

# Use of Machine Learning in Optimizing Medical Appointment Schedules

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**Abstract** -Approximately 98% of work operations within organizations, particularly health systems, have activities that can be completed with the adoption of available scheduling. This element highlights the importance of scheduling in reducing the problems that face predictive activities that can be optimized through proper planning and forecasting. Machine learning as a branch of artificial intelligence entails providing machines with the ability to learn without assistance or any form of human intervention. This paper sought to determine the feasibility of machine learning in enabling the effective scheduling of medical appointments for doctor scheduling. The general objectives were to understand the application of machine learning in the optimization of medical appointment schedules. The study's specific objectives included understanding the concept of machine learning and its significant applications in healthcare and highlighting the use of machine learning in optimizing health operations. Furthermore, the study sought to determine the application of machine learning towards optimizing medical appointment schedules and establish the outcomes of using machine learning in optimizing appointment schedules in healthcare. The research was based on the Machine Learning Theory and the Formal Learning Theory as the theoretical frameworks. This study employed the qualitative narrative literature review that summarizes the outcomes of different peer-reviewed journals. The researcher conducted a literature search and assessed several selected peer-reviewed journal articles. These findings were summarized based on the research objectives. They included machine learning techniques enabling the improved and effective use of health data, the scheduling of hospital operations and the classification of patients. The study recommended further research in predictive scheduling concerning patient and doctor scheduling.

## 1. INTRODUCTION

According to Aytug et al. (2014), approximately 98 per cent of work operations within organizations entailed non-value-added activities that can be accomplished using proper scheduling procedures. However, scheduling is considered a highly complex task involving aligning organizational activities towards a given objective and meeting the desired outcomes. Most environments, particularly manufacturing, experience high levels of uncertainty, have detailed and specific processes and comprise varied and dynamic management objectives. This element brings to the fore the underlying scheduling problems that may hinder the effective optimization of the planning and forecasting of process activities (Samorani & Blount, 2020). In healthcare, concerns exist regarding using machine learning and related algorithms to create and perpetuate various inequalities. Therefore, it is essential to

understand the impact and uses of machine learning in healthcare.

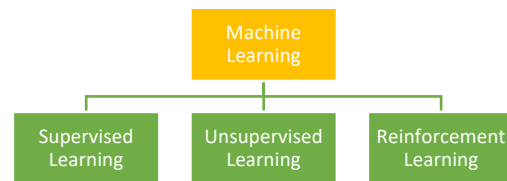


Fig 1: Basic Machine Learning Concepts

Machine learning from a healthcare perspective has been studied over the years with researchers and scholars aiming to reveal the impact of modern technology on health systems and operations (Toh & Brody, 2021). It is important to note that machine learning as a concept entails integrating the ideologies of artificial intelligence (AI) to provide the machine with the ability to learn without assistance or any form of human intervention. By employing machine learning, both individuals and organizations have the capability of deploying machine learning algorithms that include unsupervised and supervised learning. These categories usually utilize mathematical models that seek to provide computer systems with the ability to learn the process and objectives of performing tasks (Jain & Chatterjee, 2020). This paper seeks to highlight the application of machine learning in healthcare with specific focus on the impact of the technological advancement on health appointment scheduling.

## 2. BACKGROUND

Abdalkareem al., (2021) conducted a study to summarize the recent studies on healthcare scheduling issues, particularly the problems associated with patient scheduling, nurse scheduling, surgery scheduling and other scheduling problems in healthcare. The study surveyed the major healthcare scheduling issues using the latest literature thus providing much needed insights and solutions towards resolving the underlying problems. The author's revealed that healthcare scheduling offers insightful solutions towards cost optimization, improvement of patient flow and the prompt provision of healthcare services. Samorani and Blount (2020) reviewed the link between machine learning and medical appointment scheduling which has the potential to create and perpetuate inequalities in healthcare. The theoretical review was concerned with how machine learning algorithms can influence the health of individuals and communities with an emphasis on medical processes.

Gattermann-Itschert et al., (2022) conducted a study on the use of machine learning to include the preferences of planners when optimizing railway crew scheduling. The study sought to address the problems associated with the application of machine learning to predict planners' preferences towards scheduling crew members operations. The authors combined machine learning in detecting complex patterns that related to duty aspects that are favorable and optimizing operations to create cost effective and feasible crew schedules. Panch et al., (2018) conducted a study on the impacts of artificial intelligence and machine learning within the current health systems. The study focused on the concepts related to AI and machine learning and how their application in healthcare across the globe. Machine learning is regarded as a subset of artificial intelligence that is concerned with computer programs or algorithms that learn the associations related to predictive power. As a result, the study investigated the potential impacts of machine learning and artificial intelligence on both healthcare workers and the provision of clinical care.

### Research Objectives

This study comprised of general and specific objectives that sought to highlight the anticipated outcomes related to the overall research questions. The general objective was to understand the application of machine learning in the optimization of medical appointment schedules.

The specific objectives of the study were.

- To understand the concept of machine learning and its major applications in healthcare.
- To highlight the use of machine learning in optimizing health operations.
- To determine the application of machine learning towards optimizing medical appointment schedules.
- To establish the outcomes of using machine learning in optimizing appointment schedules in healthcare.

### Literature Review

This subchapter sought to understand the theories and theoretical underpinnings that offer an understanding with regard to the application of machine learning in optimizing medical appointment schedules. In this case, the theories that provided a framework for understanding the application of machine learning in optimizing health operations with regard to medical appointment scheduling were the Machine Learning Theory and the Formal Learning Theory. The Machine Learning Theory which is also referred to as the Computational Learning Theory seeks to understand the foundational principles regarding learning as more of a computational procedure (Blum, 2021). Simply, the theoretical model draws its ideologies from the application of tasks such as providing guarantees that algorithms shall succeed under given conditions and creating mathematical-based models that integrate the main aspects of machine learning.

Furthermore, the computational learning theory encompasses the mathematical frameworks that quantify the learning of algorithms and tasks (Kearns & Vazirani, 2014). In practice, the theory encourages the use of formal

methods or techniques to study task and learn about algorithms, offers ways to quantify the computational issues within a machine learning task, and provides the pathway towards determining the computational capacity of any given machine learning algorithm. Also, computational learning theory uses the theories of computer science to quantify problems that arise during learning. As an extension of its sibling, the Statistical Learning Theory, the Machine Learning Theory focuses on studying the learning of tasks while the latter is concerned with the study of learning computational algorithms (Vitányi, 2015). These theoretical frameworks provide an understanding of how machine learning can be incorporated into the optimization of medical processes or operations. Below is a diagram illustrating how the theory works.

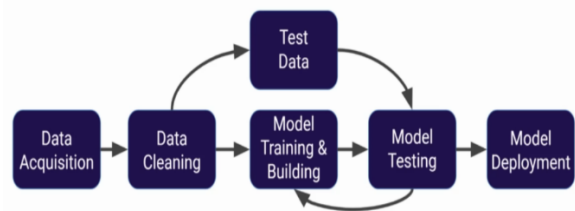


Fig 2: Machine Learning Theory

On the other hand, the Formal Learning Theory is regarded as a mathematical embodiment of the widely known normative epistemology. According to Shalev-Shwartz and Ben-David (2014), the theory is concerned with the question of whether and how agents ought to utilize observations about their environment thus arriving at the most accurate and informative assertions or conclusions. From a terminological perspective, learning as a component of the theory entails the process of acquiring information through various means, particularly observation. The element of formality involves distinguishing the learning theory from the paradigm of the behaviourist theory. As a result, the Formal Learning Theory has been seen to play a critical role in providing a description when characterizing the concept of the inductive practice (Osherson & Weinstein, 2011). This element provides a justification of how relevant the theory is towards the application of machine learning on optimizing medical operations.

### 3. FRAMEWORK

Within this section, the study integrated the selected methodologies that would facilitate the synthesis of the information to provide responses to the research question. The study adopted the most appropriate methodology that would enable the gathering and analysis of informational data from the defined sources. The methodology selected encompassed the applicable research design, study population, data sources and methods of analysis (Kumar, 2011). Research designs are the general plans that are used to connect conceptual research problems to empirical research design. According to Cresswell (2014), a research design is the inquiry into the study questions that offers the specified direction for processes and procedures in the research study. There are three types of research designs

which include quantitative, qualitative, and mixed method research designs. This study shall adopt the qualitative approach with a specific focus on the narrative literature review that summarizes the outcomes of different peer reviewed journals.

Green et al., (2011) assert that reviewing the literature is a method of research that involves scrutinizing published articles that have been listed in peer-reviewed journals. This approach aims at providing the author and reader with a more comprehensive overview of literature or information related to the research topic thus placing the information into perspective. In addition, literature reviews focus on retrieving data that is used to write the final report based on the outcomes of the published literature. It is important to note that narrative literature reviews seek to identify several published studies that describe a given research problem or topic of interest. However, these studies do not follow a systematic approach and thus may not rely on a specific protocol (Demiris, Oliver, & Washington, 2019). As a result, the author focused on providing a discussion of the problem and the possible interventions thus enabling the readers to arrive at a deeper understanding of the research topic.

According to Baethge et al., (2019), narrative reviews are common in medical literature formal hence the development of formal tools to assess the quality of such reviews. One of these tools is the Scale for the Assessment of Narrative Review Articles (SANRA) which was developed by a team of journal editors to enable the assessment of the quality of narrative reviews within the field of healthcare. The assessment tool comprises of various scales that include face validity, reliability scores and item correlations. Also, the tool has revised scales that are rated from low standard to high standard and encompass topics related to the highlighting of the relevance and objectives of the reviews, the search of literature as well as referencing, endpoint data and presentation of evidence (Green, Johnson, & Adams, 2011). Therefore, the researcher employed these scales while conducting the narrative review of pre-selected peer reviewed journal articles that are relevant to the study topic.

In addition, the selection and use of peer-reviewed journals were guided by robust inclusion and exclusion criteria as developed by the researcher. Patino and Ferreira (2018) agree that establishing inclusion and exclusion criteria for study participants which in this case were published journals is critical and standard practice for ensuring the highest quality in terms of the research protocol. Therefore, the researcher adopted a criterion that guided the selection and utilization of peer-reviewed journals that enabled the gathering of data that would answer the research question. In this case, the inclusion criteria for the research studies to be included in the study focus on the appropriateness of the study design, the characteristics of the study population, the nature of the intervention being studied and the measurable outcomes in terms of the clinical changes (Hornberger & Rangu , 2020). On the other hand, the exclusion criteria were based on the defined characteristics for excluding the studies.

#### 4. REVIEW

After conducting a rigorous literature search and employing the selection criteria, the study generated findings based on the scale and analysis mentioned in the methodology or framework section. As a result, the study assessed the selected peer-reviewed journal articles to determine their quality and relevance to the study topic. The assessment included scaling the attributes of the articles based on the underlying justification of the journal's relevance to the study, the concreteness of the research aims, the literature search, scientific reasoning, and presentation of data (Baethge, Goldbeck-Wood, & Mertens , 2019). Also, the researcher conducted a narrative analysis of the journals to capture outcomes related to the study objectives and thus provide answers to the research questions. These findings were summarized based on the research objectives discussed in the previous sections which aimed at providing a structure for answering the overall research question.

##### ***To understand the concept of machine learning and its major applications in healthcare.***

Machine learning as a modern and innovative concept was found to have increasing uses in healthcare. Toh and Brody (2021) revealed that machine learning techniques enabled the improved and effective use of health data thus enhancing patient outcomes. The major areas of application in terms of machine learning healthcare include genetic information, language processing of health documents and medical imaging. Other applicable fields include diagnosis, prediction, and case identification. Furthermore, machine learning was found to have an impact in the creation of clinical data sets and mechanisms that are required in the sharing of data as well as collaborative investigations that seek to establish safety and efficacy (Panch, Szolovits, & Atun, 2018).

##### ***To highlight the use of machine learning in optimizing health operations.***

Machine learning was found to have numerous uses and dynamics when it comes to optimizing health operations. One of the most significant uses was the predictive capability of machine learning techniques that enabled the scheduling of hospital operations (Srinivas & Ravindran, 2018). Patient scheduling is an important practice in healthcare that ensures the optimal allocation of medical resources towards diagnosis and disease management. Therefore, the application of machine learning in patient scheduling was found to reduce wait times by making the health provider's workday highly efficient. Also, the scheduling enabled the prediction of patient visits and 'no shows' that affect medical practice.

##### ***To determine the application of machine learning towards optimizing medical appointment schedules.***

In terms of medical appointment schedules which encompass the efficient scheduling of health workers workdays and shifts, machine learning was found to play a critical role in optimizing appointment scheduling while reducing the underlying challenges. Ala et al., (2021) asserted that effective appointment scheduling which entailed developing working schedules for health workers, particularly doctors was important towards quality healthcare and patient satisfaction. As a result, the study

provided a framework for deploying machine learning as a reliable technique for developing workable medical appointment schedules. These frameworks include the whale optimization algorithm (WOA) and the fairness policy of first come first serve which always gives priority to the first patient.

**To establish the outcomes of using machine learning in optimizing appointment schedules in healthcare.**

Based on the analysis of the study outcomes from the peer reviewed journals, the search and analysis revealed that the application of machine learning in optimizing medical appointment schedules had both positive and negative outcomes. According to Srinivas and Ravindran (2018), machine learning can be used in optimizing medical appointment scheduling by enabling the classification of patients based on their historical data based on compliance or the risk of not showing up to the health facility. This element can be made

possible using the application of prescriptive analytics as a framework that schedules patients and visitors in real time based on the sequencing and bookings.

### DISCUSSION AND CONCLUSION

The application of machine learning in healthcare has been found to have significant impacts and outcomes in terms of the predictive and prescriptive capability of the technology. By utilizing the ability to learn without human assistance, machine learning offers medical systems with techniques that improve the provision of care. This paper sought to highlight the use of machine learning in health appointment scheduling with a particular focus on doctors' scheduling. The study employed a narrative literature search and review to analyze several peer reviewed journals that were related to the research topic. The findings were based on the study objectives which included understanding the concept of machine learning and its major applications in healthcare, highlighting the use of machine learning in optimizing health operations, determining the application of machine learning towards optimizing medical appointment schedules, and establishing the outcomes of using machine learning in optimizing appointments schedules in healthcare. The outcomes were that the application of machine learning in optimizing medical appointment schedules had both positive and negative outcomes. However, future studies should be conducted to highlight the potential opportunities of machine learning in healthcare.

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