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Multimorbidities Network Analysis for Neurodegenerative Diseases

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TREO Talk Paper

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Abstract

Millions of people in the US and worldwide are suffering from neurodegenerative diseases (NDDs). Alzheimer's and Parkinson's diseases are the most common neurodegenerative diseases, with Alzheimer's alone being the sixth leading cause of death in the US. These diseases occur when nerve cells in the brain or nervous system lose functionality or die. The risk of being affected by such diseases dramatically increases with age, and there is no way to stop or slow their progression, according to the National Institutes of Health (NIH). In short, these are complex diseases that even their diagnosis by specialists is not free from error. So, it is crucial to study these diseases and develop clinical decision support systems based on accessible data. In this regard, the study of multimorbidities (i.e., co-occurring diseases) of NDDs in the light of descriptive analytics can establish a bedrock understanding of these diseases, which can help enhance predictive models. Multimorbidities could be mutually fatal. They may co-occur independently or from a common antecedent. Biological, behavioral, social, or environmental factors can instigate several diseases simultaneously. The study of associations among diseases could lead us to discover the root causes or common antecedents. At the minimum, such a study can hint the onset of NDDs in the case of observing multimorbidities or vice versa.

We use network analysis to address the co-occurrences of diseases. Network analysis has been leveraged in many fields, from manufacturing and supply chain management to social sciences. The strength of such analysis is its combinatorial nature, which helps explain complex relations and rationale among a massive number of elements. In addition, the existing advanced graph theories, measures, and algorithms can result in discovering novel phenomena and patterns.

In this research, we use the Cerner HealthFacts data warehouse, one of the US's largest and most complete EHR datasets, to study over 25 million encounters of more than eight hundred thousand patients diagnosed with neurodegenerative diseases sometime in their lives. We transform the data into a network, where the nodes are the diseases, and the edges represent the existence of a patient diagnosed with both disorders. So, the interactions between the diseases are implicit, i.e., the relationship exists by some underlying exchanges. Such a network is called an implicit or inferred network or a network of similarities where common behaviors of nodes can infer the connections among the nodes.

Thanks to our large dataset, we build two networks of multimorbidities. One is based on the data before a patient is diagnosed with NDDs (pre-d) and one on the post-diagnosis data (post-d). From the literature, similarity indexes such as Pearson's Correlation Coefficient and Salton Cosine Index are commonly adapted to explain the multimorbidities of the diseases. However, the network design enables us to employ graph theory in two veins. First, the analysis of network measures such as degree, betweenness, and closeness centralities describes the central measures showing the health discrepancies of the patients with NDDs. Second, network optimization tools such as models and algorithms for solving the maximum clique problem can point out the most robust relations among multiple diseases. These can potentially explain or indicate the onset of NDDs in our pre-d network and infer the future comorbidities in our post-d network.