A Model-Driven Framework to Recommend E-prescriptions

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Annex A

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A Model-Driven Framework to Recommend E-prescriptions

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A thesis submitted to National University of Science and Technology, Islamabad in partial fulfillment of the requirements for the degree of

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Dedicated to my dear mother and late father, and also the rest of my family, for their continuing support, collaborative effort, and prayers that have led me to this incredible accomplishment. I'd want to specifically thank my mother for her unwavering dedication and hard work, which laid the groundwork for my academic career and this wonderful achievement..

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ABSTRACT

E-prescription systems are the way of using computing devices to input, amend or review medication prescriptions. These systems are difficult to manage and develop as low-level implementations are carried out separately during system development and can essentially require analysis after implementation. As today's modern technology is raising the need for a more accurate way of electronically prescribing treatments to patients is required. Existing literature has tried to accomplish the objective of how to reduce development complexity, do analysis and testing of the system at development time. However, these issues can be resolved using Model-Driven-Architecture (MDA), which is commonly utilized in the implementation of automation systems of healthcare and monitoring, etc. The following are the contributions of this paper: 1) a framework named as "Model-Driven Framework to Recommend E-Prescriptions" is proposed. 2) Specifically, a meta-model for e-prescription is presented. It decides which recommendations should be given to the prescriber that will make it more user-centered while minimizing the error rate in the procedure. Consequently, the proposed meta-model makes the system less complex and more testable. This meta-model is modeled and visualized using the Eclipse Modeling Framework (EMF) and visually represented using the Sirius tool. It also provides a foundation for M2M and M2T model conversions using the Acceleo to generate functional Python code.

Keywords: Model-based systems. E-prescription. Meta-modeling. Model-Driven-Architecture (MDA) ·Graphical Representation · Sirius tool · Random Forest · ANN · Decision Tree

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CHAPTER 1: INTRODUCTION

This section offers a comprehensive introduction to the research and its underlying concepts, organized into several sub-sections. **Section 1.1** presents the background study, while **Section 1.2** outlines the problem statement of the research. In **Section 1.3**, we discuss the proposed methodology. **Section 1.4** highlights the research contributions, and finally, **Section 1.5** provides an overview of the thesis organization.

1.1. .Background Study

World is switching from manual prescription to e-prescribing including many countries progressively. There are various advantages to switching from traditional prescription to e-prescribing. Healthcare professionals can use e-prescribing to electronically submit prescriptions to pharmacies, removing necessity handwritten and printed prescriptions. This not only decreases the possibility of prescription mistakes, including illegibility or improper dose, but also improves patient safety. Built-in tests for medication interactions and allergies are common in e-prescribing systems, alerting healthcare practitioners to possible dangers first before prescription is completed. Furthermore, e-prescribing increases efficiency by expediting the prescribing process and minimising administrative responsibilities involved with dealing with and processing paper prescriptions. Overall, e-prescribing improves drug management accuracy, safety, and efficiency. In the health care sector, E-prescribing (Electronic prescribing) is on the rise. These systems are quite promising to advance the overall efficiency of the healthcare sector. Today's doctors are also shifting to e-prescribing making it to be a must-have thing. E-prescription systems enable health care providers, such as physicians and nurses, to electronically give, amend, or cancel a prescription issued to a patient. According to a nationwide assessment of pharmacy practice in hospital settings in the United States, automated dispensing and barcode-assisted medicine administration are employed in 89 percent and 50 percent of hospitals, respectively. But these systems should be accurate enough because a little error can bring forward a life-threatening situation. The correctness of systems employed in critical moments, including such healthcare and

emergency response, is essential because even tiny errors can have life-threatening repercussions. Miscalculations, misinterpretations, and system flaws can result in catastrophic injury or loss of life in industries such as healthcare, where accuracy and dependability are critical. In medical diagnosis, for example, inaccurate test findings and misread imaging scans might lead to wrong therapies including delays in providing necessary care. As a result, it is critical to guarantee that these systems are subjected to various tests, quality assurance, and constant monitoring in order to reduce the likelihood of mistakes. Extensive validation methods, compliance to industry norms, and regulatory monitoring all play critical roles in keeping such systems accurate. Regular audits, performance assessments, and feedback loops for users of the system are also necessary components for quickly identifying and correcting any possible errors. In addition, the accuracy of crucial systems can be increased by utilizing advanced technologies like machine learning (ML) and artificial intelligence (AI). These technologies can help with real-time data analysis, fault diagnosis, and predictive modelling, allowing for proactive mistake detection and prevention before they become life-threatening situations. We may decrease risks and protect the safety and well-being of persons who rely on critical systems for their lives and livelihoods by prioritising accurateness in critical system design, development, and implementation.

As stated by Anwar et al [52], Model Driven Architecture (MDA) is defined by how through modeling we can achieve the concept of abstraction as well as we can reduce complexity while developing software. MDA considers models and transformations to be fundamental artifacts for automation designing, implementing, and modification of model-based software systems. This article proposes a meta-model model for infallible e-prescribing procedures consisting of diverse concepts such as patient, doctor, prescription, history, etc., and a recommendation system that will give a recommendation to the doctor, which will make the system more user-centered and improve its accuracy. Moreover, these systems can be easily integrated with numerous systems. The practicality of the suggested meta-model is shown through a case study. The results show that the suggested meta-model is a perfect solution for modeling and graphically representing e-prescription activities, as well as a very effective tool for developing MDA-based systems. This framework supports modeling, graphical visualization, and a custom-built tree editor created with the Sirius tool. Additionally, it provides strong underpinnings for model transformation processes, including the Acceleo model-to-text conversions for writing Python code that may be executed.

1.2 Problem Statement

According to the studied literature, one out of ten computer-generated prescriptions highlights the significance of an efficient e-prescription system. had at least one inaccuracy, with one-third posing a risk of damage. Electronic prescriptions have been shown to minimize medication mistakes, prevent errors, productivity, and resource management; yet, if not properly designed and performed, they may pose new difficulties and irritate physicians. Errors associated with computerized prescriptions typically create workflow delays. Despite their obvious benefits, computerized prescription systems face several challenges. Each computerized prescription system had a different quantity, kind, and severity of errors, indicating that even some services are more effective at preventing errors than others. However, if an electronic prescription is not correctly done, it might introduce additional mistakes. To aid in the discovery of systemic solutions, the healthcare industry should establish a quality-improvement review method. Solutions might range from improving the architecture of an e-prescription system to focusing on the usability of the e-prescription system. Since usability and user-centered design (UCD) can increase physician adoption, decrease physician dissatisfaction, and improve patient safety, they are important considerations in the design and implementation of digital prescriptions and electronic medical records in general. The better design may include drop-down menus, less complex interfaces, user-friendly interfaces, etc. Insufficient usability frustrates clinicians, as well as it also raises the chance of mistakes, posing a significant danger that can harm the safety of patients The rise of MDSE is defined by the achievement of abstraction by reducing development complexity, increasing testability and analysis at the development time of software systems through modeling. As discussed by Anwar et al [28] MDSE emphasizes the use of modeling to achieve abstraction and reduce the development complexities of software systems. As Rasheed et al [27] proposed modeling and performing either transforming from a model to a model or model to a text are the core artifacts and fundamental organizational resources for model-based software development's automated design, development, and other tasks. As discussed by Rasheed et al [27] the MDA process begins with the development of a formal model known as a meta-model utilizing the Ecore Modeling Framework, a general-purpose modeling language such as UML or a Domain Specific Language (DSL). This power abstraction method has benefited a variety of fields, Information management, software firms, systems engineering, and integrated devices are just a

few examples. As in the literature review, no such studies have been found which suggest a meta-model for e-prescription systems. So to implement these e-prescription systems, there is a need for a broad-based Model-driven Architecture approach

Preventing medication mistakes is a significant priority for health-care practitioners worldwide. Electronic prescriptions have been shown to minimize medication mistakes, prevent errors, productivity, and resource management; yet, if not properly designed and performed, they may pose new difficulties and irritate physicians. Errors associated with computerized prescriptions typically create workflow delays. Despite their obvious benefits, computerized prescription systems face a number of challenges. One out of every ten computer-generated prescriptions had at least one inaccuracy, with one-third posing a risk of damage. This is consistent with findings on the mistake rates of human handwritten prescriptions. Depending on the computerized prescription system, the quantity, kind, and seriousness of errors varied, suggesting that certain systems are more effective at preventing errors than others.[33] In the US, medical errors rank as the third leading cause of death. with drug errors accounting for around 20% of all errorsA solution to this issue is electronic prescription, or e-prescribing, which has been shown to offer a number of benefits. However, if electronic prescription is not correctly done, it might introduce additional mistakes. [35] Proportion and contributing factors to e-prescribing errors are:

- Computer (technical) variables account for 12% of e-prescribing mistakes
- whereas human factors account for 40%
- interaction factors account for 31%
- organisational factors account for 17%. [30]

1. In the absence of external contacts, computer components result in errors in e-prescribing software; these errors are most likely caused by bugs or program design. In addition to software issues, technical difficulties, or network latency that could slow down or even cause the process to malfunction, the main technical factors are delayed system performance during workdays, system downtime, and recurring software indications or notifications.

2. These elements are characterized by improper or inaccurate human participation in e-prescribing-related activities. Inaccurate information entered accidentally is one of among the most often cited reasons for e-prescribing issues.

3. The point at which technological and human factors combine to cause errors in e-prescribing are known as interaction factors. These situations can lead to e-prescribing errors when users' careless or improper behavior is combined with the distracting features of e-prescribing software. The phrase "human impact" or "negligence" describes the potential role that people may play in errors. An e-prescription system's drawbacks could include anything from subpar design to technical difficulties.

Another study claims that the errors found in generated electronically medications were iteratively categorized in order to create a framework for determining the root cause of the issues. The most common cause of errors (60.7 percent of all errors including 50.9 per cent of possible ADEs) was omitted information. Missed dosages were the most likely to result in a hypothetical ADE, and duration, dose, as well as frequency are possibly the most probable data to be overlooked accountable for 35% of the study sample's putative ADEs. Information was either clinically erroneous (7.5 percent of total inaccuracies 13.5 percent of the possible ADEs), incompatible (15.7 percent of total mistakes, 16 percent of potential ADEs), or unclear (16.1 percentage of total mistakes, 19.6 percent of potential ADEs) if the cause of an error hadn't been omitted. [37]

1.3 Proposed Methodology

To aid in the discovery of systemic solutions, the health-care industry should establish a quality improvement review method. Solutions might range from improving the architecture of an e

-prescription system to focusing on the development of pharmaceutical personnel. According to one study, pharmacy technicians play a significant part in the e-prescription process as well as drug dispensing community pharmacies. Many particular features of pharmacy technicians have been linked to greater assistance for pharmacists in carrying out their patient care obligations and more effective assessment and remediation of prescription mistakes. The exact significance of these relationships with crucial outcomes, like as profitability and clinical outcomes, is unclear at this time. Future study might be conducted to discover these relationships; measures may be properly informed to prioritize possible opportunities for improvements in an effort to enhance the e-prescription mechanism and the sturdiness of pharmacist training in order to improve drug safety. [18], when it comes to pharmacist interventions, the most prevalent category of prescription

mistakes is connected to the requirement for pharmacological therapy and dose selection. [39] Because they can increase patient safety, usability and user-centered design (UCD) are important considerations in the creation of electronic prescriptions and electronic medical record, or EHR, systems in general., boost physician adoption, and reduce physician dissatisfaction. The better design may include drop-down menus, less complex interface, user-friendly interface etc Insufficient usability not only frustrates clinicians, but it also raises the chance of mistakes, posing a significant danger to patient safety. The purpose of this study is to enhance the productivity of the software of e prescriptions by mitigating the risk of inaccurate medication selection and shortening physicians' prescribing time. We will develop a meta model for EP that will include concepts such as prescriber, medications, patients, and so on, and then we will employ various OCL constraints to ensure error avoidance.

The implementation of a quality control review technique in the healthcare business can help to identify systemic solutions for improving the e-prescription system plus pharmacist training to increase medication safety. More study is needed to understand the particular interactions that exist amongst pharmacist, pharmacist interventions, and critical outcomes including profitability as well as clinical outcomes. Exploring these linkages allows healthcare practitioners to highlight possible areas of concern and execute appropriate solutions. Pharmacist interventions in the e-prescription procedure frequently focus on resolving prescription mistakes relating to pharmacological treatment and dosage selection. Identifying and resolving these frequent types of errors can dramatically enhance patient safety and overall healthcare delivery efficacy. User-centered Design (UCD) and usability play critical roles in the development and design of electronic prescription as well as electronic health record (EHR) platforms. A well-designed system featuring user-friendly features including clear interfaces & drop-down menus can increase not just patient safety and also physician adoption and minimise unhappiness among healthcare workers. Inadequate usability can frustrate doctors and increase the chance of mistakes, putting patient safety at risk. Efforts can be made to reduce the risk of drug selection mistakes and shorten physicians' prescribing time in order to increase the productivity and precision of e-prescription software. One option would be to create a meta-model of electronic prescriptions (EP) which incorporates key concepts such as prescribers, drugs, and patients.

1.4Thesis Organization

The overall thesis is structured as follows and Figure 16 also represents the organization of the thesis**.**

- Error! Reference source not found. deals with the introduction having detailed background s tudy about the concepts used in the research, problem statement, research contribution and thesis organization.

- Error! Reference source not found. discusses the major concepts of the Metamodelling in d etail. Each concept is explained.

- Error! Reference source not found. contains the literature review which provides a d escription of work done in the field of E-prescription or electronic prescription. In the Literature review, we also highlight the advantages and disadvantages of the different approaches that we encountered.
- Error! Reference source not found. **e**xplains the challenges that we face in the conventional a pproach and also covers the details of the proposed methodology that is used to mitigate the performance bottleneck of the conventional methodology.

- Chapter 5 provide the implementation regarding the proposed methodology and selection of multiple datasets, different algorithms. Validation of the proposed methodology is also performed in this chapter using a case study.

- Chapter 6 This section concludes the thesis. A summary of all of the findings along with an overview of future work is presented.

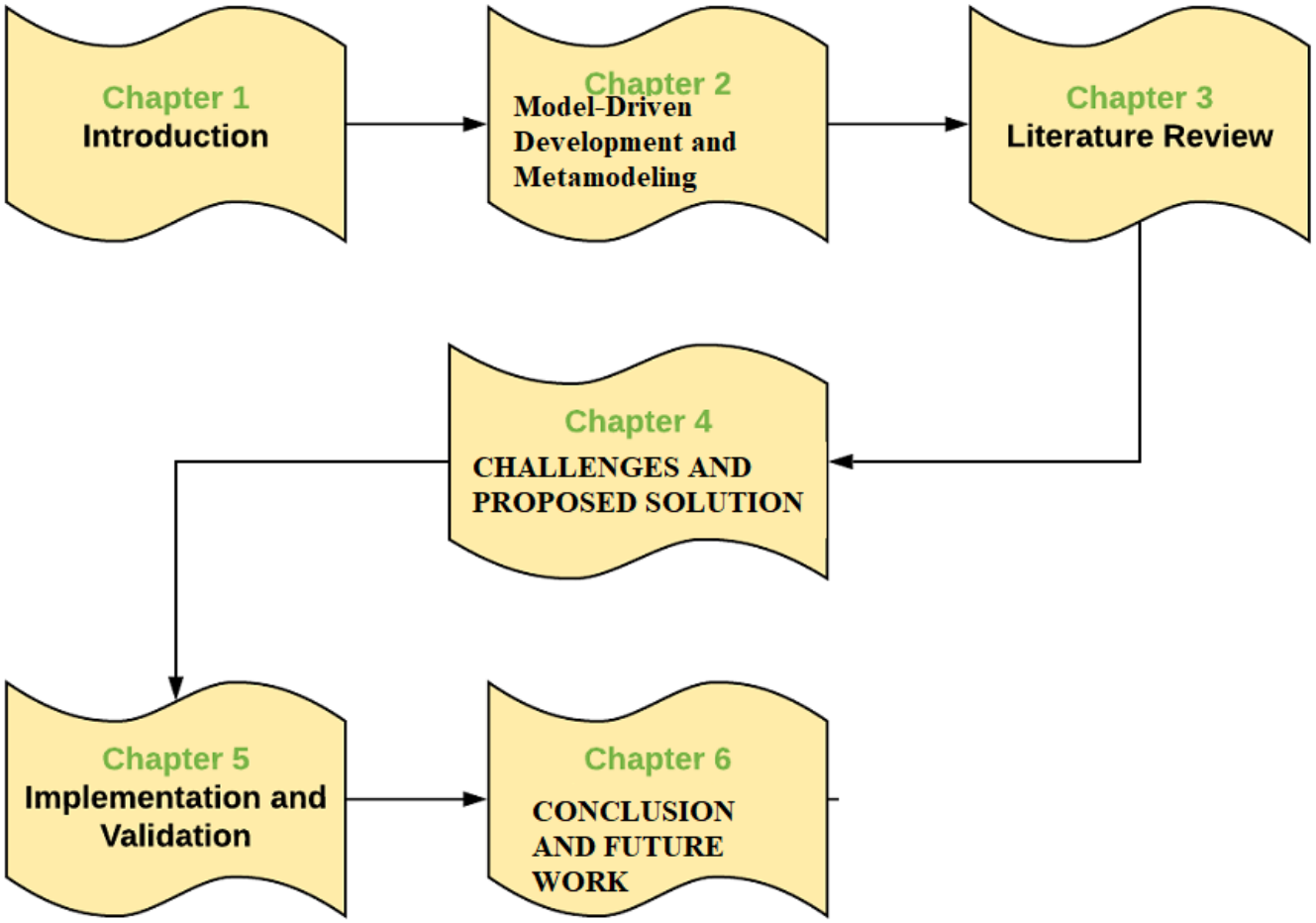


Figure 16: Complete Thesis Flow

CHAPTER 2: Model-Driven Development and Metamodeling

This chapter offers a comprehensive introduction to model-driven development and metamodeling, organized into several sub-sections. **Section 2.1** presents an understanding of models and their significance in software development. In **Section 2.2**, we explore the specific terminology established by the Object Management Group (OMG), providing essential definitions for context.

2.1 Understanding Models and OMG Terminology

Although modeling is becoming more popular in software engineering, it must become more widespread. MDE, or engineering in methodology of model, is a software development methodology. Models are the main component of design. Models are used to build the initial idea of something to obtain before the actual implementation starts. Models are employed to circumvent the inherent and inevitable complexity of software. There are two types of model transformation: model-to-model transformation and model-to-text transformation. Text, such as test cases, documentation, or program code, is the result of the model-to-text translation. Concepts like meta-models are modeled using the enhanced version of the UML.

Different definitions of models and words like metamodel were misinterpreted by engineers. They are defined.[51]

- A simplified representation of a system is called a model. Due to a more thorough definition, a simplified depiction of a system created with a specific goal in mind. The model may be used to answer questions instead of something similar to the real system. (Favre, 2005) [51]

- A formal expression of the concept (a simplification) is called a metamodel. To characterize the abstraction, the meta-model identifies a set of key concepts and a set of terms that are in agreement with each other.[51]

The data structure kept in the model that depicts the abstracted object or concept is built upon the metamodel. According to Hayes, our representation choices reflect our understanding of the topic or concept being abstracted, and thus no modeling or expert system is truly a data model. (Hayes, 1979) [51]

The model is structured according to the frames and guidelines of the metamodel. Models are the language in which things, or outlooks, are generated by an access engine querying the model. Whole manuscripts may be represented by the objects. The model is structured using a tool-specific language, such as XML, or an information storage language. The terms associated with the model-driven approach to modeling that we have covered in Figure 1 include

1. MDD

Models are the main artifacts of the development procedure in a process known as "model-driven development." Models are the primary objects in Model-Driven Development (MDD) and play an important role in the whole software development process. Models are used extensively throughout the MDD process, encompassing requirement gathering, system design, development, and testing. The fundamental purpose of MDD is to close the gap among both system requirements as well as their execution through the use of models' abstraction and automation. MDD attempts to improve productivity, ease of maintenance, and improving software quality by using models as the primary development artefacts. One significant advantage of MDD is that it allows for higher-level modelling, allowing software developers to capture complicated system specifications and design features from a more conceptual standpoint. This abstraction aids stakeholders in better understanding the software system and allows efficient communication among project stakeholders such as developers, designers, and customers. Models may be built using MDD by employing domain-specific modelling languages (DSMLs) that are suited to certain application domains. These DSMLs provide conceptual models, notations, and abstractions suitable for expressing domain-specific notions and needs. Another important component of MDD is the capability to rapidly produce code or other artefacts from models. MDD facilitates effective and convenient implementation by decreasing the human work necessary for code authoring using model transformations & code generation techniques. Furthermore, MDD encourages reusability since models may be used as templates to generate code and other such system artefacts across several projects or versions of a software application. This reuse may boost development efficiency, eliminate mistakes, and assure project consistency. Software developers can benefit from increased efficiency, maintainability, as well as the ability to quickly react to changing needs by embracing MDD. Furthermore, MDD permits the incorporation of model-based approaches

such as model checking and verification, which can assist verify the software's correctness and stability. Overall, Model-Driven Development provides a systematic approach model-centric development approach, allowing for improved understanding, collaboration, and automation across the software engineering process. MDD promotes stakeholder engagement, improves software quality, and aids in the creation of complex as well as scalable systems by stressing the usage of models.

2. MDA

As a result, it depends on OMG standards being adopted. The procedure of MDA is driven by the task of modeling your software system. Formal models, as well as models that computer can comprehend, are the artifacts that have been produced. The MDA's main components are as follows: -

- PIM (Platform Independent)
- PSM (Platform Specific Models)
- Prog.Lang. Code

We will want a different method for developing language in the MDA context because modeling languages are not required to be written in text, and they frequently aren't (though they may). We call this approach metamodeling. It needs to be articulated in a clearly defined language. We call this language a metalanguage.The language is fully defined by the metalanguage. Consequently, it is neither required nor beneficial to distinguish between the metalanguage along with the metamodel which specifies the language; they are interchangeable for all intents and purposes.

Adoption of Object Management Group (OMG) guidelines is critical in Model-Driven Architecture (MDA) for assuring interoperability as well as consistency across diverse software systems. The work of modelling the software system, as acts as the key driver behind all this MDA process, is central to MDA. MDA artefacts are formal models, or representations the computers can understand and process. These models are organised around MDA's key parts, which comprise Platform-Independent Models (PIM), Platform-Specific Models (PSM), as well as the accompanying programming language code. One of the most important aspects of MDA is the awareness that modelling languages used for the MDA domain may not need to be text-based. In reality, they frequently use diverse ways to create languages. This method is referred to as

metamodeling. Metamodeling is the process of expressing a modelling language in the well language known as a metalanguage. The metalanguage defines the modelling language in detail, including its ideas, connections, and limitations. No need to separate between metalanguage as well as the metamodel that specifies the language for all practical purposes.

Metamodeling enables the detailed development and modification of modelling languages to meet the needs of individual application domains or projects. It provides a robust tool for building well-defined and reusable modelling languages, boosting the MDA approach's flexibility and adaptability.

MDA provides a structured and model-centric development approach by applying OMG standards, concentrating on modelling the software application, and utilising metamodeling techniques. It permits the generation of formal models, which can then be converted into platform-specific models and, finally, executable code. This allows for concern separation and improves the automation and uniformity of the development phase.

To summarise, MDA is based on OMG standards and is centred on modelling the software system. MDA distinguishes between Platform-Independent Models, Platform-Specific Models, as well as the resultant programming language code when creating formal models as artefacts. Metamodeling, which is articulated from a well language defined as a metalanguage, is critical in creating and modifying modelling languages. Software development teams may gain interoperability, uniformity, and productivity across the development lifecycle by embracing these basic MDA ideas.

3. MDE

MDE encompasses more model-based duties of the complete software engineering process in addition to development-only tasks. Software models are created by MDE as a basic design artifact. Before beginning the actual implementation, the initial notion of something is designed using models. Models are employed to get around software's unintentional and necessary complexity.

Model-Driven Engineering (MDE) broadens the context of software engineering past pure development tasks to include a variety of model-based responsibilities across the software engineering process. Software models are key design artefacts in MDE, playing an important role in conceiving and modelling a software system.

MDE use models to create the basic concept and roadmap of the software application. Before moving on to the real implementation phase, this first concept is constructed utilising models. MDE uses models to help stakeholders see and evaluate the overall structure, behaviour, and interaction of many system components, assisting in ensuring that the system satisfies intended goals and objectives.

One of the primary advantages of employing modeling in MDE is their capacity to handle both accidental and necessary complications in software development. Accidental complexity refers to problems caused by the complexities of a specific language, platform, or implementations technique, whereas fundamental complexity is tied to the nature and complexities of the issue domain itself. Models give a greater degree of abstraction, enabling software engineers to concentrate on critical complexity while automating and generating code to avoid unintentional complications.

Organizations can get various benefits by using MDE concepts. First, MDE encourages reusability and modularity by utilising models, which may be readily altered, reused, and merged to provide multiple functionality or variants of the software system. This results in increased efficiency, decreased development time, and greater maintainability.

Additionally, MDE promotes collaboration and communication between project stakeholders. Models offer a common vocabulary and graphical demonstration of the software system, allowing developers, designers, subject matter experts, as well as other stakeholders to communicate effectively. This common comprehension and image of the system promotes improved decision-making and synchronization throughout the development cycle.

Another essential component of MDE is the ability to transform models. Model transformations automate the development of code or other artefacts from models, decreasing the amount of manual labour necessary for implementation. This automation promotes uniformity, precision, and the rapid conversion of design decisions to operational software components.

In summary, MDE expands software engineering's duties beyond development operations, stressing the usage of software components as fundamental design artefacts. Models help in the creation of the initial idea, overcoming complexity, and boosting stakeholder engagement and communication. MDE improves reusability, modular, and overall performance by employing models all through the process of software development, allowing for the development of elevated software systems.

4. MBE

They play a crucial role in models but are not the primary results of the entire development process.

Models are vital and indispensable in software engineering, even if they are not the major emphasis or final result of the whole development process. Models help to understand and analyse the structure, behaviour, and functionality of the system under development by representing and conveying various elements of it.

Models serve as plans or prototypes for the software system, capturing the crucial elements and design decisions. They enable developers to envision and perfect their ideas prior to final execution. Software developers can use models to illustrate the interactions between various components, discover potential defects or ambiguities, and assess the system's compliance with requirements and objectives.

Models also encourage collaboration and effective communication amongst project stakeholders. They act as a similar language that connects technical professionals, analysts, and end consumers. Models give a visual depiction that is easy to understand and debate, enabling stakeholders to provide meaningful input, make intelligent choices, and ensure the system fulfils their expectations.

Models may also be used for many types of analysis and validation. Early in the design process, software developers can replicate, test, and update models to discover possible bottlenecks, performance concerns, or design errors. This proactive strategy reduces costly rework while improving overall system quality.

Models also enable the use of model-driven approaches including code creation and automatic documentation production. Model transformations allow models to be used to generate source codes or complete documentation that represents the structure and behaviour of the system.

In conclusion, while models are not the main output or ultimate objective of the software development, they are critical in promoting understanding, cooperation, and analysis. Models are design artefacts that help in visualising, improving, and verifying the structure and behaviour of a system. Software engineers may increase communication, improve the system quality, and expedite the development process by successfully using models.

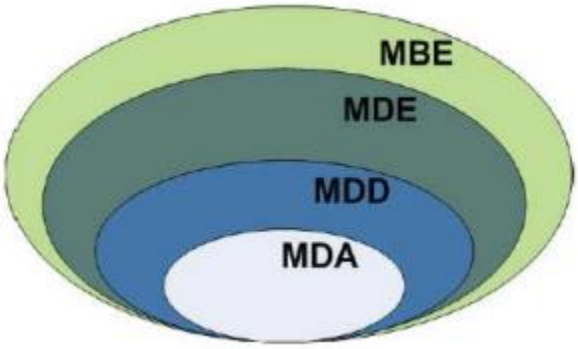


Figure 1 Terminologies

2.2 OMG Terminology

Metamodeling may be further discussed by going into how model are grouped I to various levels which gives the terms model and meta-models a distinct significance.

The OMG uses a four-layered architecture for its standards. In OMG M0, M1, M2, and M3 are the layers

Layers	***Layers in OMG***	***Description***
M3	Meta Metamodel	M2 level's model
M2	Metamodel	Model's model
M1	Model	Model
M0	Object	Instances

Table 1 OMG metamodel layer

Model-Driven Development (MDD) is a method of software development that emphasises the use of models as fundamental artefacts all through the development process. MDD uses models to improve understanding, communication, and visualisation of complex software systems. These models help pave the way or preliminary concept, encapsulating the key characteristics of the system is being created. Model-Driven Architecture (MDA) is a methodology inside MDD that uses industry standards established by the Object Management Group (OMG). MDA is concerned with modelling the software system and build detailed models that computers can understand. The Platform-Independent Model (PIM), which describes the system independently of every specific platform, Platform-Certain Models (PSM), which are adapted for particular platforms or technologies, and the produced programming language code are the fundamental components of MDA. Metamodeling is an essential feature of MDA since it provides a method for constructing modelling languages inside an MDA environment. Metamodeling entails creating a metalanguage, which is a well language that thoroughly defines the concepts and agreed-upon terminology of the modelling language. The metalanguage and the metamodel that defines the language are basically the same thing, and they lay a foundation of language definition and modelling. MDE goes above development activities to include extra model-based tasks across the software engineering lifecycle. MDE considers software models to be key design artefacts that contribute in the recognition and control of complexity. Models are used to conceptually describe the system prior to actual implementation, allowing for greater plan, assessment, and testing for system requirements and behaviour. Models are important in MDE, but Model-Based Engineering (MBE) emphasises that they are not really the primary output of the whole development process. MBE, on the other hand, recognises the critical role that models play all through the software engineering lifetime, spanning requirement gathering to validation and maintenance. The OMG nomenclature has a four-layered architecture: M0, M1, M2, and M3. These layers allow modelling with a hierarchical framework. The actual created objects exist at the M0 layer. M1 covers models, in which a model is a system representation often stated in a modelling language. Metamodels, which describes the structure, logic, and ideas of models, are included in the M2 layer. Finally, the M3 layer represents the meta-metamodel, which defines the semantics and organisational structure of metamodels. Finally, model-driven approaches such as MDD and MDE push modelling techniques to the centre of software engineering, allowing for better understanding and control of software complexity. Metamodeling is critical in developing modelling languages and creating a shared

conceptual understanding and words. Software engineers may design, create, and sustain software in a far more methodical and efficient manner by embracing these approaches and OMG standards.

For this project to create a model we are going to require

- An IDE (Obeo Designer Community)
- Sirius Tool
- OCL Tool

CHAPTER 3: LITERATURE REVIEW

This chapter provides a comprehensive literature review, organized into several sub-sections. **Section 3.1** presents the background of the study, setting the context for the research. In **Section 3.2**, we outline the research sequence, which includes specific sub-sections: **Section 3.2.1** discusses the research questions, **Section 3.2.2** outlines the inclusion/exclusion criteria, and **Section 3.2.3** details the keywords used in the research. Finally, **Section 3.3** reviews related work in the field, highlighting key studies and findings relevant to this research.

Background

Research evidence implies that, despite its perks, e-prescribing produces different types of unexpected failures that do have the capability to endanger the safety of patients. Because of the rapid advancement of technology, many studies have been undertaken on this subject in recent years. Research evidence implies that, in spite to its perks, e-prescribing produces different types of unexpected failures that do have the capability to endanger the safety of patients. Because of the rapid advancement of technology, many studies have been undertaken on this subject in recent years. The major goal of the study. The major goal of the study as stated by Pouyan et al [30] is a review of related research and suggested e-prescribing categorization: Functions, assimilation steps, benefits, problems, and risks was to get to know what e-prescribing is, how it fits with health-care sectors such as hospitals and pharmacies, the possible advantages, the dangers and problems associated with e-prescribing, variables influencing e-prescribing mistakes. Despite this, the overall design of e-prescribing systems facilitates errors. Inadequate drop-down lists, poor screen design, and incorrect drug interaction lists are all instances of system design errors that might endanger patient safety. One of the most difficult components of implementing e-prescribing applications is handling these day faults and onerous program characteristics that may irritate users. Sometimes software makers' technical employees remain inaccessible, and on many other occasions, they are slow or reactive in fixing difficulties.

3.1. Research Sequence

Here, we will explain the steps which we follow to do the literature review for our thesis.

3.2.1. Research Questions

The following are the research questions for our thesis.

- How E-prescriptions could cause a risk to patient if not done accurately?
- What are the ways to reduce the risk related to E-prescriptions?
- What is the worth of the traditional methodology used for implementing E-Prescriptions?

3.2.2. Inclusion/Exclusion Criteria

Inclusion and exclusion criteria of our reviewed papers are as follows:

- Subject Relevant papers are selected.
- Papers published after 2010 are selected and literature published before 2010 is not considered.
- Papers from renowned digital libraries are selected such as IEEE, Science Direct , Springer, ACM.

3.2.3. Keywords

Following are the keywords for our literature review:

- E-prescription
- Electronic Prescriptions
- Model-based systems
- Prescribing Electronicaly

3.2. Related Work

As stated by Sherman et al [31], various other papers highlighted in this research about risks associated to e-prescription includes World Health Organization (WHO) data, which suggest that conventional prescribing errors fall under five categories: mistaken patient, false drug, incorrect dosage, incorrect dose strength or frequency, incorrect dosage formulation, and incorrect amount. According to Hincapie et al. [32], e-prescriptions with contradicting information, errors in dosage, amount, and medication selection, and teaching errors are the most common kind of e-prescribing

errors. Nanji et al [33] propose preventing medication mistakes is a significant priority for healthcare practitioners worldwide. According to Ghasemi et al [34], Approximately 20% of every mistake are related to drugs, making medical errors the third leading cause of death in the US. The proportion of e-prescribing mistakes and thus the variables that contribute to them as discussed by Pouyan et al [30] are the computer (technical) variables that account for 12% of e-prescribing mistakes these are the absence of external interactions, computer elements produce e-prescribing software mistakes; faults are probably triggered by program glitches and can also relate to the model. The key technical issues include prolonged system operation during workdays, system downtime, recurring technology indications or notifications, as well as software difficulties, technological obstacles, as well as communication overhead which might hold back or cause the process to fail. Another variable is Human factors account for 40%, these aspects are defined as incorrect or improper human involvement in e-prescribing-related operations. The most often mentioned cause of e-prescribing problems is unintentionally entering incorrect information. Moreover, interaction factors account for 31%, these elements points at which both human beings as well as technological variables contribute which can cause mistakes. When irresponsible or incorrect practices of users are mixed with distracting characteristics of e-prescribing software, these circumstances can contribute to e-prescribing mistakes. Another factor could be organization factors account for 17% as organizational circumstances, attributes, characteristics can also contribute to the e-prescription system's failure.

According to Pizzi [35], the expenses for design and operation, including the time necessary to incorporate new technologies into the workflow, are the most major challenges with employing e-prescribing. Money spent on teaching employees to tackle technical issues related to using e-prescribing services is regarded as the underlying cost of e-prescribing. As Hor CP et al [36] stated the main challenges to electronic prescribing implementation are the high installation costs, failure to give financial advantages, as well as the absence of unified software because multiple e-prescribing software providers provide a range of EMR systems with this functionality, effectiveness may be threatened due to variances in software protocols and database systems. The demographic information of patients has been recorded therein computer networks of eleven hospitals. Prescribers and 1 to 19 pharmacies may not always be in sync as result, prescribers are filling drugs for the wrong person. According to Nanji et al [37] the most common source of

inaccuracy was omitted information, the total of sixty percent out of 100 is because of omitted information.

Odukoya et al [38] propose in their study that pharmacy technicians play a significant part in the e-prescription process as well as drug dispensing community pharmacies. According to Donyai et al [39] when it comes to pharmacist interventions, the most prevalent category of prescription mistakes is connected to the requirement for pharmacological therapy and dose selection. Many particular features of pharmacy technicians have been linked to greater assistance for pharmacists in carrying out their patient care obligations and more effective assessment and remediation of prescription mistakes. The exact significance of these relationships with crucial outcomes, like profitability and clinical outcomes, is unclear at this time. A future study might be conducted to discover these relationships; measures may be properly informed to prioritize possible opportunities for improvements to enhance the e-prescription mechanism and the sturdiness of pharmacist training to improve drug safety.Table III shows a comparative summary of the approaches discussed above.

Table II: Comparisons of techniques used in different papers

Title	**Author(s)**	**Database**	**Publishing Date**	**Approach/Methodology**	**Advantages**	**Lacking**	**Case Study**	**Comments**
Implementation of Electronic Health Record Integration and Clinical Decision Support to Improve Emergency Department Prescription Drug Monitoring Program Use	Jason A. Hoppe, Caroline Ledbetter, Heather Tolle, Kennon Heard	ScienceDirect	2024	Three interventions—PDMP integration, risk scores, and CDS alerts—were tried in phases across five emergency departments.	-highlighted obstacles to the implementation of PDMPs, such as clinical bias, subjective data interpretation, and workflow disturbances. -evaluated cutting-edge methods that somewhat increased PDMP review, such as interruptive CDS alerts and PDMP risk scores.	L-ow rates of PDMP reviews overall, notwithstanding interventions. -Because the study was restricted to a particular state and healthcare system, its generalizability was constrained. -The interventions may not have a direct correlation with the decline in opioid	-	Although the PDMP is an effective tool for avoiding opioid abuse, it is still difficult to ensure consistent use and integrate it smoothly into clinical processes

					-showed that in individuals with a high number of previous opioid prescriptions, PDMP reviews decreased the likelihood of prescribing opioids. -provided insightful information about how PDMPs are incorporated into EHR systems and how they impact clinical judgment.	prescriptions over time. -Underreporting may have occurred because the EHR integration did not fully capture delegated access to PDMP data.		. While highlighting some minor advancements, this study also demonstrates that additional effort is required to fully fulfill the promise of the PDMP.
Implementation of an Electronic Prescription System for Ambulatory Care [1] 'C'	Nyssen, M., Piedra, Y.	Springer	2019	Case study	- Optimization of time spent on prescription of drugs and reduction of the possibility of error. - minimising the rate of medication errors and adverse drug reactions - Improved patient safety - The support of health care workers as they interact with the patients - Increased prescription legibility - Better prescription tracking system and information reporting	- Unfortunately little or no comparison has been made on the aspect of the effects of cost. -There is disappointingly little that can be said about the individual experiences of users. - There is no comparison that can be made with the traditional system of paper-based prescription being used in the hospitals.	An evaluation of the program of an electronic prescription system in a Belgian hospital	This paper aims at using a real-life case in an ambulatory care setting to analyse the implementation of an electronic prescription system. This study established that the system offered organisation and enhancement of efficiency,

								accuracy and safety of the patients besides enhancing coordination amongst care givers. Nevertheless, the study did not contrapose electronic prescription system with traditional paper-based procedure, thus, there is no mentioning of cost effectiveness. Altogether, the paper gives considerable source of data regarding utilisation of electronic prescription in ambulatory care.

Evaluation of the effectiveness of electronic prescription in reducing medical and medical errors (systematic review study) [2] 'C'	F. Osmani, M. Arab-Zozani, Z. Shahali, F. Lotfi	Science Direct	2022	Systematic review	- This brief review of literature presents the extent of previous studies that have examined the ability of electronic prescription system to enhance the reduction of medication and medical errors. - Find out the potential drivers that determine the viability of e-prescribing systems	- No original data but it shows a schematic of getting a new concept into practice as a map to guide researchers in their endeavours. - Only including articles in French and English - There is not a single analysis of the outcomes comparing the costs and the effects.	N/A	The current paper provides the author's comprehensive synthesis of the findings regarding the e-prescribing systems and medication and medical mistakes. However, the related research should advance extended to assess the value proposition and possibilities to spread these systems all over the world more efficiently, and to respond to the methodological shortcomings of the-existing literature

								including language bias.
Regulated Digital Pharmacy Based on Electronic Health Record to Improve Prescription Services [3] 'C'	Zhong, J., Mao, Z., Li, H., Masuda, Y., Toma, T.	Springer	2021	Case study	Eases the process of prescribing and reduces incorrect prescriptions. - It also helps improving the patient safety since it minimizes the incidences of medication errors. - Real time monitoring and management of prescription services	- Based only on one company - It can be noted that there is no adequate evidence regarding the subject of cost estimates of the project by the evaluation.	A case study of the implementation of a regulated digital pharmacy based on electronic health records in a hospital in China	The present study is an effort to describe the benefits of the regulated digital pharmacy available through EHR in a hospital in China. But, the conclusion may not take place in the different settings or environment of healthcare and more research is also required to establish the value and cost of the study along with value added to the patient outcomes.

Supporting drug prescription via predictive and personalized query system [4] 'C'	Samamon Khemmarat and Lixin Gao	ACM	2015	Semi pull and proactive information retrieval-based query system	- Improves the effectiveness and safety of prescriptions by delivering individualized drug suggestions of the patient. - Minimizes the dangers that arise from interactions that may be between drugs prescribed by the same physician in this case the patient. - Actually helps in monitoring and controlling of prescription services in a real-time manner.	- The present approach is restricted to a proof-of-concept system. - Everyone did not perform any cost effectiveness and assessing user satisfaction.	N/A	It is through this paper that the development of a predictive and personalized query system that would aid in prescription of drugs for patients is presented with consideration of their history and choice. The approach uses data mining to recommend specific drugs that should be prescribed for a given patient so as to enhance patient safety. The paper does not explain the selection process

								of the dataset used in experimentation and only gives a little proof to the proposed method. However, by implementing the proposed system, one can expect that both patients' statuses and costs related to the treatment can vary for the better.
E-prescription using blockchain technology [5] 'C'	S. -V. Ionescu	IEEE Xplore	2022	Blockchain technology	- Improves the protection of prescriptions and their respective information. - Real time tracking and monitoring of the prescription data – prevention of fraud and wrong prescriptionlas -Able to track and monitor the prescription data in real-time – A way to cut the incidents of	- There is no assessment of the usability or the satisfaction level recorded by the users. - Contained only at the level of the theoretical research - There is a common absence of discussion as to cost considerations in making decisions.	N/A	This paper aims at proposing a new solution in implementing e-prescription solution based on the blockchain. However, further studies must be conducte

					fraud and wrong prescription.			d to assess its feasibility, satisfaction of the users, and economical benefits in practical health care context. Furthermore, it is necessary to take into account such factors as implementation challenges and possible regulatory obstacles.
Risk Assessment of Pharmacies & Electronic Prescriptions [6] 'C'	M. Bowman and S. Acharya	IEEE Xplore	2019	Risk assessment	- Explores possible security-related problems in relation to e-prescription and pharmacies - Raises issues for the risks assessment and management regarding e-prescription and pharmacy service Provides a framework	- The lack of samples to complete the proposed framework - This study did not focus on the cost aspect or the effectiveness of the program, the cost-effectiveness. - In this topic, there is no case study or implementation in the real business environment.	N/A	From the discussion of the paper, one gets a framework of how to assess risks and therefore, manage risks in e-prescription and pharmacy services. However, in order to provide

								solid evidence of this tool's efficiency and applicability, more studies need to be conducted in real-life contexts. However, this is another disadvantage since it will show means of implementing such a framework and whether it is cost effective to implement such a framework, and whether it complies with the laws of the State.
Harmonizing sensitive data exchange and double-spending prevention through blockchain	Vincent Schlatt, Johannes Sedlmeir, Janina Traue, and Fabiane Völter	Distributed Ledger Technology	Just Accepted (December 2022)	Blockchain and digital wallets	- Provides an integrated and reliable solution for Issuing e-prescription via blockchain and digital wallets - We meet with the double-	- There is no practical application and assessment of the developed system in the presented work. - It should be noted that there	N/A	So this paper aims at implementing secure e-prescriptions managem

and digital wallets: The case of e-prescription management [7] 'J'					spending problem and guarantee the secrecy of the exchanged data. - Can enhance the possibility of accurate and fast prescription dispense and keep track.	are no discourses made regarding cost efficiency or the possibility of contentious regulation.		ent system with the help of blockchain and digital wallets. However, based on the proposed system, there seems to be several benefits that would be necessary to undertake a study that would allow effective comparison and identify critical indicators of the system's feasibility. However, the benefits of such a structure in terms of its cost, efficacy and the fact that its implementation

								may be arguably already regulated, may also be taken into account.
Developing, applying and measuring an e-Prescription Information Systems Success Model from the perspectives of physicians and pharmacists [8] 'J'	Özel Sebetci, Mustafa Çetin	Science Direct	2016	Case study	Presents a framework that can be used to estimate the effectiveness of e-prescription systems by observing perspectives of physicians and pharmacists	As we can clearly observe, they are restricted to a single case study.	There is a case study which has been conducted in a public hospital in Turkey.	Offerson some success factors to e-prescription systems from the points of view of physicians and pharmacists. However, generalization of the findings could be a major drawback of this study since it focuses on one case only.
Analysis of e-prescription system and awareness of pharmacists on reimbursement program in ukraine [9] 'J'	N. Maksymovych, O. Zaliska, V. Huz, O. Brezden, A. Solovei, Z. Zabolotnya	Science Direct	2020	Survey-based study	These are the findings of the study in relation to awareness of the pharmacists of Ukraine with regards to reimbursement program concerning e-prescriptions.	Lack of generalization, research is limited to pharmacists of one country	Ukraine	The result gives useful insight on the level of awareness and understanding of the reimbursement

								program by the sample population of pharmacists in Ukraine. However, the applications of the study results are restricted to the specific area of the study or the country under study.
Implementing digital signature for the secure electronic prescription using QR-code based on Android smartphone [10] 'C'	M. A. Sadikin and S. U. Sunaringtyas	IEEE Xplore	2016	Experimental research	It enable efficient and secure e-prescription using digital signature integrated with QR code on Android smart phone	Few concerning problems and weakness about the proposed system	N/A	From this perspective, the paper offers a workable and inexpensive means of developing secure e-prescribing in a developing country context. Nevertheless, some issues arise that may affected the consistencies of

								the system and to obviate these hurdles, more study is required.
Configuration Systems Applied to the Healthcare Sector for an Enhanced Prescription Process [11] 'J'	I. Campo Gay, L. Hvam	Springer	2022	The paper describes the impact of the a configuration system adopted for the purpose of enhancing prescription in a hospital. The authors explain the steps taken to build and to interface the system with the current EMR program. An appraisal of the system was done through surveying the stakeholders, namely doctors, nurses, IT staff among others.	The paper shows the versatility of configuration systems for enhancing sector outcomes especially in prescription management. The authors also mention that the implementation of the system help to decrease the number of errors and improved the efficiency of the process as well as enhancing the safety of the patients.	Altogether, the case study contributed some measure of understanding of how the system works and could be improved; however, the authors' observations would have been more convincing if supported by more facts and figures. However, the paper does not discuss possible barriers or risks of leveraging configuration systems more so in the healthcare organisations.	The case study was done in relation to the installation of a configuration system in a hospital in Denmark. It enabled doctors presetting the configuration of prescription templates and select the drugs and dosages that are appropriate for the patients. It was interfaced in with the hospital's Electronic Medical Record system and the doctors could access the prescription templates right from	In general, the paper can be of great benefit to the scholars as it explains real-life implementation of configuration systems in the healthcare sector. In their work, the authors give some valuable considerations regarding the design and the deployment of the system, as well as the advantages that may be produced by the system.

							the patient record. The evaluation of the system was done through surveys of other stakeholders and analysis of prescription data before and after the implementation	Nonetheless, the paper could have benefited from offering more factual evidence in substantiation of the authors' arguments and identifying some challenges that could be associated with the wide-scale deployment of such systems.
An Architecture for Electronic Prescribing in Physiotherapy in Belgium [12] 'C'	R. Buyl, S. Van Laere, M. Nyssen	Springer	2016	Architecture design and implementation	Improves the ability to prescribe medication electronically in physiotherapy, contributes to making decision, and helps to share information between healthcare workers	Without the specified elements, it is impossible to evaluate the effectiveness of the system, assess the level of users' satisfaction.	A case study is prepared based on the experience and observation of the first author who is a surgeon working in a public hospital in Turkey.	This paper gives an overview of the architecture of electronic prescribing in physiotherapy as well as the strategy for its implementation but fails to assess the

								efficiency of the system as well as the level of satisfaction of users.
Sending and Retrieving e-Prescriptions across Europe: Lessons Learned [13] 'C'	Trupec, T.P., Ljubi, I., Belani, H.	Springer	2015	Therefore, this research review the current literature and offer a case study to assess the trends of e-prescription and the factors that inhibit its implementation in the European countries. In this paper the authors researched the case of Croatia to get insights into the process of implementing e-prescription, technical support, legal and ethical factors and advantages and disadvantages of e-prescription.	The study makes contribution to the understanding of the Italian and other European hospitals' experience in e-prescriptions and the issues they face to adopt them fully. In tracing through the case study of e-prescriptions the various advantages are identified including but not limited to patient safety, effectiveness and accuracy of prescription	The study does not contain explanation of the technical, legal, as well as the ethical issues arising from implementation of the e-prescriptions in Europe. It also fails to evaluate the process of implementation, and their resultant effects in the various countries of Europe.	Mobile and Electronic Prescribing for the purpose of this paper has been investigated on a case of Croatia. They conducted interviews with the stakeholders, described the documents which were available, assessed the technical facilities, as well as legal and ethical concerns. In the case study, e-prescriptions were described as having advantages that included; Patient safety, medication errors, and efficiency.	The study is important in understanding some of the issues that can be expected and the advantages of e-prescription in Europe. Though, it would be interesting to examine the two processes and their respective results in different countries of Europe. To this end, the study also cautions that more common technical platform

								must be developed for e-prescription implementation alongside legal and ethical regulation of this fairly new technology across European countries.
Prevention of inappropriate prescribing in hospitalized older patients using a computerized prescription support system (INTERcheck®) [14] 'C'	Ghibelli, S., Marengoni, A., Djade, C. D., Pasina, L., Perticone, F., & Nobili, A.	Springer	2013	This paper set out to evaluate the impact of a Computerised Prescription Monitoring System, INTERcheck® in decreasing the use of contraindicated medicine with elderly patients who had been admitted to hospitals for other complaints. The system was to perform prescription review for drug-drug interaction, drug-disease interaction, wrong dose and duplicate prescriptions.	Kelm and colleagues concluded that the INTERcheck® system minimized the incidence of untimely prescriptions and conversely the possibility of the adverse drug event in older hospitalized patients. The system was also described as being easy to operationalise, and thus can be incorporated into practice.	a major drawback was the samples which was relatively small thus reducing the validity to the larger population. Furthermore, the study had no way of measuring the effect of the system on the patients for example the length of hospital stay and re-admissions.	The aim of this study was carried out on medicines administration in a large teaching hospital in Italy with a total of 2,038 medication orders in 501 patients.	This paper brings valuable information that will help in the reinforcement of the implementation of computerized prescription support system in avoiding the giving of wrong prescriptions to the older patients who are hospitalized. The study confirms that

				The study was conducted in two phases: the first evaluation actually looked at medication orders that were placed before and after the INTERcheck ® system was put into place, the second evaluation looked at the quality of prescribing once the system was put into play.				INTERcheck® system may be useful in increasing medication safety and decreasing the incidence of ADEs in this population. Nevertheless, more investigations are necessary to evaluate the consequences of the system on the results of the patients and to reveal its efficiency in various clinical environments.
Using EMR-enabled computerized decision support systems to reduce prescribing of potentially	Scott, I.A., Pillans, P.I., Barras, M., Morris, C.	Springer	2018	The authors' approach to synthesising the literature was a narrative review to identify whether EMR enabled	This paper gives a systematic synthesis of existing studies concerning the effective utilization of EMR-enabled CDSS to minimize PIMs.	The paper also lacks a actual case study or quantitative evidence or the impact of CDSS on PIMs reduction. In the same regard, the authors did not	N/A	As such, this paper is a valuable starting point in understanding the positive applicatio

inappropriate medications: a narrative review [15] 'C'				computerised decision support systems (CDSS) would decrease PIM prescribing.	The authors further elaborate on the need for making use of CDSS in the reduction of PIMs noting that it will enhance the safety of medication administration, reduce health costs and improve patient outcome.	address the possible constraints and barriers of integrating CDSS in practice.		ns that can be derived from the use of EMR-enabled CDSS as to the issue of PIMs. Nevertheless, there are some limitations such as the absence of some specific examples or, in other words, the case reports or evidence-based researches, which investigate how CDSS work in the real world. Thus, further studies should direct to measuring the impact of CDSS for PIMs reduction and/ or revealing possible difficultie

								s appeared at implementation level.
The Use of ATC Codes as Index for Decision Support in Computerised Physician Order Entry Systems[16] 'J'	Helle Ovesen	Science Direct	2017	The paper also presents the application of ATC codes as a reference tool in decision making within the context of computerised physician order entry (CPOE) systems. In this paper, the author performs a brief overview of the literature concerning the application of ATC codes in CPOE systems and examines the strengths and weaknesses of the approach.	It has also noted that with the use of ATC code index in decision support in CPOE systems medical errors in prescription are reduced hence increasing patient safety. It can also enhance the process of prescription since it will offer the clinician with important information concerning the medication, including the dosage pattern and the possibility of the drug to interact with other medications.	she presented a new method for employing ATC codes to provide the index for decision support in the CPOE systems; however, she failed to offer a detailed-case study and/or empirical evidence in the paper.	N/A	The paper is quite informative on the ways through which the ATC codes can be used in CPOE systems and how it can be beneficial and disadvantageous. However, one finds some weakness in the argument presented by the authors because no elaborate case study or empirical evidence have been explored regarding the use of ATC codes in CPOE systems. More

								investigation has to be conducted in order to establish the efficiency of employing ATC codes as an index for decision support in CPOE systems.
Drug-drug interactions that should be non-interruptive in order to reduce alert fatigue in electronic health records.[17] 'J'	Phansalkar, S., Edworthy, J., Hellier, E., Seger, D.L., Schedlbauer, A., Avery, A.J., & Bates, D.W.	ACM	2013	The authors reviewed the DDI alerts that are produced by EHR systems and the method of classifying them followed a consensus approach which involved the use of a DDI panel of experts. They pointed out a list of criteria for DDIs to include the following criteria which they noted are non interruptive in that they do not warrant an immediate clinician	The study offers a specific procedure of recognizing DDIs that would not contribute to alert fatigue and interfere with the caregivers practice. Through the authors' approach, more focus can be placed on DDIs with the EHR developers as well as healthcare organisations and potentially design a better alert system. Persistent alerting leads to overwhelming of clinicians hence overlooking significant safety signals; clinicians can	this did not explore whether non-interruptive DDIs influenced some clinical end-points including, but not limited to, AE or hospital re-admission. Thus the study recommends that more studies need to be carried out to measure the impact of non-interruptive DDIs in enhancing patient outcomes.	N/A	this gives a contribution in the literature regarding alert fatigue and how to develop the effective CDSSs. This approach knowledge can assist the authors and others in healthcare to enhance their alert systems and hence patients safety. However,

				intervention. These criteria include the intensity of interaction between the organisms involved, the potential for harm in the process and the existence of alternatives in the form of the treatment.	therefore be alerted with few relevant signals that will enhance patient safety.			the following sources of bias are worth mentioning again: no data were obtained from the patients, and, most importantly, there was no case study in the research. These are the limitations of the current study which could be improved in the next studies focusing on non-interruptive DDIs.
How do community pharmacies recover from e-prescription errors? [18] 'J'	Olufunmilola K. Odukoya, Jamie A. Stone, Michelle A. Chui	Science Direct	2014	it was conducted in a qualitative research design to understand the process through which the community pharmacies manage to get back on track in the face of e-	The study offers important information about how e-prescription errors can be recovered in community pharmacies. The research method used here involved the collection of qualitative data which was	The study was conducted on pharmacies in only four states in the United States and therefore the findings cannot be generalised to other pharmacy settings. Furthermore, the study failed to assess the part played by	This is one reason why the study had no defined case study for the comparison; instead, the study researched on different Community Pharmacies	The current study contributes valuable information to the identification of factors on how community pharmacy

				prescription errors. Pharmacists and pharmacy technicians from four states in the United States of America were interviewed using semi structured questionnaires. First, to carry out the thematic analysis of the data.	suitable for the given study to establish the experiences and attitudes of the pharmacists and pharmacy technicians	technology in eradicating the e-prescription mistakes	limited to the views and experiences of the staff, patrons and the management bodies.	practice deals with e-prescription errors errors recovery. Also the study suggests that the pharmacy staff needs to involve communication with their other care colleagues effectively. It also points out where it is possible to draw more conducive lines in the location of their recovery, For instance the use of technology should be improved for accuracy and Pharmacy staff should also be

								trained more. Therefore, this research offers valuable information for the evaluation of patient safety and quality of service delivery in community pharmacies for potential pharmacy managers and policymakers.
Rapid Development of m-Health application with the Sprint Design approach and Scrum process: Application Development for e-Prescribing [19] 'J'	Rapid Development of m-Health application with the Sprint Design approach and Scrum process: Application Development for e-Prescribing	IEEE	2018	Hence this paper samples the application of the Sprint Design approach and Scrum process in the development of an m-Health application for e-Prescribing. For development of the application the authors have considered the user	The paper also discusses benefits of Sprint Design approach and Scrum process to create m-Health applications in a short time. UCD is very helpful and effective in this case since the application is developed in accordance with the end-users. It also means that using the Scrum process, the application is built iteratively, which means that the defects	Braithwaite writes in the paper and yet he does not give an evaluation of the application after developing it. I think it would have been preferable to find the reactions of the target clients after using the created application	Analyzing the paper, one can find that the paper offers a case study of the development of an m-Health application for e-Prescribing. The application target user groups were the doctors and the patients. The application	The work is well-organized and simple to follow as it presents the paper's purpose and outline of the Sprint Design approach and the Scrum process to create an m-Health app for e-

				centered design (UCD) and Scrum methodology. The application was developed in six sprints where each of the sprints would be completed within two weeks.	and weaknesses of the result would be eliminated in the process based on feedback from the end-users.		enables doctors to write and send messages in form of an electronic prescription to the patients and the patients use the application to receive and read the prescriptions.	Prescribing in the healthcare sector. This way, it becomes possible to implement the UCD and Scrum methodology to design and develop the application based on the end-users' needs. Nevertheless it would have been preferable should the author provide a more thorough and extensive assessment of the application after it has been developed. In conclusion the paper offers beneficial

								information regarding the adoption of Agile approach for the development of m-Health applications.
Implementation the Mutual Authentication with Key Agreement Scheme for Securing Web-Based E-prescribing System [20] 'J'	D. Jayanti and H. Setiawan	IEEE	2019	In the paper, the author aims at presenting a mutual authentication with a key agreement mechanism in an e-prescribing system Web based. The scheme that has been put forward in this paper employs the ECC algorithm in combination with a hash function for the lowest chances for the message's integrity to be compromised while in transmission.	It offers both identities' verification at both ends and confidentiality of the communication between the user and the server through the use of a shared secret key. The compensation of losses with the ECC algorithm keeps the scheme computational low and is very useful in environments that are resource-limited.	Actually, the paper provides with no analysis of the security properties of the new scheme, its potential vulnerabilities and its ability to withstand the known attacks as well as with no comparison of the performance of the new scheme to other similar ones.	N/A	The paper describes a mutual authentication system for the protection of the web-based e-prescribing system which is easy to implement and more effective. Since the ECC algorithm is employed in the scheme, the implementation of the work can be done in low-powered platforms like the

								mobile device. However, there is no detailed security analysis on the proposed scheme s and comparis on with other security schemes in order to assess the practical efficienc y of the proposed scheme .
Implementat ion of medical error prevention system for hypertension disease based on fuzzy [21] 'J'	R. Soelistijorin i, M. Yuliana, I. Prasetyanin grum and L. Pratiwi	IEEE	2016	With regard to the nature of errors and duration of treatment of hypertension, the authors recommend the use of a fuzzy logic-based medical error intervention system. Different patients' characteristic s like age, blood pressure, medical history, and many others can also be included in the system to	The used system of fuzzy logic can minimize an medical mistakes incidence in treatment hypertension depending on characteristic features of a patient and individual recommendation s.	There are no descriptions of experimental outcomes or assessment of the proposed system on this paper and there are no indications of any in the paper either.	N/A	The paper offers an interestin g approach towards the managem ent of hypertens ion the use of fuzzy logic in preventin g medical errors. Despite this, there is a concern with fairly scanty experime

				suggest suitable treatment for the patient.				ntal results and case studies of the proposed system. To examined the empirical support of the proposed system and to evaluate the effective ness of the proposed system in enhancin g the quality of hypertens ion treatment , further investigat ions are required.
Patient-centric e-Prescription Services - An Integrated System Architecture Proposal [22] 'C'	J. Pereira, M. Beir, J. Teixeira, and R. J. Machado	IEEE	2018	In this work, the authors have postulated an integrated e-prescription services delivery architecture for patients. This system is work on the concept of patient safety, this is because it has shown that the	It has been noted that the proposed system can enhance patients' safety, decrease the number of medication-related errors, and enhance performance at the stage of prescribing and dispensing medications. The application of the blockchain	It is also important to note that the paper gave a proposal for a system architecture but there was no substantial assessment or affirmation of the system architecture. I believe that it would have been ideal to design it in the paper or describe a pilot or first attempt at	N/A	The prospect of the described system architectu re helps to enhance the safety of patients in prescribe d medicatio ns and faster

				prescription errors will be reduced once this method of prescribing and dispensing drugs is adopted. The constructed architecture comprises of the sub-modules for patients identification, medication, prescription approval, dispensing, and monitoring. The authors also point on the possible advantages of applying the blockchain concept in increasing the security and confidentiality of the e-prescriptions	concept is efficient in promoting the security as well as the privacy of e-prescriptions.	implementing this system.		dispensing of such prescription. However, it is found that a further assessment or legitimation of the proposed system will be advantageous. Further, an implementation of the system in terms of a case study or a pilot implementation would show more feasibility in use cases.
Weak eyesight therapy: A case study in designing an application for m-health systems [23] 'C'	A. Saini and P. Yammiyavar	IEEE	2013	The paper aims at focusing on a particular m-health application which deals with the weak eyesight therapy case through the methods of user-centered design. It is designed as	This paper offers information on the design process of m-health applications for weak eyesight therapy which should prove helpful to designers and developers. The major strengths include the user centered design	It remains apparent that the paper does not present a cogent assessment of the utility of the application in enhancing vision in consumers diagnosed with the condition. The participants used in the study were few in number and the	This paper gives a case of an m-health application that has been developed to encourage the therapy of a weak eyesight. The study was	The pieces of work in this paper are useful in offering insights towards formulation of m-health applications for the therapy

				an application that contains visual exercises, games and messages or reminders of eye care.	and the treatment through visual exercises and games.	other existing therapies or applications were not compared.	conducted on ten people and all of them had poor eyesight and used the application for four weeks. The interviews and questionnaires used were self-administered with the aim of capturing the respondents' feedback.	for weak eyesight. This study however has a major limitation in not providing a detailed assessment on the viability of the developed application. Further studies that should be conducted in the future should involve a comprehensive analysis of the usefulness of the application and compare it with other therapeutic methods or applications. Some of the things that will be remarkable and could be

								used in developing similar applications for other illnesses include: The paper adopted a user-centered design and the therapy games and exercises used in the paper are examples of visually stimulating games or exercise that can be used in therapy.
Towards Intelligent and Interoperable Medical Prescriptions [24] 'C'	A. Khalili and B. Sedaghati	IEEE	2013	To develop smart and interoperable medical prescriptions the authors have recommended a semantic approach utilizing the technique of semantic web. They employed the RDF and OWL to model the	According to the observations made in this paper, the semantic approach would lead to advanced and reusabale medical prescriptions. This way, the use of medication ontology eliminates the need of the prescriber searching for	Unfortunately, the paper lacks a comprehensive assessment of the feedbacks collected regarding the proposed prototype system. It also fails to explain any weakness or disadvantage that comes with the proposed approach or any foreseeable difficulty that	To illustrate the usefulness of their prototype system, the authors construct an example of how the system would be used to create a medication order for an	This paper therefore provides a novel approach towards the designing of smart and exchangeable medical prescriptions.

				knowledge which is medical and develop a medication ontology. The authors also developed an actual prototype system known as PrescribeMe that warrants the feasibility of the approach being taken.	potential drug interactions or other related information on the Internet. This approach may also help prevent mistakes in the ordering medication and enhance patients' safety.	may arise.	imaginary patient.	There is a belief that employing Semantic Web technologies, particularly a medication ontology makes it possible to enhance patient safety and decrease medication-related mistakes. However the study lacks a detailed evaluation and discussion on the limitations of the study hence this is another major weakness. All in all, the given paper may be considere

								d as a good starting point for further investigation of the topic.
Indigo Identityware secures e-prescriptions with finger biometrics [25] 'J'	Biometric Technology Today	Science Direct	2013	From the presented article the reader can learn that Indigo Identityware, a company specialising in biometric authentication, has introduced the application of finger biometrics in creating a safe e-prescription environment. The system identifies the prescriber through fingerprinting and the registered fingerprint of the prescriber is kept in the system database. The prescriber then places her signature on it through use of a smart card and then the prescription	This is because, apart from the biometrics of finger marks, e-prescription system has incorporated measures of minimizing fraud amongst its users. The system is also intuitive and it can be integrated to the current prescription software.	The authors do not elaborate about the staff management system's technical characteristics or describe its performance in practice.	N/A	This article gives a general insight of how Indigo has applied finger biometrics in the protection of e-prescriptions. However, there are no exhaustive and profound technical data and practical examples and situations are illustrated in a rather simplified way. However, that is a general fact that biometric authentication

				is encrypted and sent to the pharmacy.				systems are not 100% accurate and they sometimes get either false positives or false negatives. Obviously, more systematic studies and experiments would have to be carried out to evaluate the practical efficiency of this system.
Topic Maps as knowledge base to automatically generate medical recommendations[26] 'C'	D. Dragu, V. Gomoi, V. Stoicu-Tivadar	IEEE	2011	In this paper, an approach based on the knowledge representation using topic maps for automatic generation of medical recommendations is discussed. The authors employed a topic map to identify medical concepts and their connections and resorted	This is a promising solution to 'filter out' approximate and contradictory medical recommendations as the basic knowledge is encoded in the knowledge base of medical concepts and their relationships. Such organization of the information is free from many restrictions and	There is still no comprehensive assessment of the proposed approach; in addition, the authors do not compare the results and effectiveness of their proposed method with other similar methods for providing medical advice. However, there is lack of information regarding the applicability of the proposed	N/A	In my opinion, the paper covers an interesting idea regarding to the creation of recommendations in field of medicine by means of topic maps. However, due to the absence of the detailed

				to rule-based reasoning for the formulation of prompt recommendations of patients' treatment options based on their medical history.	Topic Maps can be used for the representation of Medical knowledge while the rule-based reasoning can provide individualized recommendations for Patients.	approach in large scale and realistic conditions.		comparative analysis of the introduced approach to the other methods, it is impossible to estimate the efficiency of the proposed approach. However, the practicality of the approach regarding curb shoppers in actual environmental conditions and possible generalization of the approach to other forms and settings of retailing must be examined.
Design a novel electronic medical record	Lijun Pan, Xiaoting Fu, Fangfang Cai, Yu	IEEE	2016	The authors presented a new EMR system aimed at the	The design of the system and product is intentionality made to be easy-	It is integrated with user interface, most cost effective and compatible	N/A	In conclusion, it can be said that this

system for regional clinics and health centers in China.[43] 'C'	Meng, and Changjiang Zhang.			regional clinics and heath centre of China by integrating the web technology and mobile devices. They made a questionnaire to know the specification of the system to be developed; the team followed the Waterfall model to implement & test the system.	use, efficient, and integration with existing hetero-health-care system in China. It can be of immense benefit in an expansion of the efficiency of delivery of health care, reduction of errors, and increase in safety of patient.	with CHI system of China. It can assist in making the work process more effective in the delivery of health care services with less chances of making mistakes that would compromise the safety of the patient.		paper provides a relevant and valuable contribution to the literature on healthcare information technology, especially the China's health care system. It is apparent, coherent and well-described as to how the strategy and the processes of designing and developing EMR system were initiated, planned and executed. However, this paper could have been enriched with more details on

								what the specific aspects of this system are, what it can do as well as other aspects such as gaps or issues encountered while developing the system. In essence, this paper would be useful in the development of future research in this area of study.
A Framework of Hybrid Recommender System for Personalized Clinical Prescription [44] 'C'	Q. Zhang, G. Zhang, J. Lu, and D. Wu	IEEE	2015	A novel System of hybrid recommendation for clinical prescription has been developed in the context of this paper using the patient EHRs and medical knowledge. The proposed system incorporates an efficient blend of the	The proposed framework possesses several advantages including prescription recommendation for each patient, combining EHRs and medical knowledge, real time recommendation and scalability	The weakness that is noticeable in the paper is the absence of assessment of the proposed framework in real clinical practice. The evaluation is done with a small dataset only and it could be very beneficial if there are more data sources integrated in the proposed framework	In the paper, the authors utilized, as the case study, a dataset of 291 patient records in order to test the applicability of the proposed framework. The evaluations made in the experiments prove that	In particular, the paper introduces a new hybrid recommender model for the clinical prescription recommendation. The proposed system is well

				collaborative filtering, content filtering, and knowledge integration methods to develop prescription recommendation for the clinicians. The system employs a multiple recommendation approach which includes the above methods to improve on the result set.			the introduced framework is more effective than the classic CF model	developed and this system has several merits. Nevertheless, as a part of the paper's limitation, it is also important to mention that the authors do not provide an extensive assessment of the proposed framework in a real clinical environment. However, If proposition is concerned, the proposed framework is useful for clinicians to prescribe personalized recommendations
Smart electronic medical record based	H. Mhamdi, S. B. Othman, A.	IEEE	2022	As a result, there is a paper on a smart	The formulation and implementation of the proposed	Unfortunately, the authors of the paper fail to offer a detailed	N/A	The paper presents one

on blockchain technology to combat Covid-19 pandemic [45] 'C'	Zouinkhi, and H. Sakli			electronic medical record (SEMR) system for Covid-19 using blockchain. The system apply the distributed ledger network to facilitate the patient's data storage and management in a secure and transparent way but preserving the data confidentiality. The proposed medical record database system SEMR also has a patient/health care practitioner's side application that allows them to view the medical record and update it on real-time basis.	SEMR system have several benefits, such as better data protection and confidentiality and better data dissemination and availability besides real-time data update. The utilization of blockchain technology makes it ring-fenced from alteration to make the medical data retrievable only by the right people. This means that using the mobile application, patients are easily able to access their medical records especially in an emergency.	explanation of the way how the proposed SEMR system can be put into practice in technical terms. There are no explanations of the challenges and limitations associated with the implementation of blockchain in the health care sector by the authors of the literature.		distinct idea on the application of blockchain in the sphere of healthcare with reference to the Covid-19 pandemic. However, there are few technicalities and empirical assessment provided that can give actual insight concerning the efficacy and scalability of the proposed SEMR system. In turn, the future studies might be directed towards the elaboration of the disadvantages of the proposed SEMR

								system and towards investigating its effectiveness in practical conditions.
Development of a Smart Medical Prescription Service Model [46] 'C'	B. Lala, S. Naher, M. A. Mahmood, M. M. Hoque	IEEE	2018	The authors integrated the smart service concept by adopting the AI and IoT technologies to come up with the smart medical prescription service model. This applies machine learning algorithms into patient's data and then comes up with prescription based on the patient's status, complaints among other conditions. Then the prescription is sent wirelessly to the patient's smartphone using an IoT gadget with alerts for proper consumption of drugs and	The smart medical prescription service innovative model can offer prescriptions more accurately and offer better advise, decrease medical errors and enhance patient compliance to the medical advice and appointment schedules. It also has an added advantage of leading to reduction of the rise of health care bill and also improving the health care results.	There is no mention of its testing and validation using real life data in the paper to affirm the positions taken.	N/A	It provides a unique solution toward enhancing the Medical Prescription services accurateness and effectiveness through the incorporation of AI & IoT. However, they are still lacking more information on the testing and validation of the model to determine the effectiveness of the same in the real environment.

				the date to attend the next appointment.				
The COLLABORADI project: A rule-based diagnostic imaging prescription system[47] 'C'	D. Calcaterra, G. Di Modica, O. Tomarchio and P. Romeo	IEEE	2016	COLLABORADI is an IT system that provides the physicians with rule-based diagnostic imaging prescription to help them in prescribing diagnostic imaging examinations. It applies a rule-based system by referring to the clinical practices and protocols to identify the particular imaging examination perfect for each patient depending on the patient's records and the physician's diagnosis.	Through the COLLABORADI project, physicians are provided with more information on diagnostic imaging examinations, enabling them to take informed decisions thus benefitting the patients, cost saving and increasing effectiveness of workflow. This system ensures its simplicity and gives physicians an opportunity to get acquainted with the information concerning the diagnostic imaging examinations, their indications, contraindications and risks.	Finally, the paper fails to give implementation details, and validation of the system and it lacks quantitative assessment of the system.	An actual case of a patient examined for abdominal pain is discussed in the paper, where the application of the COLLABORADI system is considered in order to identify the most optimal imaging examination for the patient. The given case also illustrates the effectiveness of the system in assisting physicians in providing better decision regarding the diagnostic imaging examinations.	This paper offers a working context of the COLLABORADI project, the general and the specific framework in which the study operates. Although it supplies an overall account of the development and the process involved in the creation of the system, there are certain aspects including the way it was put into practice and how it was able to undergo validation which

								are left out. Further, the paper failed to show any kind of quantitative assessment of the efficiency of the system. Hence, it would be beneficial to gather more data about the further utilization and testing of the system and its effectiveness in clinical setting.
The Framework of 3P-Based Secure eHealth-Information System [48] 'C'	D.-H. Kim and J. Kwak	IEEE	2018	The authors present the details of a system that should be used in supporting eHealth-information system with the help of the 3P (People, Process, and Product) model. This framework relies on the ISO 27001 and to ensure	The proposed framework is elaborate and encompasses technical, organizational and personnel security as a way of ensuring safe eHealth-information systems. It also provides a convenient and portable system in which the solution can be modified for various scopes of the healthcare	While having presented the proposed framework, the paper fails to provide a thorough analysis of the offered solution on expressibility, practicality, and extensibility. It also lacks an example of how the framework can be used in real life or at least one case study that can	N/A	The paper provides a clear and coherent picture of a secure eHealth-information system which is useful and covers essential security concerns in the

				the confidentiality, integrity and availability of the eHealth-information, the security measures include access control, authentication, encryption etc.	organizations and facilities.	show potential application of this framework.		healthcare sector. However, the paper has the problem of no evaluation and case study; therefore, it is not very helpful in contributing to the field. However, the proposed framework lessons can be used more as further avocation research and real-life applications investigation.
An e-Health tele-media application for patient management [49] 'C'	C. Mwesigwa	IEEE	2013	The paper includes the conception of an e-health tele-media application for patient management in an attempt to enhance the quality of the healthcare services in the developing	The proposed system has the prospect of positively impacting the quality of healthcare service delivery in the developed nations in the following manners;	The paper misses a comprehensive assessment of the proposed system's performance and its users' ability to interact with it. Furthermore the paper does not discuss the difficulties and constraints that may be	N/A	The paper is very informative and unique in addressing the issue of how to advance the provision of health care

				countries. The adopted system involves Mobile phones, the Internet, and Multimedia Messaging Service (MMS) to enable the patients to receive advice or receive reminders from their physicians.		encountered when using the proposed system and the adoption of the proposed system.		services in developing nations. Nonetheless, one of the main weaknesses of the paper is the absence of an elaborate assessment of the study alongside failure to identify possible limitations and challenges in the research. In general, the paper can be used as a foundation for future investigations and innovations about e-health tele-media applications for patient care.
PEM-A New Patient Centred Electronic Prescription	Luis Patrao, Raquel Deveza, Henrique Martins	Science Direct	2013	The paper aims at introducing and elaborating	The contemplated PEM platform raises patients awareness about	There is no assessment of the PEM platform and even no research	N/A	Conclusively, the paper forms a

Platform[50] 'C'				on a new electronic prescription system that has been developed and launched in Portugal known as PEM (Prescrição Eletrónica Médica) that is centered on the patient. The technology on which the platform was based has been the electronic system of Portuguese prescription and has been complemented with specific patient's preferences such us reminders and patients' prescription history access.	their roles in their treatment processes as it allows patients to read through their prescription history and reminds them of their medication. It also offers decision support tools for physicians and also improves the relative security and accuracy in writing the prescription.	evidence concerning its efficiency is presented in the paper.		valuable addition to the existing knowledge on the topic of electronic prescribing while emphasizing the need for patient centred care. Nevertheless, the failure to find concrete research to validate the utilization of the show PEM platform is one shortcoming of the research. Subsequent research is required to determine efficacy of this platform within the context

								of patients' outcomes and prescribing practices.

CHAPTER 4: CHALLENGES IN E-PRESCRIPTION AND PROPOSED SOLUTION

This chapter addresses the challenges in e-prescription and presents the proposed solution, organized into several sub-sections. **Section 4.1** discusses the challenges associated with e-prescription systems, highlighting key issues faced in implementation and usage. In **Section 4.2**, we outline the proposed methodology to address these challenges, which includes specific **sub-section 4.2.1** that defines the requirements necessary for an effective solution.

4.1. Challenges in E-prescription

The reviewed literature revealed the importance of an accurate e-prescription system as one out of every ten computer-generated prescriptions had at least one inaccuracy, with one-third posing a risk of damage. Electronic prescriptions have been shown to minimize medication mistakes, prevent errors, productivity, and resource management; yet, if not properly designed and performed, they may pose new difficulties and irritate physicians. Errors associated with computerized prescriptions typically create workflow delays. Despite their obvious benefits, computerized prescription systems face several challengesAccording to computerized prescription systems, there were differences in the quantity, kind, and seriousness of errors, indicating that certain services are even more effective at preventing errors than others. However, if an electronic prescription is not correctly done, it might introduce additional mistakes. To aid in the discovery of systemic solutions, the healthcare industry should establish a quality-improvement review method. Solutions might range from improving the architecture of an e-prescription system to focusing on the usability of the e-prescription systemBecause they can increase patient safety, usability as well as user-centered design (UCD) are crucial considerations in the creation of electronic medication and electronic medical records in general., boost physician adoption, and reduce physician dissatisfaction. The better design may include drop-down menus, less complex interfaces, user-friendly interfaces, etc. Insufficient usability frustrates clinicians, as well as it also raises the chance of mistakes, posing a significant danger that can harm the safety of patients The rise of MDSE is defined by the achievement of abstraction by reducing development complexity, increasing testability and analysis at the development time of software systems through modeling.

As discussed by Anwar et al [28] MDSE emphasizes the use of modeling to achieve abstraction and reduce the development complexities of software systems. As Rasheed et al [27] proposed modeling and performing either transforming from a model to a model or model to a text are the core artifacts and fundamental organizational resources for model-based software development's automated design, development, and other tasks. As discussed by Rasheed et al [27] the MDA process begins with the development of a formal model known as a meta-model utilizing the Ecore Modeling Framework, a general-purpose modeling language such as UML or a Domain Specific Language (DSL). This power abstraction method has benefited a variety of fields, Information management, software firms, systems engineering, and integrated devices are just a few examples. As in the literature review, no such studies have been found which suggest a meta-model for e-prescription systems. So to implement these e-prescription systems, there is a need for a broad-based Model-driven Architecture approach

Preventing medication mistakes is a significant priority for health-care practitioners worldwide. Electronic prescriptions have been shown to minimize medication mistakes, prevent errors, productivity, and resource management; yet, if not properly designed and performed, they may pose new difficulties and irritate physicians. Errors associated with computerized prescriptions typically create workflow delays. Despite their obvious benefits, computerized prescription systems face a number of challenges. One out of every ten computer-generated prescriptions had at least one inaccuracy, with one-third posing a risk of damage. This is consistent with findings on the mistake rates of human handwritten prescriptions. The number, kind, and severity of mistakes varied by computerized prescription system, implying that some systems are better than others at preventing errors[33] Medical mistakes are the third biggest cause of mortality in the United States, with drug errors accounting for around 20% of all errors. Electronic prescription (e-prescribing) has been developed as a means to this problem, and it has been demonstrated to have several advantages. However, if electronic prescription is not correctly done, it might introduce additional mistakes. [35] Proportion and contributing factors to e-prescribing errors are:

- Computer (technical) variables account for 12% of e-prescribing mistakes
- whereas human factors account for 40%
- interaction factors account for 31%
- organisational factors account for 17%. [30]

1. Absence of external interactions, computer elements produce e-prescribing software mistakes; faults are probably triggered by programme design or glitches. The primary technical considerations are delayed system operation during work days, system downtime, recurrent software indications or notifications, while also software difficulties, technical challenges, or network latency that may slow down or cause the process to malfunction.

2. These factors are defined as incorrect or inappropriate human engagement in e-prescribing-related activities. One of the most often mentioned causes of e-prescribing problems is unintentionally entering incorrect information.

3. Interaction factors are the points at which both human and technological variables contribute to e-prescribing mistakes. When irresponsible or incorrect practices of users are mixed with distracting characteristics of e-prescribing software, these circumstances can contribute to e-prescribing mistakes. The term "human factor" or "negligence" refers to how humans might contribute to mistakes. Distracting aspects of an e-prescription system might range from poor design to technological issues.

According to another study, the mistakes detected in computer-generated prescriptions were iteratively categorized to construct a framework to identify the underlying cause of the problems. Omitted information was the most prevalent source of mistake (60.7 percent of total errors and 50.9 percent of potential ADEs). Timeframe, dose, or frequency are perhaps the most likely data to be missed, and skipped dosages was the most liable to resulted in a putative ADE, responsible for 35% of all putative ADEs in study sample. If the reason of an error was not omitted information, the information was ambiguous (16.1 percent of total errors, 19.6 percent of possible ADEs), contradictory (15.7 percent of total errors, 16.0 percent of potentially ADEs), or clinically inaccurate (7.5 percent of total errors, 13.5 percent of potential ADEs). [37]

To aid in the discovery of systemic solutions, the health-care industry should establish a quality improvement review method. Solutions might range from improving the architecture of an e-prescription system to focusing on the development of pharmaceutical personnel. According to one study, pharmacy technicians play a significant part in the e-prescription process as well as drug dispensing community pharmacies. Many particular features of pharmacy technicians have been linked to greater assistance for pharmacists in carrying out

their patient care obligations and more effective assessment and remediation of prescription mistakes. The exact significance of these relationships with crucial outcomes, like as profitability and clinical outcomes, is unclear at this time. Future study might be conducted to discover these relationships; measures may be properly informed to prioritize possible opportunities for improvements in an effort to enhance the e-prescription mechanism and the sturdiness of pharmacist training in order to improve drug safety. [18], when it comes to pharmacist interventions, the most prevalent category of prescription mistakes is connected to the requirement for pharmacological therapy and dose selection. [39] Usability and User-centred Design (UCD) are key factors in the design and development of electronic prescription and electronic health record (EHR) systems in general, since they can improve patient safety, boost physician adoption, and reduce physician dissatisfaction. The better design may include drop-down menus, less complex interface, user-friendly interface etc Insufficient usability not only frustrates clinicians, but it also raises the chance of mistakes, posing a significant danger to patient safety. The purpose of this study is to enhance the productivity of the software of e prescriptions by mitigating the risk of inaccurate medication selection and shortening physicians' prescribing time. We will develop a meta model for EP that will include concepts such as prescriber, medications, patients, and so on, and then we will employ various OCL constraints to ensure error avoidance.

4.2. Proposed Methodology

The goal of this research is to improve the productivity of e-prescription software by mitigating the risk of inaccurate medication selection and shortening physicians' prescribing time. For this purpose, we have developed a meta-model in model-driven approach in Obeo Designer Community for e-prescriptions which will include concepts such as prescriber, medications, patients, pharmacist, etc., as well as a recommendation system which will give a list of predicted drugs to the doctor and develop graphical visualization and customized tree view editor in Sirius tool and then we have applied various Object Constraint Language (OCL) constraints to ensure error avoidance. Quoc et al [53] define the meta-model for a list of important ideas and a collection of accordance with agreed terms between these concepts to describe the abstraction.

Today's modern e-prescribing technologies are used by healthcare workers to prescribe, monitor, and connect pharmaceutical systems with current electronic health record (EHR) systems. An e -prescribing (EMR) is a computerized representation of a patient's medical record (EHR) focusing on the patient on real-time data that deliver the message to authorized users in a timely and secure manner. These systems are regarded as a necessary component of the healthcare sector. They are intended to go further than standard medical information recorded in a supplier's clinic and thus can comprise a fuller picture of a patient's care. Therefore, that EHR system can store a patient's pharmaceutical care history. A study [54] proposes that EHRs provide functions like maintaining a record of a patient's condition, diagnosis, medications, potential treatments, vaccination dates, reactions, radiology pictures, plus laboratory and medical tests results, providing clinicians with access to scientific proof technologies that they may are using to make choices that affect a patient's care and simplification and automation of provider workflow.

Dobrev et al taxonomy's of e-Prescribing [55] systems emphasize the need for connectivity with EHRs. We must concentrate on our user-centered design to maximize the productivity of the e-prescribing mechanism by mitigating the risk of wrong medication selection and reducing the work and effort necessary to obtain the correct prescription. We are developing a recommender system that will recommend drugs to doctors as they are giving medications to patients based on their EHR or history. Sidnooma et al [56] stated that personalized recommendation expert systems are computer programs and approaches that provide suggestions for items that a user may find useful. The term item is used in this context to refer to anything. It can represent a variety of ideas. For example, recommender systems may suggest content on a news portal, items in an online store, or even services. The recommendations are often targeted to a certain sort of user or user group. Because suggestions are individualized, they may differ from one customer to the next either from 1 workgroup to the next. There are several websites where you may observe the recommender system in action. Googlebot, the Yahoo gateway, Pandora, Spotify, and Netflix are a few examples

4.2.1 Definition of requirements:

The definition of requirements for Chemotherapy e-prescription system would
Include

- **Authorization and Authentication:**

The system should be designed so that only authorised personnel have access to it.

- **Authenticity:**

Only one login credential is available to a prescriber, and it cannot be duplicated.

- **Precision:**

The admins and prescribing physician should be able to process data and generate patient rx reports extra precisely and accurately.

- **Integrity:**

Only the designated healthcare professional can change, update, or delete a patient's prescription log.

- **Reliability:**

The solution should be designed to deliver prescriptions to pharmacists in less time and work reliably without any record loss due to a good and reliable database.

- **Convenience:**

The doctors who prescribe or healthcare professional should be capable of completing the rx operation in a timely manner. Pharmacists no longer need to call back to doctors; doctors have extremely convenient access to a patient record; and patients can get prescription medications from pharmacists without having to wait in line.

CHAPTER 5: IMPLEMENTATION AND VALIDATION

This chapter presents the implementation and validation of the proposed solution, organized into several sub-sections. **Section 5.1** discusses the implementation process, including key components such as the meta model and OCL in sub-sections **5.1.1** and **5.1.2**, respectively. In **Section 5.2**, we outline a case study using the proposed methodology, with **sub-section 5.2.1** focusing on the Sirius representation. Finally, **Section 5.3** details the application of the case study.

5.1. Implementation

5.1.1. Meta Model

A meta-Model for the e-prescription system is given in fig.7 .This meta-model is a generic model which can be used for prescribing treatments for any disease. This meta-model contains all the required concepts, relations, attributes, and operations. Concepts for recommendation systems include Model, FeatureExtraction, DecisionTree, NeuralNetwork, RandomForest, Classifier, List, Recommendation system, Prediction. Classes for prescribing or user interactions include Patient, Doctor, Stock, Pharmacist, Drug, Disease, Prescription, and History (EHR). The model also contains enumerations of Severity, Drug type. E-prescription is the root class that composes most of the classes except FeatureExtraction and Model which are composed of Classifier concept. Model is an abstract concept which is a superclass of DecisionTree, RandomForest, and NeuralNetwork. Because of the notions of inheritance, all of this class's characteristics and operations are also available to its subclasses. The classifier concept contains a dataset that is used for making predictions, the FeatureExtraction class also gets data from the History concept which contains the record of the patient. The patient can have one or more diseases and can be prescribed one or more drugs. For accurate prescription, the RecommendationSystem provides a List of predicted drugs that comes from the Prediction concept and go to the Doctor. A doctor can prescribe many prescriptions, these prescriptions are stored in the Prescription concept. The pharmacist can get this Prescription and can check the availability of prescribed drugs through the Stock concept which is also composed of the EPrescription root concept.

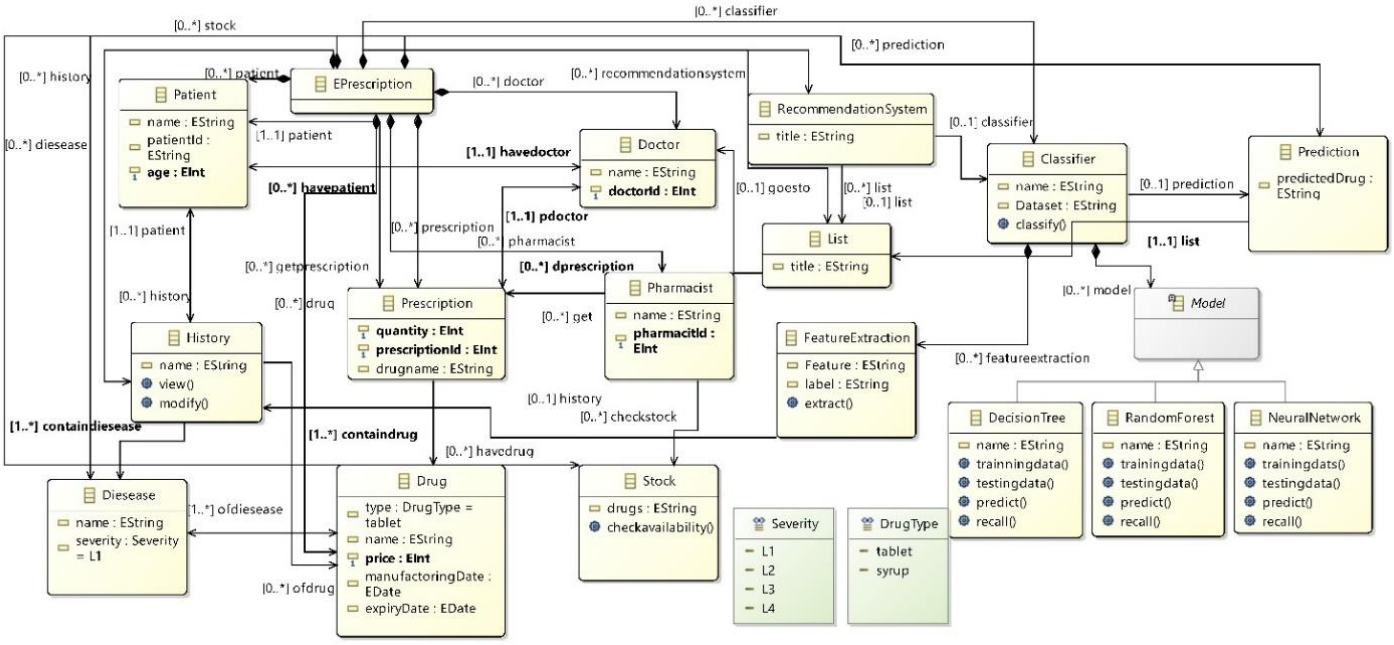


Figure 2: Meta Model

5.1.2. OCL

OCL stands for an object-oriented language. It is a language which is developed by IBM that describes rules that apply to UML's models. OCL started from being a description for models of UML. It is a standardized, non-proprietary rules language and is a partner standard to UML. It supplements natural language rules by expressing rules unambiguously in OCL then generating code. The advantage of model-driven software development is that it allows you to analyze your application early on. You may apply constraints to your model and check whether or not your model is confirming them. We can apply diverse ocl on our e-prescription for instance Patient's age must be greater than 18, If the patient is both diabetic and cancerous patient he must not be given zyfnol drug, If patient's age is 70 then he must not be prescribed zyfnol(drug's name), If patient's age is 70 then the quantity of prescribed drug must be only 1 and Pharmacist check the stock if the prescribed drug is available in stock or not.

We can apply diverse ocl on our eprescription:

- Patient's age must be greater than 18

```
class Patient
{
    invariant ageristriction: self.age>=18;
    property history#patient : History[*|1] { ordered };
    property getprescription#patient : Prescription[*|1] { ordered };
    property havedoctor#havepatient : Doctor[1];
    attribute name : String[?];
    attribute patientId : String[?];
    attribute age : ecore::EInt[1];
}
```

Figure 2 Constraint on patient about age

- If patient is both diabetic and cancerous patient he must not be given zyfnol drug

```
class Diesease
{
    invariant med: self.name='cancer' and self.name= 'diabetes' implies ofdrug->excludes('zyfnol');
    property ofdrug#ofdiesease : Drug[*|1] { ordered };
    attribute name : String[?];
    attribute severity : Severity[?];
}
```

Figure 3 Constraint on disease

- If pateint's age is 70 then he must not be prescribed with zyfnol(drug's name)

```
class Patient
{
    invariant drugtoage: self.age>70 implies self.getprescription.drugname<>'zyfnol';
    property history#patient : History[*|1] { ordered };
    property getprescription#patient : Prescription[*|1] { ordered };
    property havedoctor#havepatient : Doctor[1];
    attribute name : String[?];
    attribute patientId : String[?];
    attribute age : ecore::EInt[1];
}
```

Figure 4 Constraint on patient

- If pateint's age is 70 then the quantity of prescribed drug must be only 1

```
class Patient
{
    invariant drugquantitytoage: self.age>70 implies self.getprescription.quantity=1;
    property history#patient : History[*|1] { ordered };
    property getprescription#patient : Prescription[*|1] { ordered };
    property havedoctor#havepatient : Doctor[1];
    attribute name : String[?];
    attribute patientId : String[?];
    attribute age : ecore::EInt[1];
}
```

Figure 5 Constraint on patient about drug quantity

- Pharmacist check the stock if the prescribed drug is available in stock or not

```
class Pharmacist
{
    invariant check:self.get.drugname=self.checkstock.drugs;
    property get : Prescription[*|1] { ordered };
    property checkstock : Stock[*|1] { ordered };
    attribute name : String[?];
    attribute pharmacitId : ecore::EInt[1];
}
```

Figure 6 Constraint on pharmacist to check drug

Our tool is available on Github publically containing its workspace folder(metamodel, .edit, and .editor) as well as its runtime folder (Sirius and instance model or tree view) [58]

5.2. Case Study using Proposed Methodology

The proposed approach is illustrated using a case study. First, we are going to test our meta-model through a real-world case study of e-prescriptions for a chemotherapy patient. Using our tree editor in a runtime environment by running a New Configuration of Obeo designer, we have created an M1 level instance model. By instantiating key concepts from our suggested meta-model and defining relationships among instances accordingly, these requirements of a given case study are captured through this model created at the M1 level. As shown in Fig.8 a patient peter goes to Doctor daniel for getting a prescription Abraxane this patient has a disease cancer he is also a

diabetic patient, he is using 3 Drugs Abraxane, Cytoxane, and sitaglumet, each patient has a history based on his diseases and drugs while prescribing a doctor will get a list of recommendations these recommendations are generated from a recommendation system consisting a classifier, feature extractor and model, whereas Decision Tree, Random Forest, and Neural Network commonly known classifiers further specialize the classifier class which will make a list l1 of predicted drugs (Abraxane) on the bases of a dataset and data of the patient's diseases and drugs stored in history.

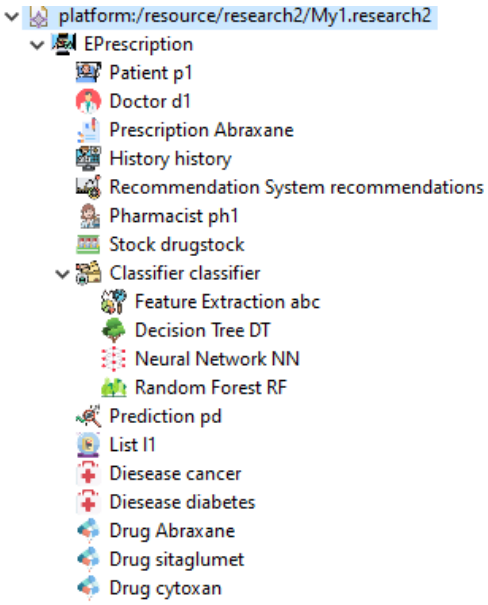


Figure 8 Tree view of instances

5.2.1. Sirius Representation:

For Sirius implementation of our e-prescription meta-model, we first had to design a design file in the Sirius viewpoint specification project by defining and designing the nodes and relation-based edges in a viewpoint specification file, all the nodes and edges were designed one of which composes other nodes we have further added images and icons respectively. Later on, through defining and styling these edges and nodes following representation in Fig.11 is created it can be further enhanced by adding more related instances or by modifying the instance model in the tree view. Later on, we have also designed a palette for the tool to further enhance our representation and add more related nodes and edges by just a simple drag and drop. Through designing a palette, we have created a tool that is in running form or executable form palette can also be seen in Fig.11

To design a design file in Sirius viewpoint specification project by defining and designing the nodes and relation based edges in a viewpoint specification file, all the nodes and edges were designed one of which nodes composes other nodes we have further added images and icons respectively as shown in figure 9 and figure 10

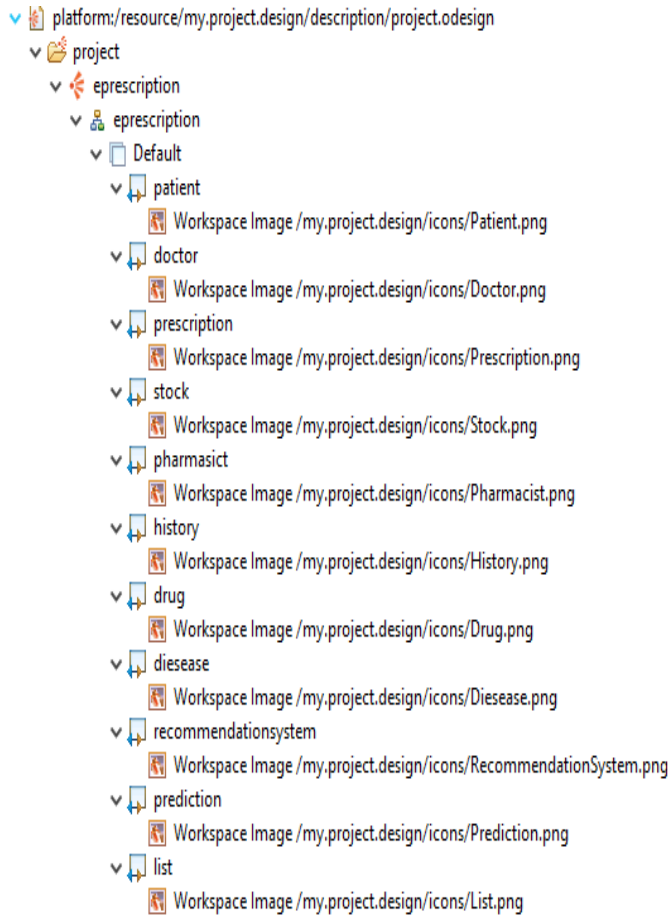


Figure 9 Sirius Design File

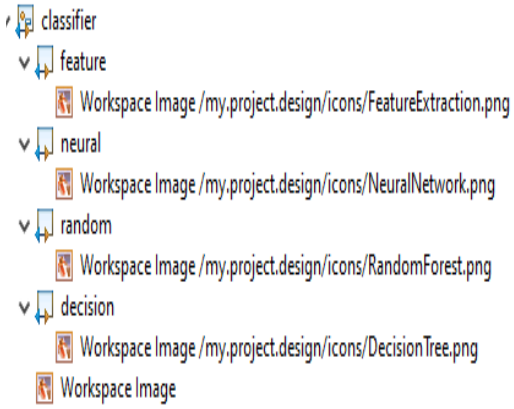


Figure 9 Sirius Design file

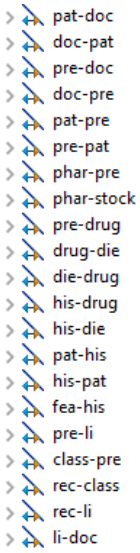


Figure 10 Sirius design file(relations)

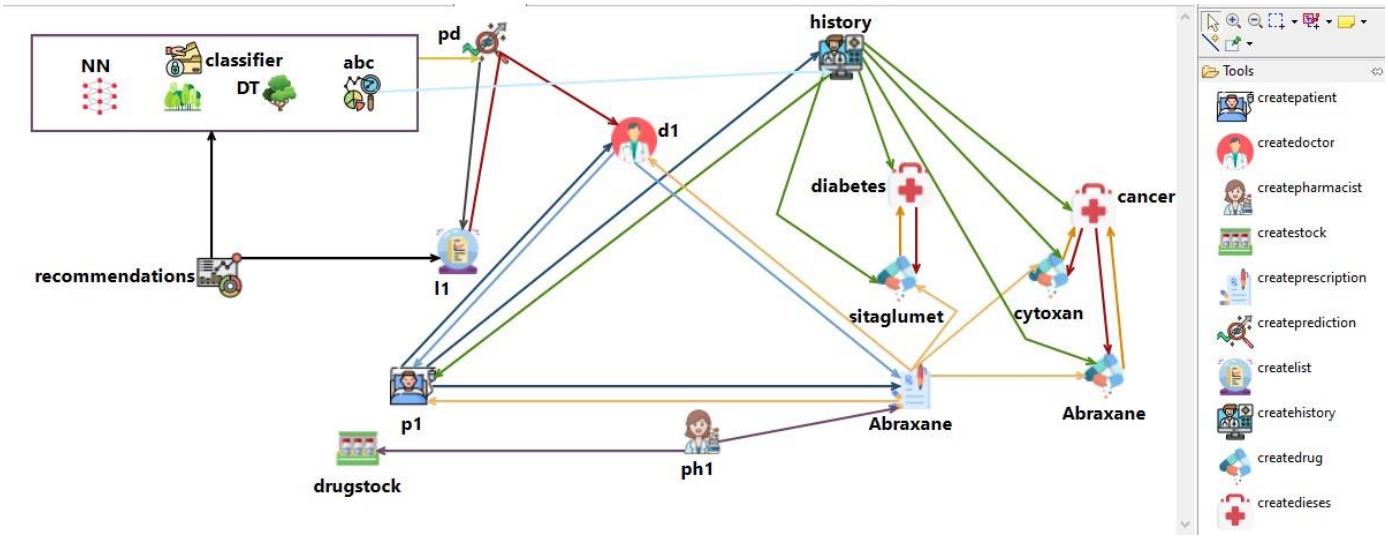


Figure 11 Graphical Sirius representation of instances

Later on, through defining and styling theses edges and nodes following representation is created it can be further enhanced by adding more related instances or my modifying the instance model in tree view Through the above case study of a a patient getting a prescription from a doctor for disease or diseases the prescription can contain more than one disease all the drugs and disease related to that's patient is stored in the history concept and through which a component of recommendation system known as feature extraction get data and model train and test on this data as well as a data set and provide a prediction list which is sent to the doctor later on the prescription

prescribed by doctor on the bases of recommendation is taken by pharmacist as well who check the availability of the prescribed drug or drugs in the stock

Later on we have also designed a palette for the tool so that later on we will be able to further enhance our representation and can add more related nodes and edges by just a simple drag and drop. Through designing a palette we have created a tool which is running form or executable form the designing of palette is shown in figure 12, figure 13, figure 14 and figure 15

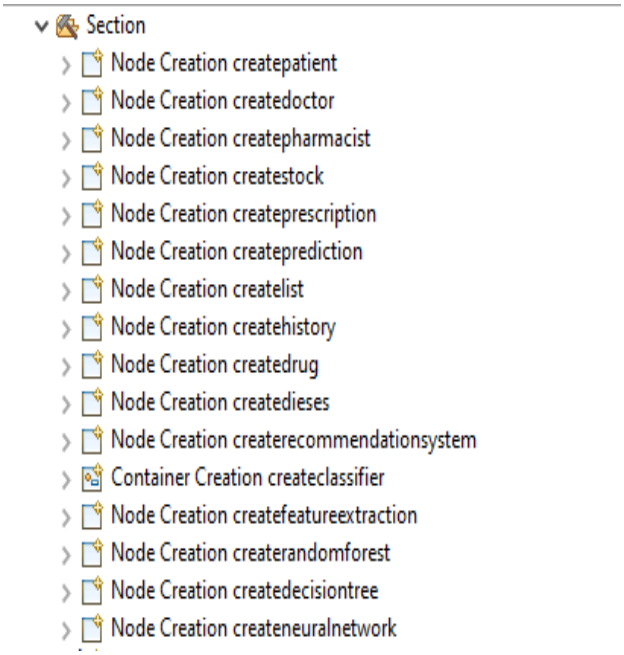


Figure 12 Node creation

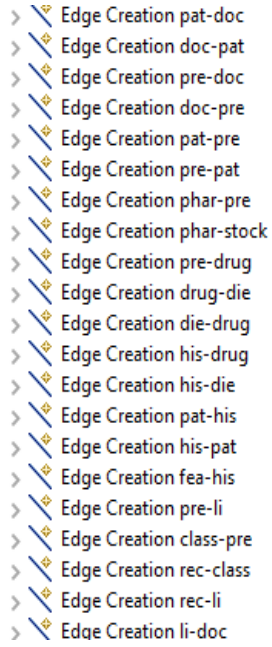
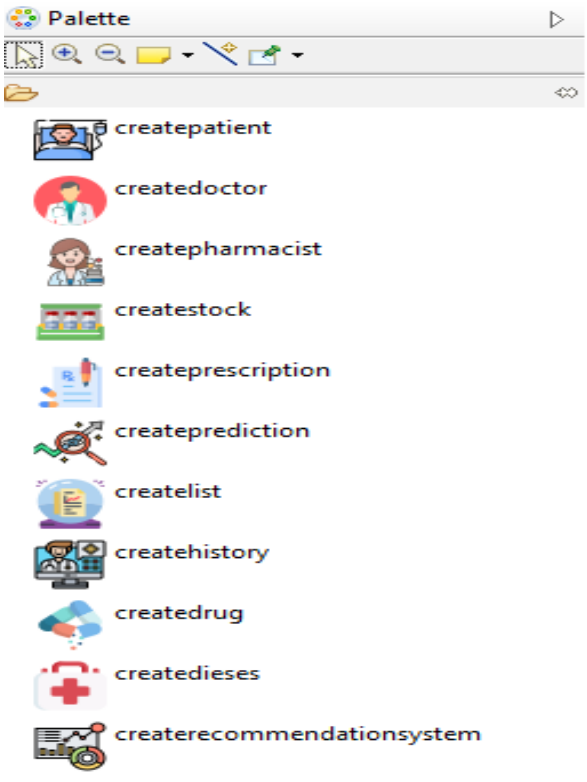


Figure 13 Edge Creation



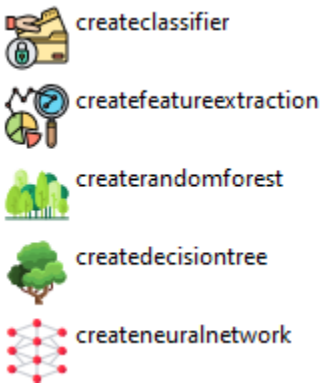


Figure 14 Sirius Palette

Figure 14 Sirius Palette

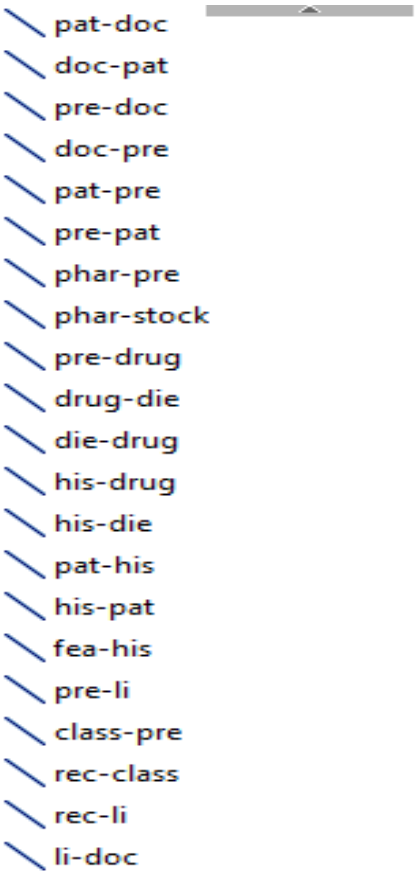


Figure 15 Sirius Palette(relations)

5.3. Case Study Application:

The participants also included experienced MBBS Doctors such as Dr. Abu Bakar (Urologist,DHQ D.G.khan), Dr Irfan Siddique (Dermatologist, CMH Gujranwala) and Dr. Shoaib Naz (General Physian , Al Noor Hospital, (Kanjwani) Faisalabad)

Dr Irfan Siddique (Dermatologist, CMH Gujranwala):

Patient Profile:

Name: Ayesha

Conditions: Skin cancer, diabetes

Current Medications: Abraxane, Metformin, Cytoxan

Scenario:

The skin cancer treatment of Ayesha is being taken from Dr. Siddique. With the help of e-prescription system, Dr. Siddique types an input about Ayesha's medical conditions as diabetes and her current medications. The recommendation system gives the list of recommended medication according to her conditions and the previous prescription history. The classifier then uses the result of the similar cases in the past and the data of ayesha to come up with the finding.

Expected Outcome:

Other opinions given to Dr. Siddique is in other chemotherapeutic agents particularly Abraxane, any other treatment, which would enhance the treatment of Ayesha. He consequently prescribes the most suitable medicines in a way that fits her type 2 diabetes condition.

Dr. Abu Bakar(Urologist,DHQ D.G.khan):

This is the testimony of Dr. Abu Bakar a qualified urologist – DHQ D.G Khan.

Patient Profile:

Name: Ali

Conditions: Bladder cancer, hypertension

Current Medications: Abraxane, Lisinopril, Cytoxan

Scenario:

Ali narrates his type of cancer to Dr. Bakar as bladder cancer. The above system is used to capture his medical history and the medications he is on at the present time. The recommendation system takes Ali's data and applies it before generating a list of potential treatments which takes into account the hypertension.

Expected Outcome:

They are both forms of treatment where Dr. Bakar gets a list that contains chemotherapy as well as the medications for the management of Ali hypertension. Taking into consideration this recommendations he has made the right decision on the compatibility of the medicine that has been prescribed to Ali.

Dr. Shoaib Naz (General Physian , Al Noor Hospital, (Kanjwani) Faisalabad):

Dr. Shoaib Naz – General Physician practicing at Al Noor Hospital – Faisalabad

Patient Profile:

Name: Fatima

Conditions: Breast cancer, Type II diabetes

Current Medications: Abraxane; Sitagliptin; Cytoxan

Scenario:

Fatima visits Dr. Naz to get a routine and cancer follow up check up. Once she signs in into the e-prescription system, Dr. Naaz enters her health profile and in the list having her as a patient she has cancer treatment and diabetes. The recommendation system is able to suggest treatments based on the inputs it receives, as well as her condition regarding being a diabetic patient.

Expected Outcome:

Dr. Naz gets suggestions of drugs such as Abraxane and possible other co-sympton drugs that will not be bad for her diabetic condition. He has to be sure about what type of treatment is necessary and the modern one that would be suitable for the patient.

Summary:

Thus, using the meta-model proposed in this work to analyze each doctor's practice will serve to verify the efficiency of the e-prescription and recommendation system. The patient data and history of drug efficacy combined with the classifiers (Decision Tree, Random Forest, Neural Network) to show how individualized medical advice can improve patient outcomes for various disciplines. This case study offered information about the feasibility and flexibility of using the model in various medical situations.

CHAPTER 6: CONCLUSION AND FUTURE WORK

This paper proposes a framework for an error-free e-prescription system consisting of a recommendation system that allows e-prescription operations to be executed using MDA. This is a significant step forward as a complete and open-source approach. It's difficult to locate a literature-based foundation for a model-driven approach to electronic prescription procedures. This will provide visualization or modeled solution for future works in this area. MDA provides various advantages including model transformation support. There are two kinds of transformations. 1) Transformation from a model into a model 2) Model into text conversion this meta-model can serve as the foundation for M2T conversion using the Acceleo tool. There are no transformations presently being created, to build appropriate low-level implementations; however, because this meta-model allows all M2M and M2T transformations, such transformations may be readily built as per needs as a result making implementation procedure quite easier by providing flexibility. Because of this flexibility as compared to previous solutions this solution can act as the basis for future research. This meta-model can be easily mapped in Python language all concepts like a patient, doctor, prescription, etc can be mapped into python code easily and all the classes which is the part of a recommendation system for instance classifier, model, feature extraction can also be mapped into respective python code. In this paper, we are not going to transform our meta-model into python code but in the future, this meta-model could be transformed into executable python code. Some of the classes dealing with recommendations could be mapped into corresponding python code as given in table 3

TABLE III Transformation rules

Modeling concept	**Target python concept**	**Syntax mapping(modeling) concept arrow python code**
Classification	Dataset declaration Dataset Dimension Data visualization	**Name→**dataset string **Dataset→**dataset.shape **Dataset→**dataset.head(value) dataset.describe() dataset.hist() pyplot.show() scatter_matrix(dataset)

Modeling concept	Target python concept	Syntax mapping(modeling) concept arrow python code
Feature Extraction	Feature Extraction Label Extraction Overfitting risk reduction	**Feature→**Feature String **Label→**Label string **Extract→**trainingdataset=pca.transform(trainingdataset)testingdataset = pca.transform(testingdataset)
Decision Tree	Split-out validation dataset Predicting drugs	**Dataset→**Xtrain, Xtest,Ytrain, Ytest = train_test_split(X, y, test_size=0.20, random_state=1) **Name→**name string **name→**model = DecisionTreeClassifier(criterion='entropy', max_depth=x, random_state=0) model.fit(train_X, train_y) **Predict→**y_pred = model.predict(test_X) **recall→**ac=recall_score(test_y,y_pred) acc.append(ac)

This work proposes a framework "A Model-Driven Framework to Recommend E-prescriptions" in which MDA is utilized to perform key e-prescription processes. Specifically, a meta-model is created to express fundamental e-prescription concepts. Sirius is then used to construct our instance model in tree view editor at the M1 level, we have also visualized our meta-model graphically using the Sirius tool. As a consequence, using the MDA development cycle provides solid practicalities for performing e-prescription operations with simplicity. This is a noteworthy breakthrough, as a comprehensive MDA framework for e-prescription is rare to find in literature and industry projects. A case study is utilized to demonstrate the usefulness of the proposed framework. The findings indicate that the proposed framework is an excellent option for modeling and visualizing e-prescription operations, as well as a powerful tool for constructing MDA-based systems. We want to extend the proposed framework in the future by incorporating the Acceleo as it can help to create other artifacts. This meta-model could be transformed into executable python code. Changes necessary while implementing the system in code can be made as our meta-model provide flexibility. Furthermore, test cases can also be developed for this framework.

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