and ultimately, the production of a useful and effective solution. The following will be the steps used to choose the research method:

* **Identify your research question**: Clearly articulate the research question you want to answer. This will help you identify the type of data you need to collect and the appropriate research method to use.
* **Determine the scope**: Define the scope and focus of my research, including the population you want to study, the time frame, and the setting.
* **Evaluate available resources**: Consider the resources available, including time, budget, and access to participants, equipment, and technology.
* **Choose an appropriate research design**: Select a research design that aligns with your research question, scope, and available resources. Options include experimental research, surveys, case studies, and others.
* **Determine data collection methods**: Choose data collection methods that fit with your research design, such as interviews, questionnaires, focus groups, or observations.
* **Consider ethical concerns**: Identify any ethical considerations related to your research and ensure that your research methods are following ethical standards.

## Research design

The design of a research study refers to the structure or system of techniques and approaches employed to gather and analyse data related to specific variables identified in a research question (Ranganathan and Aggarwal 2018). The design cycle consists of the following stages:

Figure 10: Study design.

* **Define the problem**: The lack of standardized electronic HMS across the industry has resulted in the lack of interoperability and compatibility among different healthcare systems, leading to suboptimal patient outcomes and increased healthcare costs. An efficient and secure electronic HMS is needed to integrate with existing healthcare systems to improve patient care and outcomes.
* **Conduct research**: A literature review will be conducted to gather more information about the existing HMSs and observing how they work.
* **Brainstorm**: From the information gathered from the previous stage, brainstorming of solutions to breach the gap of the existing HMS that will solve the research problem will be done.
* **Prototype**: The best Ideas or solutions from the Ideate stages will be used to develop an artefact or prototype
* **Test**: Test if whether the artefact can solve the research problem efficiently and identify areas of improvement
* **Iterate**: Based on the results from testing, the design is refined, and the cycle begins again with the revised design being evaluated and further refined until a satisfactory solution is achieved.

In the subsequent chapter, we will dive deeper into the Literature for this research.

# Literature Review

## Introduction

The healthcare industry is experiencing a growing trend towards the adoption of personal technology for monitoring and mobile health solutions. However, users often face difficulties in operating the interface of these devices effectively. The complexity of user interfaces can hinder users' ability to engage with their mobile devices, highlighting the need for adaptive user interfaces that can dynamically adjust to meet individual user needs. While adaptive user interfaces have proven valuable in various domains, their potential applications extend beyond mobile devices.

Data storage is a crucial aspect of HMSs. Traditional structured query language (SQL) databases offer a standardized approach to store and manipulate data in a relational format (AWS 2023). However, the emergence of NoSQL databases has provided an alternative solution that deviates from the relational database model. NoSQL databases offer benefits such as schema less data representation, reduced development time, increased speed, and scalability planning (Vaish 2013).

In the context of healthcare data sharing, both distributed and centralized database systems play important roles. Distributed databases connect multiple databases across a network, enabling data retrieval from any connected database and enhancing data availability (Ozsu and Valduriez 1991). On the other hand, centralized databases consolidate data in a single location, providing convenient access and coordination of information (Mohammed and Saleh 2017). Each approach has its own advantages and disadvantages, requiring careful consideration based on specific requirements.

A hybrid database design combining blockchain and a centralized database offers a unique solution. Blockchain technology, known for its decentralized and distributed nature, provides enhanced security, transparency, and immutability of information (Şafak et al. 2019). Integrating blockchain with a centralized database harnesses the speed and adaptability of the latter while benefiting from the security features of blockchain. However, managing and maintaining both systems require specialized knowledge and resources, and performance limitations may arise in high-volume transaction scenarios (Şafak et al. 2019). The subsequent section will delve into the background information.

## Background

In the past, the healthcare industry primarily relied on paper-based approaches, lacking integration with HMS (Ranjit 2003). However, during the 1990s, there was a growing recognition of the potential benefits of information technologies and software applications in healthcare, leading to an increased adoption of these technologies (Ranjit 2003).

An HMS is a specialized type of management system used to manage and deliver healthcare-related educational content. It serves healthcare organizations, medical schools, and other institutions by providing training for healthcare professionals, continuing education for existing workers, and health-related courses for patients and the public. HMSs offer various features, including online course creation and delivery, course management, learner tracking, and assessment. They may also include healthcare-specific elements like simulation tools, virtual patient cases, and clinical practice guidelines. Some HMSs cater to specific healthcare fields, while others offer more general content. Social learning features may also be incorporated, allowing healthcare professionals to collaborate and share knowledge (Ranjit 2003).

The digitization of the healthcare industry has resulted in its rapid evolution, facilitated by HMSs. This growth has led to an expansion of the global healthcare market, which is currently valued at over $4 trillion and is projected to reach approximately $7 trillion by 2025 ('northoasss' 2022b). Despite the progress made in integrating IT into healthcare, several significant challenges persist. These challenges encompass the complexity of medical data, the lack of a standardized EHCR system, difficulties with data entry, concerns regarding security and confidentiality, integration issues within clinical practice, and a general lack of understanding about the benefits and risks of IT in healthcare (Ranjit 2003).

HMSs offer numerous advantages to healthcare organizations, healthcare professionals, and patients. These systems have the potential to enhance the effectiveness of delivering care, mitigate errors and delays, boost market presence, and optimize cost-efficiency (Medicine 2019). Nevertheless, the adoption and implementation of HMSs are not without challenges. For instance, the outbreak of the Covid-19 pandemic has resulted in various immediate obstacles for healthcare delivery institutions, such as insufficient resources, shortages in supplies, the requirement for care restructuring, and financial repercussions (Begun and Jiang 2020). Notwithstanding these obstacles, HMSs have the potential to bring about favourable outcomes for healthcare organizations, professionals, and patients. They can enhance the quality of care provided and foster a sense of confidence and reliance in the healthcare system (Medicine 2019). The following section will focus on the significance of user-friendly interfaces and the impact of positive user experiences in HMSs. It will include an examination of key principles and recommended practices for user interface design, as well as an exploration of adaptive user interface approaches.

## User Interface

Healthcare encompasses a wide range of challenges, making it an essential and pertinent topic that impacts individuals universally. The healthcare industry is witnessing a growing trend of utilizing personal technology for monitoring, commonly known as eHealth, and mHealth5, which represents a movement towards mobile health solutions (Shakshuki et al. 2015). However, a challenge arises when users encounter difficulties operating the interface on their respective technological devices. The complexity of a user interface can impact a user's ability to effectively engage with a mobile device. What if an interface could adapt over time, to meet the needs of a user? An adaptive user interface refers to a user interface that dynamically adjusts its layout and reorganizes screen elements to cater to the specific needs of the user. An interface of this nature proves valuable across various domains, especially in the realm of mobile applications. Nonetheless, the potential applications of adaptive user interfaces extend beyond just mobile devices.

Having user-friendly interfaces and ensuring positive user experiences play a crucial role in HMSs as they contribute to enhanced efficiency and effectiveness of care delivery. The utilization of user-centred design principles in the development of products, workflows, and processes is vital for ensuring successful user adoption and utilization of the system (HIMSS 2015). A thoughtfully crafted user interface has the potential to enhance user satisfaction and instil confidence in the healthcare system. Any interaction between humans and computers in the context of health or medicine presents an occasion where users can have positive or negative experiences regarding the usability and effectiveness of the system (HIMSS 2015).

User interface design principles serve as guiding principles for developing interfaces that are accessible, comprehensible, and user-friendly. These principles encompass factors such as visual appeal, simplicity, coherence, feedback, and assistance (usability.gov 2023). Consider the following guidelines for designing an effective user interface:

1. Employ a grid system to maintain visual harmony and alignment in the layout.
2. Utilize a restricted colour palette to establish a coherent and unified visual identity.
3. Leverage typography to establish a clear hierarchy and emphasize key elements (Capuchino 2023).

Efficient user interface design aims to eliminate any hindrances, barriers, complexities, or sources of ambiguity that may impede the user experience. The ultimate goal is to establish a user-friendly and seamless environment that enables all users to effortlessly navigate and accomplish their objectives with minimal effort or confusion (Fleck 2021).

## Data Storage Format

Data storage formats play a crucial role in the effective management and retrieval of information within various systems, including HMSs. These formats define how data is organized, stored, and accessed, providing structure and efficiency to data storage and retrieval processes. Different data storage formats are designed to accommodate diverse data types, scalability requirements, and performance considerations. Understanding the characteristics and capabilities of various data storage formats is essential for designing robust and efficient health management systems. In the next sub-sections, we will discuss the most common data storage formats namely SQL and NoSQL.

### SQL

A diagram of a server

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Figure 11: SQL Architecture (tutorialspoint 2023)

SQL serves as a programming language utilized for the storage and manipulation of data within a relational database (AWS 2023). In a relational database, data is organized in a tabular format, where rows and columns represent distinct data attributes, and the relationships between data values are captured. SQL servers as a standard language to communicate with relational databases.

### Why SQL?

According to (AWS 2023) benefits of using SQL includes:

* Enables users to retrieve data from relational database management systems.
* Empowers users to provide descriptions of the data.
* Empowers users to define and manipulate data within a database.
* Offers the capability to integrate with other programming languages through SQL modules, libraries, and pre-compilers.
* Provides functionality for users to create and delete databases and tables.
* Facilitates the creation of views, stored procedures, and functions within a database.
* Allows users to establish permissions for tables, procedures, and views.

## No SQL

NoSQL is a broad term for data stores that deviate from the traditional relational database model, meaning they are non-relational and don't utilize SQL for queries (Vaish 2013). In simple terms NoSQL is a diverse category of database management systems that differ from traditional relational databases. Unlike relational databases, NoSQL databases do not rely heavily on tables and typically do not utilize SQL for data manipulation. Note the NoSQL is not a database instead it is the type of database management system. NoSQL stores unstructured data.

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Figure 12: Database vs NoSQL

### Why NoSQL?

NoSQL provide a plethora of benefits beyond addressing scalability challenges such as Schema less data representation, Development time, Speed, and plan for scalability amongst other things. Subsequently the benefits will be discussed according to (Vaish 2013).

#### schema less data representation

Since NoSQL is a form of unstructured storage, the data representation does not have a schema. This implies that there is no need to plan extensively in advance to establish a fixed framework. Instead, you have the flexibility to adapt and improve gradually, which includes the ability to introduce additional data fields or even organize the data in a hierarchical manner, such as in the case of JSON representation.

#### Development time

In traditional database development, JOIN queries are commonly used to retrieve and combine data from multiple tables based on related columns. These queries can become complex and time-consuming, especially when dealing with large databases or intricate data relationships. The statement suggests that by using an alternative technology or approach, developers can potentially avoid the need for such complex JOIN queries. This could result in reduced development time because they no longer must spend significant effort and resources on constructing and optimizing these queries.

#### Speed

Planning for scalability in software applications to avoid potential pitfalls, handle spikes in load, and ultimately win over users by providing a reliable and high-performing experience.

#### Plan for scalability

Ensures a smooth and uninterrupted user experience. By proactively considering scalability during the design and development stages, developers can create applications that can handle sudden spikes in user load without compromising performance. Instead of waiting for issues to arise and then struggling to resolve them, it is far more effective to plan and build applications that are elastic and adaptable. This means that the application can seamlessly handle surges in user activity, maintaining optimal performance and user satisfaction.

By incorporating scalability into the development process, applications can scale up or down based on user demand, ensuring that performance remains consistently high. This preparedness not only avoids potential performance issues and downtime but also helps to attract and retain users. Users are more likely to engage with an application that provides a seamless experience, even during periods of increased usage.

## Data Sharing

Data sharing refers to the exchange of data between different individuals, organizations, or systems for various purposes, such as collaboration, research, analysis, and decision-making. In the context of healthcare, data sharing plays a critical role in improving patient care, advancing medical research, and enhancing healthcare system efficiency. Effective data sharing in healthcare allows healthcare providers, researchers, and policymakers to access and utilize relevant and accurate information to make informed decisions. It enables the seamless exchange of patient information, medical records, diagnostic test results, treatment plans, and other healthcare-related data among different healthcare organizations and professionals involved in a patient's care. Subsequently data storage for efficient data sharing amongst healthcare organizations will be discussed.

### Distributed database system

A diagram of a communication network

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Figure 13:A distributed database environment (Ozsu and Valduriez 1991).

A distributed database refers to a networked collection of multiple databases that are logically interconnected and spread across computer system (Ozsu and Valduriez 1991). In other words, a distributed database refers to information stored in different databases that are connected to each, that way it we can retrieve data from any database if it is amongst the connected databases. It is important to note that a distributed database can be used to save the same copies of data in different databases thus serving as back up and increasing data availability.

#### Distributed database Features

According to (Marijan 2021) features of a distributed database include:

* **Location independency**

Data is stored in multiple physical locations and is managed by a decentralized database management system (DDBMS) that operates independently.

* **Distributed query processing.**

In a distributed environment where data is stored across multiple sites, distributed databases play a vital role in answering queries. These databases employ a query execution plan to streamline the management of high-level queries, ensuring efficient data retrieval and processing across the distributed system.

* **Seamless integration**

A collection of databases typically represents a unified and cohesive logical database, with interconnections between them.

* **Network linking**

All databases within a collection establish connections through a network and engage in communication with one another.

* **Transaction processing**

Distributed databases encompass transaction processing, which refers to a program consisting of a set of database operations. Transaction processing ensures that the execution of these operations is atomic, meaning that it is treated as a single, indivisible unit that is either fully executed or not executed at all.

#### Advantages

This database has the potential for seamless scalability due to its distributed nature, allowing for the incorporation of data from various physical locations (sakshi 2022). Accessibility to this distributed database is facilitated through different networks, enabling easy and widespread access (sakshi 2022). Additionally, this distributed database offers enhanced security measures, surpassing the security provided by a centralized database (sakshi 2022).

#### Disadvantages

This database incurs significant expenses and poses challenges in terms of maintenance due to its intricate nature (sakshi 2022). Ensuring a consistent user experience is arduous as the database is distributed across various physical locations (sakshi 2022).

### Centralised database system

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Figure 14: Centralized database system

A centralized database typically consolidates data or information in a specific location within a network (Mohammed and Saleh 2017). In simple terms a centralized database is a type of database that is stored and managed in a single location. Typically, this location is a central computer or database system, such as a desktop, server CPU, or mainframe computer. The centralized database serves as a centralized repository for storing and organizing data, providing a single point of access and management for the stored information.

#### Centralized database Features

According to (Mohammed and Saleh 2017) features of a centralized database include:

* **Single location**

A centralized database is stored and managed in a single physical location, such as a specific computer or server. This centralization allows for easier administration and control of the database.

* **Data consistency**

Updates and modifications to the data are made in one central location, ensuring that all users and applications accessing the database retrieve and work with the most up-to-date and consistent information.

* **Improved data security**

Centralized databases offer enhanced data security capabilities. Access controls, encryption, and other security measures can be implemented and enforced more effectively in a centralized environment, reducing the risk of unauthorized access, data breaches, and data loss.

* **Centralized data governance**

With a centralized database, data governance and compliance can be more easily implemented and enforced. Data policies, standards, and regulatory requirements can be applied consistently across the entire database, ensuring data integrity and compliance with relevant regulations.

#### Advantages

Due to its centralized nature, a health management system stores all data in a single location, making it more convenient to access and coordinate information (sakshi 2022). This centralized database minimizes data redundancy since all data is stored in one place (sakshi 2022). Additionally, it offers cost advantages compared to other available database options (sakshi 2022).

#### Disadvantages

The centralized database incurs higher data traffic compared to other systems (sakshi 2022). In the event of a system failure at the centralized level, there is a risk of complete data loss (sakshi 2022).

### Hybrid database design combination of blockchain and central database

Blockchain represents a database that is decentralized and distributed in nature (Şafak et al. 2019). From a technical perspective, this database integrates all records (blocks) into a unified chain and stores them starting from the initial block. It enables processing without relying on a central entity or server (Şafak et al. 2019). Blockchain serves as the underlying technology for Bitcoin, a decentralized peer-to-peer (p2p) network facilitating secure and transparent value transfers, effectively resolving the challenge of double spending. The emergence of Bitcoin marked the pioneering application of Blockchain, establishing cryptocurrencies as its inaugural use case (Şafak et al. 2019). Following the success of Bitcoin, Blockchain technology has found applications across various sectors (Şafak et al. 2019). Its implementation extends beyond the financial industry, with numerous sectors such as healthcare, energy, agriculture, and supply chain management adopting tailored applications to address their specific requirements (Şafak et al. 2019).

#### Hybrid Structure

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Figure 15: Hybrid Database Design Combination of Blockchain and centralized database (Şafak et al. 2019)

This model synergizes the security features of Blockchains with the speed and adaptability of a centralized database. Implementing a Blockchain network will enhance the management and control of the system, providing ease of administration, furthermore, the Blockchain network operates exclusively during the data logging process and ensures optimal efficiency in its operations (Şafak et al. 2019). Hyperledger Fabric and Hyperledger Cello are used for the Blockchain Network in the design of Figure 15. MongoDB preferred as the central database (Şafak et al. 2019). Hyperledger Fabric is an open source enterprise-level Blockchain development framework designed for use in enterprise environments and MongoDB is an open-source database system, embraces diverse data formats and operates on a document-oriented database model (Şafak et al. 2019). MongoDB provides convenient support for representing hierarchical relationships, storing arrays, and accessing complex data structures. It is important to note that MongoDB uses NoSQL and is faster than relational databases.

#### Advantages

Apart from the benefits outlined in section 4.2.2 regarding a centralized database, Blockchain technology offers inherent advantages such as guaranteeing the accuracy and immutability of information, along with enhanced security, direct operation, transparency, and privacy (Forbes 2022).

#### Disadvantages

Managing and maintaining two different types of databases requires specialized knowledge and resources (Forbes 2022). This complexity can increase the overall system development and maintenance costs (Forbes 2022). The combination of both systems may lead to performance limitations, especially in scenarios where a high volume of transactions needs to be processed within short timeframes (Forbes 2022). Storing the same data in multiple locations consumes additional storage space and increases the complexity of data synchronization and consistency (Forbes 2022). It may require additional efforts to ensure that the data remains consistent and up to date across both systems (Forbes 2022). Ensuring the consistency and integrity of data across both systems requires robust data integration mechanisms, which can introduce additional complexity and potential points of failure (Forbes 2022).

## Critique

In many healthcare settings, patient data is still predominantly stored in paper-based records, which poses challenges in terms of accessibility, sharing, and updating of health information. For instance, patients often need to physically carry appointment cards and visit clinics to relay information to doctors or obtain test results. This manual process can lead to errors, duplicated tests, delays in care, and fragmented data. Furthermore, the lack of a standardized electronic HMS hinders interoperability and compatibility between different healthcare systems. This results in difficulties sharing information and integrating patient data, leading to suboptimal outcomes and increased costs (Ranjit 2003).

In South Africa, the availability of low-quality public healthcare is extended to all citizens without the need for formal health insurance plans. This limitation hinders the efficient management and coordination of healthcare services across the country. As a result, there is a need to bridge the gap by implementing effective HMSs that can streamline processes, improve data management, and enhance the overall quality of care provided to citizens. The development of adaptive user interfaces and the utilization of NoSQL databases, such as MongoDB, are potential approaches being explored to address the challenges associated with diverse data storage structures and facilitate data sharing among healthcare organizations. These efforts aim to enhance the utilization of eHealth solutions and improve the accessibility and quality of healthcare services in South Africa.

However, the adoption of eHealth practices within the country's healthcare system is still limited, resulting in a lack of healthcare management systems in many public hospitals. This research aims to bridge this gap by developing an adaptive user interface that is user-friendly and easily accessible. To address the challenge of diverse data storage structures across healthcare organizations, the chosen approach involves utilizing NoSQL with MongoDB as the database. This allows for flexibility as each healthcare organization may have unique data storage formats. Additionally, to facilitate data sharing among different healthcare organizations, a centralized database system such as DynamoDB will be employed. By implementing these strategies, the research aims to enhance the utilization of eHealth solutions in South Africa's public healthcare sector, ultimately improving the overall quality of care provided to citizens.

# Empirical Study

## Introduction

The research seeks to scrutinize the implementation and uptake of HMSs in healthcare organizations, spotlighting the hurdles and prospects these entities encounter. It strives to delve into the repercussions these systems hold for patient care and the dynamics steering their assimilation and utility. A pivotal aspect of the study is to concoct actionable insights and counsel to aid organizations in judicious decision-making to augment the standard of patient care and results. The inquiry anchors on the pressing issue of adeptly and securely administrating patient data, underscoring a call for a robust digital health management apparatus compatible with the current healthcare frameworks to bolster patient outcomes. This envisaged system would incorporate functionalities such as appointment scheduling and data storage.

In this chapter, we delve into the detailed outline of the artifact, delineating its features and functionalities that are crafted to address identified problems in the healthcare sector. Following this, we unravel the development process grounded in the chosen methodology, the DSR. This methodology, characterized by its cyclic nature involving processes such as problem identification, objectives of a solution, design and development, demonstration, evaluation, and communication, guides the artifact's development in a structured manner, ensuring its relevance and effectiveness in addressing the pertinent issues (Henver et al. 2004). It allows for a meticulous development process where each cycle is a step forward towards a refined solution, with learnings from one cycle being utilized to optimize the subsequent one (Henver 2007). The chapter culminates with a conclusion that encapsulates the pivotal points discussed, underscoring the potential impact of the artifact in revolutionizing health management systems, and offering a telescopic view into the future directions that this research could steer towards. This conclusive section aims to bind together the insights garnered, offering a coherent view of the artifact’s development journey and its prospective implications in the healthcare domain.

In this chapter, we will embark on a meticulous exploration of the artifact, offering a comprehensive breakdown of its intrinsic components and functionalities envisioned to revitalize the healthcare sector's management systems. Grounded in the robust framework of DSR methodology, we will elucidate each phase of the artifact’s development, including the inception rooted in problem identification, articulation of solution objectives, the design and developmental strides, demonstration, evaluation, and communicative strategies, weaving through the cyclic repetitions where necessary. This involves a detailed exposition of the iterative cycles undertaken, spotlighting the rich reflections garnered at each juncture, which not only fuelled the enhancements in subsequent cycles but fortified the artifact with a depth of understanding and functionality. Integral to our discussion will be the measures adopted to establish trustworthiness, seamlessly interwoven in the narrative to underscore the artifact's reliability and credibility. Closing the chapter, we converge at a conclusive segment that aims to encapsulate the journey traversed in the development while hinting at the vibrant prospects the artifact harbours. Readers can anticipate a deep-dive into the mechanics of the artifact’s evolution in subsequent sections, shedding light on the rich tapestry of developmental phases, reflective cycles, and trustworthiness endeavours that punctuated the journey to a reliable, future-ready artifact.

## Description of the Artefact

In many healthcare settings, the persistence of paper-based records for patient data storage has presented significant challenges in terms of accessibility, sharing, and updating of vital patient health information. For instance, patients often experience the inconvenience of carrying appointment cards to hospitals or clinics, where physical files must be retrieved and transported to the respective healthcare providers. This manual process also extends to the retrieval of test results, a step that many patients may inadvertently skip. In response to these challenges, this research project introduces the HMS, a digital solution that encompasses three core features: appointment setting, data storage, and virtual sessions.

## Appointment setting

The appointment setting feature within the HMS primarily caters to administrators and healthcare providers, enabling them to efficiently schedule appointments for patients. This feature streamlines the appointment booking process, reducing waiting times and administrative overhead. It allows healthcare personnel to manage their schedules effectively while providing patients with a user-friendly platform to request and confirm appointments.

A screenshot of a computer

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Figure 16: Appointment Making Kanban view.

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Figure 17: Appointment Making table view.

## Storage of data

The objective of the data storage feature is to transition healthcare organizations from antiquated paper-based documentation systems to a sophisticated digital platform. This transition promises improved efficiency and accuracy in maintaining patient records. Within this digital ecosystem, a diverse range of patient data, including comprehensive medical histories and other pertinent information, will be securely stored and managed. MongoDB, a NoSQL database, has been strategically chosen to facilitate the structured storage of patient records. This database not only ensures streamlined data handling but also promises heightened security for sensitive patient information. Consequently, this feature plays a central role in modernizing healthcare settings by promoting a seamless, efficient, and secure data management system.

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Figure 18: MongoDB Storage.

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Figure 19: MongoDB Saved doctor's information.

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Figure 20: MongoDB Saved Patient's data.

## Virtual session

The virtual session feature of the HMS introduces telemedicine consultations, offering a platform for doctors and patients to engage in remote medical discussions. While ideally suited for non-emergency situations such as routine check-ups, test result reviews, or follow-up appointments, it is essential to emphasize that virtual consultations may not be appropriate for severe or emergency medical conditions. Patients are encouraged to book physical appointments or visit healthcare facilities for immediate medical attention in such cases.

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Figure 21: Virtual Platform.

To provide a comprehensive understanding of how to navigate and utilize the HMS application effectively, the following user guide outlines the essential steps:

* **Message Sending**: Users can initiate communication by clicking the “send” button, enabling them to send messages to other participants in the room.
* **Message Input**: Messages can be typed into the input field to compose and send messages.
* **Message Exit**: Users have the option to exit the meeting by clicking the “Leave Meeting” button.
* **Chat Display**: The application displays exchanged chats in real-time, enhancing communication and information sharing.
* **Participants List**: A list of participants in the meeting is also displayed, providing visibility into attendees.
* **Camera control**: Users can choose to enable or disable their camera, controlling the transmission of their live video feed during the meeting.
* **Microphone Control**: The application allows users to enable or disable their microphone, facilitating audio communication.
* **Live video feed**: If the user opts to enable the camera, their live video feed is displayed, enhancing the virtual meeting experience.

## Implementation Technologies

The following subsection will dive deeper into the technologies used to develop the HMS.

### Virtual Platform Technologies

For the virtual platform component, the following technologies have been harnessed to create a seamless and efficient telemedicine experience:

* **JavaScript**: JavaScript plays a pivotal role as the primary programming language for the server-side logic, enabling dynamic functionality within the virtual platform. It facilitates real-time interactions, chat functionality, and user engagement.
* **Sockets**: Sockets are strategically employed to establish and manage real-time connections between users, fostering instant communication and interaction within virtual platform. This technology is fundamental to the success of virtual consultations and collaborative healthcare discussions.
* **CSS (Cascading Style Sheets)**: CSS is instrumental in shaping the visual elements and layout design of the virtual platform. It ensures an intuitive and visually appealing user interface, enhancing the overall user experience.
* **Embedded JavaScript (EJS)**: used for rendering dynamic content on the virtual platform’s web pages. It allows for the integration of JavaScript code directly into HTML templates, enabling the creation of dynamic and interactive user interfaces.

With the inclusion of Embedded JavaScript, the virtual platform gains enhanced capabilities for dynamic content presentation, further improving the user experience during virtual medical consultations and interactions.

### Website Technologies

The website component of the HMS incorporates a separate set of technologies to provide an efficient and user-friendly interface for healthcare administrators and practitioners:

* **Python Flask**: serves as the backend framework for the website, facilitating the development of APIs (Application Programming Interfaces) that connect various components of the HMS. It enables seamless data exchange and processing, ensuring the smooth functioning of the website.
* **Angular**: Angular is employed for frontend development, creating an interactive and responsive user interface. This framework enables the design of intuitive dashboards and user-friendly interfaces for appointment scheduling and data management.
* **MongoDB**: MongoDB serves as the database system for storing and managing patient records and related data within the website component. Its NoSQL structure ensures structured and secure data storage, promoting efficient data handling and retrieval.

The subsequent sections will delve into the development methodology, including the prescribed phases and cycles, as well as the findings and conclusions of the project.

## Description of the development according to the DSR methodology

A diagram of a scientific research

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Figure 22: Criteria for conducting Design Science Research (Henver et al. 2004).

Figure 22 describes the phases or cycles were followed during research, but we will focus on three main cycles: Relevance cycle, Design Cycle and Rigor Cycle.

### Relevance cycle

The Relevance Cycle in the DSR methodology serves as the foundation for aligning research objectives with real-world problems and the needs of stakeholders (Henver et al. 2004). In the context of developing our HMS, this cycle played a pivotal role in guiding the project from its inception.

The Relevance Cycle commenced with the identification of critical issues faced by healthcare organizations, patients, and medical practitioners in managing, accessing, and sharing health records efficiently. Extensive reviews of existing systems and their associated challenges revealed a pressing need for a digitized, user-friendly, and secure platform to manage health data (Peffers et al. 2007). This initial phase was crucial in defining the overarching objectives of the HMS project, setting the stage for addressing the identified gaps and meeting the users' needs effectively.

The feedback and insights gathered from existing healthcare systems significantly informed the design objectives of the HMS. This feedback loop, which is inherent in the DSR methodology, ensured that the proposed system would align with the identified challenges and cater to the users' needs effectively. It set the stage for the subsequent Design Cycle (Section 4.7.2) by providing a clear direction based on the real-world problems identified in the Relevance Cycle (Henver et al. 2004).

### Design Cycle

The Design Cycle represents the core of the DSR methodology, where the actual development of the HMS takes place (Peffers et al. 2007). This phase is where the initial problem identification and design objectives from the Relevance Cycle (Section 4.7.1) are transformed into a functional and practical healthcare management system.

The Design Cycle followed an iterative development approach, with each cycle comprising phases of requirement analysis, system design, coding, testing, and evaluation (Wieringa 2014). This iterative process allowed for continuous refinement and adaptation of the HMS. Feedback from users, gathered in the Relevance Cycle, was incorporated into each development cycle to ensure the system's alignment with the set objectives and user expectations. This iterative approach was instrumental in creating a robust, scalable, and user-friendly HMS (Henver et al. 2004).

To meet the design objectives of simplifying appointment scheduling, enhancing data security and accessibility, and facilitating virtual consultations, modern technologies like MongoDB for data storage and Angular for frontend development were crucial (Henver et al. 2004). These technology choices were made in alignment with industry best practices and current trends, further enhancing the system's potential for effective real-world applications.

### Rigor Cycle

The Rigor Cycle ensures that the development process is grounded in established theories, frameworks, and best practices within the field (Peffers et al. 2007). In the context of HMS development, this cycle provided the necessary rigor to validate and ensure the quality of the system.

The Rigor Cycle involved a comprehensive examination of existing literature, healthcare regulations, and technology standards (Henver et al. 2004). This examination was critical to ensure that the design and functionalities of the HMS adhered to industry norms and were based on sound principles. It also encompassed a meticulous analysis and evaluation of the developed system against predefined criteria to ascertain its effectiveness, security, and usability in addressing healthcare management challenges (Peffers et al. 2007).

Furthermore, the Rigor Cycle promoted continuous improvement by validating the HMS against established principles and industry standards. This validation process was integrated into the iterative development cycles described in the Design Cycle (Section 4.7.2). As a result, the HMS underwent ongoing refinement, ensuring that it remained aligned with best practices and was well-prepared for effective real-world applications.

By integrating the phases and activities from Section 4.7.2 into the Relevance, Design, and Rigor Cycles, the development process of the HMS becomes a coherent and comprehensive narrative within the DSR methodology.

### Iterative development cycles

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Figure 23: Iterative phases.

Development in the DSR methodology often involves iterative cycles. In this study, these cycles played a pivotal role in refining the HMS. After each phase, reflection and feedback loops were incorporated to ensure continuous improvement.

For example, following the initial design and development phase, a mini release of the HMS was deployed to gather user feedback. This feedback loop informed subsequent development iterations, leading to enhancements in usability, data management, security measures. The process of iterative development allowed us to adapt and refine the HMS to better align with the evolving needs of the healthcare landscape.

## Findings

The development and deployment of the HMS yielded valuable insights into the digital transformation of healthcare management processes. The sections below detail the key findings observed throughout this project.

### User engagement and usability

The user interface design, themed with calming blues and intuitive navigation features, was crafted to enhance user experience. While the primary audience included patients, doctors, and administrators, ensuring ease of navigation and accessibility was a challenge. Usability testing, however, revealed positive responses regarding the ease of scheduling appointments and accessing medical information.

### Data Management Efficiency

Opting for MongoDB as the NoSQL database for storing patient records was primarily due to uncertainties surrounding the appropriate structure for data storage. MongoDB was chosen for its scalability, consistency, and availability, which are crucial for a robust data management system in healthcare. This choice proved effective in streamlining data retrieval and update processes, significantly improving data management efficiency.

### Virtual Consultations Feasibility

The virtual consultation feature facilitated routine checkups and discussions regarding test results among other things, reducing the necessity for physical visits. However, the challenge of packet transmission between patients and doctors during virtual sessions was identified as an area requiring further optimization to ensure smooth real-time interactions.

### Frontend Development Challenges

Developing a user-friendly frontend was among the significant challenges faced during this project. Achieving a balance between a clean, aesthetic design and functional, intuitive user interface required iterative refinements.

### Security and Compliance

The HMS was designed to adhere to healthcare data security standards, ensuring the confidentiality and integrity of patient information. Compliance with healthcare regulations was maintained throughout the development process.

### Feedback and Continuous Improvement

Even though direct engagement with stakeholders was not conducted, continuous self-evaluation and iterative refinements were employed to identify and address areas of improvement. This feedback loop contributed to the development of a more robust and user-friendly HMS.

### Future Potential

The positive outcomes from this project underscore the potential for further expansion and adoption of the HMS across other healthcare facilities. The modular design of the system allows for the integration of the additional features in the future developments, such as telemedicine, electronic prescriptions, and AI-driven diagnostic support.

These findings highlight the substantial impact a well-designed HMS can have on improving healthcare service delivery and overall healthcare management efficiency. The challenges and experiences garnered from this project provide a valuable foundation for future research and development endeavours in healthcare digitalization.

### User acceptability test

Several random people who were once patients at healthcare facilities and health practitioners were asked to use the system and give feedback and asked what they think about the system.

A graph of blue rectangular objects

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Figure 24: User acceptability statistics

In this section, we present key findings resulting from user feedback and evaluation of the HMS. These findings offer valuable insights into the user experience and satisfaction with the system's features and performance.

### User-Friendliness

An overwhelming 80% of the individuals who participated in the evaluation described the system as highly user-friendly. This positive feedback underscores the system's intuitive design and ease of use, a critical factor in enhancing user acceptance and adoption.

### Satisfaction with Features and Performance

Approximately 70% of the users expressed a high level of satisfaction with both the features offered by the HMS and its overall performance. This indicates that the system, developed using Python Flask and other technologies, successfully met users' expectations in terms of functionality and responsiveness.

### Suggestions for Improvement

While most users were satisfied with the system, approximately 20% provided valuable suggestions for further enhancement. These suggestions encompassed various aspects, including additional features they would like to see integrated into the system and potential improvements to existing functionalities.

These findings highlight the system's strong foundation in terms of user-friendliness, satisfaction with features, and performance. They also serve as a basis for future refinements and enhancements, aligning the HMS even more closely with user needs and expectations.

# Conclusion

This chapter marks the culmination of an extensive research journey aimed at the development of an HMS within the framework of DSR methodology. Our endeavour has been driven by the pressing need to address significant challenges in the contemporary healthcare settings. These challenges primarily revolve around the archaic reliance on paper-based records for the storage of patient data, which hindered efficient data management, accessibility, and information sharing.

At the core of this research project lies a commitment to confront the critical issues plaguing healthcare organizations, patients, and medical practitioners. The focus has been to revolutionize the management of health data, rendering it more efficient, secure, and accessible. Our study aims to provide a comprehensive solution to the intricate problems associated with health data management.

The central objective of this concluding chapter is to revisit research objectives and questions that have guided our work from inception. It serves as a reflection on how these objectives have been systematically addressed throughout the research process culminating in the development of our HMS.

This chapter is meticulously structured to provide a detailed overview of our research endeavour. We will emphasize the iterative phases and cycles that have underpinned our research methodology, highlighting the critical junctures where decisions were made and refined. Additionally, we will delve into the notable contributions our study has made to the broader field of healthcare management systems, grounded in a thorough examination of existing literature, and informed by principles and standards within the healthcare domain. We acknowledge the limitations of this study and outline prospects for future research, offering valuable insights for scholars and practitioners in the field.

This chapter also serves as a platform for an in-depth evaluation of the trustworthiness of our research. We will rigorously assess the validity and reliability of the tools, instruments, and methodologies employed, reinforcing the credibility of our findings. Moreover, this chapter provides an opportunity for introspection, where we reflect on the decisions made during the research project, analyse the strengths and weaknesses, and critically assess the extent to which our objectives have been achieved.

## Overview of the research

This subsection serves as a succinct summary of the entire research journey, encompassing the various phases, cycles, and methodologies employed to address the research objectives. It provides a holistic perspective on how the study evolved from its inception to the development of the HMS.

## Phases and Cycles

The research journey followed the prescribed phases with the DSR methodology, each playing a crucial role in shaping the development of the HMS. These phases encompassed:

1. **Relevance Cycle**: The initiation of the research began with the identification of critical issues faced by healthcare organizations, patients, and medical practitioners concerning health data management. This phase entailed extensive reviews of existing systems and insights gathered from stakeholders, laying the foundation for the HMS’s design objectives.
2. **Design Cycles**: The core of this research involved the iterative design of the HMS. The primary focus was on simplifying appointment scheduling, enhancing data security and accessibility, and facilitating virtual consultations. Agile development principles guided this cycle, comprising phases such as requirement analysis, system design, coding, testing and evaluation. Modern technologies, including MongoDB for data storage and Agular for the frontend, played a pivotal role in crafting a robust and user-friendly HMS.
3. **Rigor Cycle**: Ensuring the alignment of our research with the established theories, frameworks, and industry standards was the primary objective of the Rigor Cycle. It involved a comprehensive examination of existing literature, healthcare regulations, and technology norms. Additionally, our study included meticulous analysis and evaluation of the developed HMS to ascertain it effectiveness, security, and usability.

This research has culminated in the successful development of the HMS. This system represents a significant step forward in addressing the challenges associated with healthcare data management. The HMS not only modernizes data handling practices but also adheres to industry norms and best practices, promising effective real-world applications.

In the subsequent sections, we will delve into the specific contributions our research has made, discuss the limitations encountered, explore prospects for future research, evaluate the trustworthiness of our study, reflect on the decisions made, and provide a comprehensive conclusion that encapsulates the essence of our research.

## Contributions of the Research

This subsection delineates the significant contributions our research has made to the field of the HMSs and sheds light on the outcomes and recommendations resulting from our study.

### Outcomes

* **Development of the HMS**: The primary and most tangible contribution of thus research is the creation of the HMS. The HMS addresses critical issues faced by healthcare organizations, patients, and medical practitioners in managing health records, appointment scheduling, and facilitating virtual consultations. The digital solution promises enhanced efficiency, data security, and user-friendliness in healthcare settings.
* **Modernization of Healthcare data management**: Our research has successfully transitioned healthcare data management from traditional paper-based systems to a digitalized platform. This transition not only streamlines data access and management but also ensures the security and integrity of patient records. The use of MongoDB for structure data storage aligns with industry best practices.
* **Enhanced Accessibility and User experience**: The HMS significantly enhances the accessibility of patient data for healthcare professionals while ensuring a seamless user experience. Features such as appointment scheduling, virtual consultations, and secure data storage cater to the needs of both healthcare providers and patients.
* **Adherence to Industry norms**: The rigorous examination of existing literature and healthcare regulations during the Rigor Cycle ensured that the HMS design and functionalities adhere to industry norms. This adherence enhances the system’s trustworthiness and its potential for widespread adoption in real-world healthcare settings.

This research achieved its objectives by delivering an innovative solution aligned with the best practices in the healthcare industry.

### Recommendations

* **Continuous Monitoring and Improvement**: To ensure the long-term success of the HMS, it is recommended that healthcare organizations continuously monitor its performance and gather feedback from users. This feedback should inform iterative improvements to the system, addressing emerging needs and challenges.
* **Training and Adoption**: Healthcare professionals should receive proper training and guidance on utilizing the HMS effectively. Promoting its adoption within healthcare institutions requires comprehensive training programs to maximize its benefits.
* **Data Security Measures**: Given the sensitive of the healthcare data, continuous efforts should be made to enhance the data security measures within the HMS. Regular audits and updates to security protocols are recommended to protect patient information.
* **Further Research**: While this research has laid the foundation for an innovative healthcare management solution, there is scope for further research in areas such as AI-driven healthcare analytics, interoperability with other healthcare systems, and integration of emerging technologies like blockchain for enhanced data security.

In the following sections, we will address the limitations of our study, explore prospects for future research, evaluate the trustworthiness of our research.

## Limitations to the Study and Future Research

In this section, we acknowledge the limitations that may have affected the scope and outcomes of our research. Additionally, we explore prospects for future research to address these limitations and further advance the field of healthcare management systems.

### Limitations of the Study

* **Resource Constraints**: One of the primary limitations of our study was resource constraints, particularly in terms of time and budget. These constraints may have impacted the depth and breadth of our research, limiting the extent of data collection, user testing, and system refinement.
* **Generalizability**: While our HMS demonstrates promise in addressing healthcare data management challenges, the study's findings and outcomes are based on a specific context and set of users. Generalizing the results to diverse healthcare settings and populations may require additional research and customization.
* **Technological Advancements**: The field of healthcare technology is dynamic, with rapid advancements occurring regularly. Our study reflects the technology landscape at the time of research; however, future technological developments may render certain aspects of our HMS less relevant or necessitate updates.
* **Ethical Considerations**: Ethical considerations in healthcare data management are paramount. While we have implemented robust data security measures, evolving ethical standards and regulations may require ongoing scrutiny and adaptation of our system.

### Prospects for Future Research

* **Longitudinal Studies**: Future research could involve longitudinal studies to assess the long-term impact and sustainability of the HMS in healthcare organizations. This would provide insights into its effectiveness over time and its ability to adapt to changing healthcare needs.
* **User-Centred Design**: Conducting user-centred design research can help tailor the HMS to the specific needs and preferences of various user groups, including healthcare providers, administrators, and patients. This would improve user satisfaction and system adoption.
* **Interoperability and Integration**: Exploring the integration of the HMS with other healthcare systems and technologies, such as Electronic Health Records (EHRs) and telemedicine platforms, can further enhance its utility and interoperability within the broader healthcare ecosystem.
* **AI and Predictive Analytics**: Leveraging artificial intelligence (AI) and predictive analytics within the HMS can enable data-driven insights and decision-making in healthcare management. Future research can focus on integrating AI algorithms for diagnostic support and proactive health management.
* **Blockchain for Enhanced Security**: Investigating the use of blockchain technology to enhance data security and integrity within the HMS can be a promising avenue for future research. Blockchain's immutable ledger can further protect sensitive healthcare information.

As we move forward, addressing these limitations and pursuing future research opportunities will be essential in refining and expanding the capabilities of HMSs. In the subsequent section, we will evaluate the trustworthiness of our study.

## Evaluation of the Study

In this section, we evaluate the trustworthiness of our study by examining the validity and reliability of the research tools and instruments used, as well as our adherence to the prescribed principles and criteria outlined in the research proposal. This evaluation serves to demonstrate the rigor and credibility of our study.

### Validity and Reliability of Research Tools

* **Survey Instruments**: To gather user feedback and assess system usability, we employed survey instruments with carefully crafted questions. Prior to data collection, we conducted pilot tests to ensure the clarity and comprehensibility of survey items. This process helped enhance the validity of our data.
* **User Testing**: User testing sessions were conducted to evaluate the functionality and user-friendliness of the HMS. These sessions included a diverse group of participants, representing both healthcare professionals and patients. By involving various user perspectives, we aimed to enhance the reliability of our usability findings.
* **Data Analysis**: Quantitative data analysis was performed using established statistical techniques, ensuring the validity of our findings. Qualitative data collected through interviews and focus groups were analysed systematically to extract meaningful insights.

### Adherence to Prescribed Principles

* **Alignment with Research Objectives**: Throughout the research process, we remained committed to the research objectives outlined in the proposal. Our iterative development cycles consistently aimed to address the identified healthcare management challenges.
* **Methodological Consistency**: We maintained methodological consistency by adhering to the principles of the DSR methodology. Each development cycle followed a structured sequence of phases, including requirement analysis, system design, coding, testing, and evaluation.
* **Literature Review Integration**: Our study incorporated insights from an extensive literature review, ensuring alignment with established healthcare standards and best practices. This integration enhanced the credibility of our system design and functionalities.
* **Reflection and Iteration**: At the heart of the DSR methodology is reflection and iteration. We meticulously reflected on user feedback and evaluation results at the end of each development cycle. This iterative approach allowed us to refine the HMS progressively, aligning it with user expectations.
* **Ethical Considerations**: Ethical principles were paramount in our study, particularly in handling sensitive patient data. We adhered to established healthcare regulations and standards to ensure data privacy and security.

By critically evaluating the validity and reliability of our research tools and our adherence to prescribed principles, we assert the trustworthiness of our study. The systematic and principled approach employed throughout the research process enhances the credibility of our findings and the practical applicability of the HMS. Let's move on to the next section, "Reflection on the Study."

## Reflection on the Study

In this section, we engage in a reflective analysis of our research project, delving into the lessons learned, the strengths and weaknesses of the study, and our overall success in achieving the set objectives. This reflection provides valuable insights into the research process and informs our future research endeavours.

### Lessons Learned

Our journey in developing the HMS and conducting this research project has imparted several valuable lessons:

* **User-Centric Design**: We learned the paramount importance of a user-centric design approach. By actively involving healthcare professionals and patients in the development process, we gained a deeper understanding of their needs and preferences, ultimately shaping a more effective system.
* **Iterative Development**: The iterative nature of the DSR methodology was a key lesson. Each development cycle provided an opportunity for improvement, and the process of reflecting on feedback and iteratively enhancing the HMS proved to be a robust approach.
* **Data Privacy**: Managing sensitive patient data underscored the criticality of data privacy and security in healthcare systems. Adhering to stringent ethical standards and regulations was imperative to instil trust in our system.
* **Interdisciplinary Collaboration**: Collaborating across disciplines, including computer science, healthcare, and ethics, was challenging yet rewarding. It reinforced the value of interdisciplinary cooperation in tackling complex issues.

### Strengths

* **Innovative Solution**: The HMS represents an innovative solution to longstanding healthcare management challenges. Its features, including appointment setting, data storage, and virtual sessions, address real-world problems faced by healthcare organizations, patients, and medical practitioners.
* **User Satisfaction**: User testing and feedback indicated high levels of user satisfaction. Healthcare professionals appreciated the streamlined appointment scheduling, while patients found the virtual session feature convenient and timesaving.
* **Alignment with Best Practices**: Our study thoroughly integrated best practices and standards from the healthcare industry, ensuring that the HMS aligns with established principles.

### Weaknesses:

* **Limited Scope**: While the HMS addresses critical aspects of healthcare management, it has a limited scope in handling emergency situations. The system's virtual sessions are not suitable for urgent medical cases, and this limitation needs to be acknowledged.
* **Resource Constraints**: Resource limitations, including time and budget constraints, influenced the depth of our study. A more extensive research effort could further refine the HMS and its evaluation.

### Achievement of Objectives

Our primary objectives were to design and develop a HMS that improves healthcare data management, appointment scheduling, and virtual consultations. In this regard, our study has been largely successful. The HMS demonstrates its effectiveness in streamlining healthcare processes and enhancing accessibility to healthcare services.

### Project Management and Timeline

Managing this research project was a challenging yet enriching experience. Adherence to timelines and meeting project milestones required diligent coordination. Group work played a significant role, with each member contributing to different aspects of the project. While challenges in cooperation and contributions arose, effective communication and problem-solving strategies ensured project progression.

In hindsight, our ability to manage the research project successfully and meet target deadlines was a testament to our commitment and teamwork.

## Conclusion of the Study

In conclusion, our research project focused on the design and development of a HMS that addresses crucial healthcare management challenges. The HMS encompasses features such as appointment setting, data storage, and virtual sessions, all aimed at improving the efficiency, accessibility, and security of healthcare services.

Our study achieved its objectives by delivering an innovative solution aligned with best practices in the healthcare industry. Users expressed high levels of satisfaction with the system, emphasizing its user-centric design. However, we acknowledge the system's limitations in handling emergency situations and recognize the influence of resource constraints on the depth of our study.

Through interdisciplinary collaboration and adherence to ethical standards, we established a trustworthy system that holds promise for effective real-world applications. This research project not only contributes a valuable artifact but also provides insights into the iterative development process, the significance of data privacy, and the importance of user-centred design.

As we conclude this study, we look forward to future research opportunities that may further refine the HMS and address its limitations. We are grateful for the valuable lessons learned during this journey and are committed to applying these insights to our future endeavours in healthcare and technology.

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