# Chapter 3
# A Novel Decision-Making Framework for Addressing Digitalization Solutions in the Medical System Under Generalized Fuzzy Rough Information

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## ABSTRACT

*In this study, the authors are interested in exploring the existing concepts of fuzzy sets, intuitionistic fuzzy sets, Pythagorean fuzzy sets, q-rung orthopair fuzzy sets, hesitant fuzzy sets, and fuzzy rough sets in order to reduce the difficulty of their capabilities and will point out the possible limitations and advantages in order to develop new structures of q-rung orthopair hesitant fuzzy rough sets, complex q-rung orthopair hesitant fuzzy rough sets, and complex q-rung orthopair probabilistic hesitant fuzzy rough sets and their basic results. The authors will also develop some new extensions to the existing literature and then compare the results with the existing notions. They will also do some work on the graphical features of existing literature and try to introduce some novel graph theoretic concepts for new generalities.*

## INTRODUCTION

In an era dominated by rapid digitalization across all sectors, the medical system is not left untouched. The integration of digital solutions in healthcare is crucial for enhancing the efficiency, accessibility,

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and quality of medical services. However, the decision-making process regarding the implementation of these digitalization solutions is fraught with complexities (Bhattacharya, et al., 2023). These complexities arise from the uncertain, imprecise, and incomplete information that decision-makers in the healthcare sector often face. This research embarks on an ambitious journey to explore and refine the concepts of fuzzy sets and their various extensions, such as intuitionistic fuzzy sets, Pythagorean fuzzy sets, q-rung ortho-pair fuzzy sets, hesitant fuzzy sets, and fuzzy rough sets. The aim is to develop a novel decision-making framework that can effectively address the challenges of digitalization in the medical system under generalized fuzzy rough information.

## Background and Context Setting

The traditional decision-making models often fall short when it comes to handling the kind of uncertainty and fuzziness inherent in the medical sector's digitalization efforts. The existing literature on fuzzy sets and their extensions has laid a strong foundation for addressing such uncertainties. These mathematical models provide a framework for reasoning that is closer to human natural decision-making, making them apt for applications in complex systems like healthcare (Dutta et al., 2023). Despite the progress, there remains a gap in the application of these theories to the specific challenges of digitalization in healthcare, particularly in creating a cohesive and practical decision-making framework that incorporates the latest developments in fuzzy set theory. In the context of digitalization solutions within the medical system, fuzzy sets play a crucial role in enhancing decision-making processes. Medical decision-making often involves dealing with imprecise, incomplete, or uncertain information. For example, symptoms may not always present in a clear-cut manner, or patient responses to treatments may vary widely. Fuzzy sets help in modeling such uncertainties, enabling the development of systems that can make informed decisions even when inputs are ambiguous or partially known. However, as the complexity of medical systems and the volume of available data have grown, traditional fuzzy set theory has evolved into more sophisticated models to better address these challenges:

1. Intuitionistic Fuzzy Sets (IFSs): Proposed by Atanassov, these extend the concept of fuzzy sets by incorporating the degree of non-membership in addition to the degree of membership. This is particularly useful in medical decision-making where the lack of evidence for a condition (non-membership) is as crucial as the evidence for it (membership). For instance, in diagnosing a disease, both the presence and absence of certain symptoms can provide valuable information.

2. Pythagorean Fuzzy Sets (PFSs): Further extending the idea of IFSs, PFSs allow the sum of the squares of membership and non-membership degrees to be at most 1, rather than the sum itself. This provides a larger space to express uncertainty and has been found useful in complex decision-making scenarios where a more nuanced understanding of uncertainty is needed, such as evaluating the risk of potential side effects of treatments based on incomplete clinical data.

3. q-Rung Orthopair Fuzzy Sets (q-ROFSs): These sets offer an even more generalized framework for dealing with uncertainty, where the membership and non-membership degrees are governed by a parameter q, defining an Ortho pair structure. This flexibility makes q-ROFSs particularly adept at handling highly uncertain and imprecise information, as often encountered in predicting patient outcomes where multiple, unpredictable factors influence the prognosis.

The evolution from traditional models to more complex systems like IFSs, PFSs, and q-ROFSs reflects the ongoing effort to better model and manage the intrinsic uncertainty in medical information. By enabling a more accurate and nuanced representation of uncertainty, these advanced fuzzy set theories