Title Page

* *The Design and Optimization of a Scalable National Product Information Management System for the NHS*
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* 3rd May 2024.

40-80 pages no word count\*\*\*

Abstract

* Concise summary of the thesis objectives, methods, findings, and conclusions.

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# Chapter 1: Introduction

## 1.1 Introduction to research

In modern day healthcare systems, efficient and standardized procurement processes are necessary in ensuring availability of medical supplies, medicines, devices, and equipment essential for the delivery of high-quality care (Steer-Stephenson, 2022). It is important to accurately manage healthcare product data because these products have a direct impact on patient health and safety. It is critical to enable the supply chain to deliver the right products to the right place at the right time (Department of Health & Social Care, 2023).

The primary healthcare provider in the United Kingdom, the National Health Service (NHS), serving millions of patients across the UK, is plagued with challenges in effectively managing product information between its suppliers and its vast network of trusts, hospitals, clinics, and healthcare facilities. Due to the absence of a unified and scalable system, product information management within the NHS is characterized by lack of standardization, inconsistency, inefficiency, and fragmentation, with disparate infrastructure and processes essentially leading to difficulties accessing accurate and up-to-date product information (Procurement, Investment & Commercial Division (PICD), 2014). This leads to delays in procurement, disruptions in the supply chain, and poor decision-making, ultimately affecting patient care and outcomes. Hence, it is imperative to address these pressing challenges and improve the management of product information within the NHS’ procurement ecosystem.

## 1.2 Problem Statement

The NHS is faced with challenges in managing medical product information within its procurement processes. These challenges include but are not limited to, a glaring inefficient data sharing process between manufacturers/suppliers and NHS trusts, a lack of standardized data formats and identifiers, disparate information scattered across repositories in different departments and healthcare trusts, manual processes for accessing and updating product information. Consequently, healthcare practitioners face difficulties in finding the right products at the right time, causing delays in care and inefficient resource allocation.

The absence of a centralized and scalable system for managing product information poses an obstruction to interoperability and efficient exchange of data with external stakeholders e.g. suppliers, regulatory bodies, patients, and other healthcare organizations. This lack of integration and interoperability brings to fore, the challenges the NHS faces in maintaining accurate and reliable product information throughout its procurement lifecycle.

## 1.3 Motivation for research

This research is primarily motivated by the pressing need to address the challenges the NHS faces in product information management within its procurement process and inventory management system. Efficient management of the procurement process is essential for an effective and functioning healthcare system. For a healthcare system such as the NHS, where resources are stretched thin, optimizing the procurement system is essential for ensuring access to products, medical supplies, and equipment.

The implementation of a scalable national product information management system will enhance procurement efficiency, ensure patient safety, and care quality, meet regulatory requirements, foster collaboration, and drive innovation within the UK’s health system.

## 1.5 Aims and Objectives of research.

### 1.5.1 Aims

The primary aim of this research is:

1. To design and optimize a scalable national product information management system for the NHS.

### 1.5.2 Objectives

In order to achieve the project’s aim, the following objectives were set:

1. To analyse the existing product information management practices within the National Health Service (NHS) procurement ecosystem, identifying key challenges and assessing the needs and requirements of stakeholders.
2. To design a conceptual framework for a scalable national product information management (PIM) system tailored to the needs and requirements of the NHS.
3. To develop a prototype of the proposed PIM system, leveraging advanced relational database management technologies and methodologies to ensure scalability, optimization, and usability in a real-world NHS setting.
4. To evaluate the effectiveness and impact of the PIM system in improving procurement processes, supply chain management, and patient care outcomes within the NHS through testing and user feedback.
5. To provide recommendations and guidelines for the implementation and adoption of the national product information management system within the NHS.

## 1.6 Research Questions

This research will be guided by the following questions:

1. What are the key challenges faced by the NHS in managing product information within its procurement processes?
2. How can the implementation of a national product information management system improve procurement efficiency within the NHS?
3. What are the essential features and functionalities required in a scalable product information management system tailored to the needs of the NHS?

## 1.4 Significance of the study.

The significance of a study on the design and optimization of a scalable national product information management (PIM) system for the NHS cannot be overemphasized. By streamlining procurement and hospital catalogue management systems through the implementation of a national PIM system, the NHS can increase its efficiency, minimize administrative burdens, and improve the overall procurement process.

A centralized and up-to-date product information management system will provide healthcare practitioners with reliable information about medical devices and products thereby minimizing the risk of errors, and further ensuring patient safety.

Furthermore, a scalable national product information system has the potential to ensure optimization of the supply chain by enhancing interoperability and collaboration between healthcare providers, suppliers, and other stakeholders critical to ensuring the delivery of service within the NHS. A seamless data exchange and real-time access to accurate product information will foster transparency and accountability across the procurement ecosystem.

Additionally, embracing the implementation of innovative technologies and digital solutions such as a product information management system can help the NHS leverage opportunities in advanced analytics, artificial intelligence, and automation in order to optimize the procurement process, identify cost saving opportunities, and position itself at the forefront of healthcare innovation.

Overall, this study has the potential to revolutionize the healthcare procurement and information management process, improve patient outcomes, and advance healthcare delivery not just within the NHS but globally.

## 1.7 Structure of the Thesis

This section explains the organizational structure of this thesis. This thesis is organized into 7 chapters, each one serving a specific purpose to providing an overall understanding of the work. Chapter 1 introduces the study. It serves as a foundational framework for the study, by providing context, outlining the background, the research problem, aims & objectives, significance of study and structure.

Chapter 2 presents a comprehensive review of relevant literature to healthcare procurement, and product information management. It discusses key concepts, methodologies, and findings in this field, highlighting existing gaps in the literature which this research seeks to address.

Chapter 3 precents a thorough assessment of the needs and requirements for the design of a product information management system for the NHS. It employs the mixed-methods approach to collecting data from primary and secondary sources on the information needs of the relevant stakeholders within the NHS procurement ecosystem.

Chapter 4 discusses the design and modelling of a conceptual framework for the proposed product information management system, including the discussion of relevant entities, database the normalization process, optimization strategies employed, and design of the user interface.

Chapter 5 focuses on the implementation and development of the system. It discusses the implementation of the database system, the user interface, and the integration with external systems. It also discusses the process of testing and quality assessment.

Chapter 6 discusses the evaluation of the developed product information management system. Specifically, it discusses the evaluation criteria employed, and the evaluation of the system in comparison with set objectives.

In conclusion, chapter 7 discusses the result of the research, draws conclusion based on the results, and presents recommendations for future research.

Chapter 2: Literature Review

### 2.1 Introduction to literature review

In today’s dynamic healthcare landscape, efficient information management systems and procurement practices are essential for ensuring access to medical products, optimizing resource allocation, and improving care outcomes. Though there is limited literature in recent times on the design and implementation of a product information management system for a healthcare organization such as the NHS, this literature review aims to explore existing literature on the design, optimization and application of scalable product information management systems, catalogue management and data sharing practices within the NHS, including challenges faced in this area. This chapter aims to inform the research objectives of this study by providing a thorough understanding of the current state of knowledge by synthesizing key concepts, methodologies, and findings from relevant sources.

### 2.2 Product Information Management

Master data is the definitive and accurate version of the information held about an

item. The use of master data in procurement is limited in the NHS, resulting in the

same item being coded and described differently by NHS providers and suppliers. (Procurement, Investment & Commercial Division (PICD), 2014)

* + Overview of NHS Procurement Practices
    - NHS Procurement
      * <https://www.nao.org.uk/wp-content/uploads/2024/01/nhs-supply-chain-and-efficiencies-in-procurement-report.pdf> how NHSSC works and NHS trust procure
      * <https://scan4safety.nhs.uk/wp-content/uploads/2022/11/Scan4Safety_Product__How_To_Guide-1.pdf>
        + scan4safety/ catalogue mgt/product information
      * <https://scan4safety.nhs.uk/how-to-get-started/first-steps-for-suppliers/>
      * supplier how to get started
    - NHS Procurement
      * <https://link.springer.com/article/10.1186/s12913-021-07065-0> : **2021**
        + Factors affecting procurement decisions:
    - Challenges in NHS Procurement
      * <https://assets.publishing.service.gov.uk/media/5a7c267840f0b61a825d6c48/procurement_development_programme_for_NHS.pdf> **2013**
        + There is very little consistency across NHS Procurement. NHS organisations currently deploy a wide range of procurement processes, methodologies, techniques, tools and templates to identify, procure and manage many similar requirements across identical spend categories. Not surprisingly, suppliers to the NHS encounter a broad range of differing documents and approaches when bidding for (often) similar requirements
        + The production, publication and sharing of procurement best practice and related case studies across the NHS is negligible. It is almost impossible to identify publications of relevant best practice
        + NHS Procurement development programme/ similar to e-procurement strategy :The programme will contain four integrated initiatives: 1. Delivering immediate efficiency and productivity gains 2. **Improve data, information and transparency including the adoption of GS1 coding standards (contains valuable information on GS1 etc.)**
      * [**https://www.gs1uk.org/sites/default/files/GS1\_UK\_Healthcare\_Terms\_2024.pdf**](https://www.gs1uk.org/sites/default/files/GS1_UK_Healthcare_Terms_2024.pdf)
  + Information Management Systems : Product information management systems

(King & Cleland, 1975)

* + **Scalability in Database Systems**
    - Replication: ensures scalability and stability by making sure application continues to be accessible in the case of server failure. you can replicate data across many servers (Šušter & Ranisavljević, 2023)
  + **Optimization strategies for relational database systems**

Explain what optimization is in the context of databases and information systems.

* + Physical programming (partitioning, indexing, data compression and data clustering) page 144 (Šušter & Ranisavljević, 2023)
    - * data types e.g use TINYINT instead of INT or BIGINT
      * storage engines
      * index design
    - field optimization-based method (Gyórödi, et al., 2021)
    - [Indexing strategies for performance optimization of rel db](https://d1wqtxts1xzle7.cloudfront.net/70501062/IRJET_V8I5695-libre.pdf?1632898460=&response-content-disposition=inline%3B+filename%3DIRJET_Indexing_Strategies_for_Performanc.pdf&Expires=1711464845&Signature=hDjSUKe2spXkGbV12Dppp9ipa7RkgtsWZnoCzrHj7m7zwgD8h0sFumeEUFgqH1F4nRNDhfQ52NAfSvFv6qKDJvCci8SkVOnIqKmuKs3svy8BRYljkycVX~4y0AA8b-WdTwRFiOLmmbAGxh30lLNpHzQ41U3Ju1uhKFsHbsrbciuF33EgRzHGQIGBIW8gp6yn8MXoaoMI8kwhIC3o3~3YEHdcXapq2LUpBSYn5udQa2R~yamfdA8v3~KzfnSXKoUoo1l3GD0LmCughdXvAcUUdcT4YOjbz9rvoMKZomnEnZUSw7OixEq2XSmDSgE~E8bsSrTaMd~l0O-OiyXvycgBBQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA) (Praveena & Chikkamannur, 2021)
    - Indexing results in a higher performance and energy efficiency. (Mahajan, et al., 2019)
  + Data Tuning (also known as performance optimization) to locate and get rid of bottle necks. page 146 (Šušter & Ranisavljević, 2023)
    - **Query optimization** is a critical part of data tuning, for ensuring that SQL queries perform better.
      * improving joins, indexing frequently queried columns (suster and ranislav). (Maesaroh, et al., 2022)
      * avoid using select \*, callout the column names (Mahajan, et al., 2019)
      * use EXISTS instead of IN
    - **server configuration**, size of buffer pool be changed to optimize memory utilization and boost query performance. max\_connections parameter increase to manage high number of concurrent users (suster and ranislav)
    - **normalization:** reduction of data redundancy and duplication can enhance query performance and lower storage costs. (find reference on normalization)
    - **Caching and replication:** caching saves frequently accessed data in memory for easy retrieval
  + Case studies and best practices – application of PIM in healthcare, and in other industries
  + Summary of key findings and gaps in the literature.

Chapter 3: Needs Assessment/Business Rules

### 3.1 Introduction to Needs Assessment

that textbook chapter 11

* + - Overview of purpose and scope of needs assessment
    - Explanation of importance of needs assessment for the development of the NHS national PIM system.

### 3.2 Identification of Stakeholders

* + - Description of stakeholders involved in NHS procurement processes.
    - Identification of key stakeholders whose needs and requirements must be considered in the development of the PIM system.

### 3.3 Stakeholder needs and requirement analysis

* + - Analysis of needs of each stakeholder group
    - Discussion of how stakeholder needs will inform the design and functionality of the system.

### 3.4 Assessment of the current state or problem within the NHS procurement system.

<https://scan4safety.nhs.uk/wp-content/uploads/2022/11/gs1_uk_inventory_management_systems_guidance-1.pdf> inventory management system implementation guidance scan4safety

* + - Evaluation of existing processes, technologies, and systems within NHS
    - Evaluation of the compatibility and interoperability of current systems with the proposed national PIM system
    - Identification of inefficiencies, gaps, and opportunities for improvement

### 3.5 Legal and Regulatory Requirements

* + - Overview of legal and regulatory requirements relevant to PIM in healthcare
    - Analysis of compliance obligations, standards, and regulations governing data privacy, security, and interoperability.
    - Influence of legal and regulatory considerations on the design and implementation of the NHS PIM system.

### Summary of NA findings

1. GDSN, suppliers and NHS datapools
2. Integration with PIM

Chapter 4: Design and Modelling

### Introduction to system design chapter 8-10

* 1. <http://www.cherrycreekeducation.com/bbk/b/Pearson_Database_Systems_A_Practical_Approach_to_Design_Implementation_and_Management_6th_Global_Edition_1292061189.pdf>
  + Overview of purpose and scope of system design phase
  + Explanation of importance of a well-designed system in meeting stakeholders’ needs and requirements.

### 4.2 Database Architecture. chapter 12

* + Description of proposed database architecture for the NHS national PIM system
  + Explanation of the database structure, including tables, fields, and relationships
  + Discussion of choice of relational Database technology and suitability for managing product information in healthcare

### 4.3 Data Modelling

* + Overview of data modelling process for the PIM system
  + Entity-Relationship model
  + Identification and definition of key entities, attributes, and relationships
  1. Normalization chapter 14-15

### 4.4 Scalability

* 1. analysis of scalability requirements
  2. discussion of scalability challenges and solutions in database design
  3. description of strategies for ensuring scalability of the database architecture

### 4.5 Introduction to Optimization Strategies

Discussion of optimization techniques employed to enhance system performance and scalability. (query optimization, Indexing, Minimizing redundant data retrieval, etc.)

### 4.6 User Interface

* 1. overview of user interface design for the NHS national PIM system
  2. description of the UI components, layout, and navigation.
  3. discussion on usability principles and best practices in interface design to enhance user experience.

### 4.7 Integration with GS1 certified data pools

* 1. Explanation of how the PIM system will integrate with GS1 certified datapools.
  2. description of data exchange protocols, standards and interfaces used for interoperability.
  3. Description of the benefits of integrating GS1 standards for product identification and synchronization

One of the purposes of deploying GS1 data standards is to improve data accuracy and consistency across multiple systems. The use of GS1 standards will also act as an enabler for Automatic Identification and Data Capture (AIDC) technology, which is used to correctly identify a product at the point of use.

### 4.8 Summary of System Design

* 1. summary of key design decisions and considerations
  2. identification of design principles and strategies aimed at meeting stakeholder needs and achieving system objectives
  3. transitioning to implementation phase, highlighting how the system design will guide the development of the system

Chapter 5: Prototyping

### 5.1 Introduction to Implementation

* + Overview of implementation phase and significance in bringing proposed PIM system to life
  + Explanation of the objectives and scope of the implementation process

### 5.2 System Development

* + Description of the development lifecycle followed for implementing the PIM system

### 5.3 Database Implementation

* + steps involved in implementing database infrastructure
  + description of the process i.e. database creation, configuration, and optimization
  + Discussion of challenges encountered during implementation

### 5.4 Integration with External Systems

* + Overview of the integration process for connecting PIM system with external systems and data sources
  + Description of standards and protocols used to facilitate interoperability
  + Discussion of integration requirements and considerations for data exchange with GS1 certified datapools and other external systems

### 5.5 User Interface development

* + Descrption of the UI development process for the PIM system
  + Overview of the design principles, UX considerations and usability testing conducted during interface development
  + Discussion on how iterative design process informed the development of the user interface
  + <https://docs.streamlit.io/knowledge-base/tutorials/databases/postgresql>
  + <https://www.datacamp.com/tutorial/streamlit>
  + <https://www.youtube.com/watch?v=ns-Pd-1F4uU>

### 5.6 Testing and QA

* + explanation of the testing methodologies to validate functionality and performance of PIM system
  + description of testing phases
  + discussion of results, bug fixes, and QA measures implemented to ensure efficiency and reliability of system

### 5.7 Summary of Implementation

* + key milestones and successes
  + Challenges encountered and solutions adopted during implementation.
  + recommendations for future system implementations

Chapter 6: Evaluation and Results

### 6.1 Introduction to Evaluation

* + overview of the evaluation phase and importance in assessing the effectiveness and performance of the developed PIM system
  + Explanation of the objectives and scope of the evaluation process

### 6.2 Evaluation Metrics and Criteria

* + description of metrics and criteria used to evaluate the PIM system
  + KPI and criteria for assessing system effectiveness, usability and impact

### 6.3 Evaluation methodology

* + Overview of evaluation methods i.e. surveys or interviews employed to collect feedback from stakeholders

### 6.4 Evaluation of System Scalability

* + analysis of the scalability of the PIM system to handle increasing volumes of data and user traffic
  + description of tests for assessing system performance
  + discussion of scalability challenges and recommendations for enhancing system scalability

### 6.5 Presentation of Results

* + presentation of data collected during evaluation process
  + SWOT analysis of the PIM system

### 6.6 Comparison with objectives and requirements

* + comparison of evaluation results with objectives and requirements defined for the PIM system
  + Assessment of the extent of the system meeting stakeholder needs, fulfill project goals and addresses identified challenges

### 6.7 Summary of findings

* + Summary of key findings, insights and conclusions from evaluation phase
  + Summary of recommendations for enhancing system performance, usability and scalability

Chapter 7: Discussion and Conclusion

### 7.1 Interpretation of the findings in relation to the research objectives.

### 7.2 Discussion of implications, limitations, and future directions.

### 7.3 Summary of key findings and contributions of the thesis.

### 7.4 Recommendations for practice, policy, or further research.

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Appendices:

* Supplementary materials such as raw data, survey, or technical documentation.