Predicting the Unpredictable: A Novel Mathematical Model to Analyze and Accurately Predict Multiple Sclerosis Patient Outcomes

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Multiple Sclerosis (MS), an autoimmune disease affecting millions worldwide, is characterized by its unpredictable course. Mathematics as a tool for predicting MS outcomes and identifying factors influencing progression remains underexplored. I developed a novel stochastic model utilizing Markov Chains to predict the future disability status of MS patients on a granular scale. I was able to improve the statistical significance of the model to increase predictive accuracy despite MS's variable nature. I found patients stabilized over time due to consistent cycling, and confirmed MS disease course is memoryless. Using sigmoid modeling, I also analyzed MS on the individual level, investigating the use of MRI imaging and clinical tests such as the 9-hole peg test (9HPT) and 25-foot timed walk (25FTW) to predict patient outcomes for individuals. I identified the 9HPT and 25FTW as predictive biomarkers for progression, meaning they can be used to place patients on the correct treatments and avoid the guesswork and trial-and-error based decision making that currently occurs due to not knowing which patients need high efficacy medications. The success of mathematical methods used in this study offers insight into the disease and suggests that mathematics can answer more questions about MS, building a framework and process that can be used to better analyze and improve patient care. As next steps, in addition to publishing my current findings on the behavior of MS cohorts over time (as suggested by my model) to help neurologists make informed treatment decisions, I will be furthering the findings from the multi-center clinical trial data, replicating it against data from additional clinical studies to prove it to be fully generalizable in a routine clinical population.