

Making Every Component Count: Using the Shapley Value To Improve Win Ratio Analysis

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Clinical trials often utilize composite endpoints to provide a comprehensive evaluation of a treatment's effects by combining multiple related outcomes into a single measure. While traditional methods, such as time-to-first-event analysis, are widely used, they face limitations, including equal weighting of components, disproportionate influence of non-fatal events, and neglect of recurrent outcomes. The win ratio has emerged as an alternative, prioritizing outcomes by clinical importance and offering greater flexibility. However, it provides limited insight into the contributions of individual components to the overall treatment effect. To address this gap, we develop the SEWRA (Shapley-Enhanced Win Ratio Analysis) algorithm, which integrates the Shapley value, a concept from cooperative game theory, into win ratio analysis. SEWRA fairly allocates the total treatment effect across the components of a composite endpoint, reflecting their relative contributions within the context of the overall win ratio. This approach enhances the interpretability of the win ratio and provides a deeper understanding of the treatment's impact on individual outcomes. Through simulations and case studies, we demonstrate how SEWRA offers a nuanced framework for analyzing composite endpoints, complementing existing methodologies and addressing their limitations. Our work aims to advance the analytical tools available for clinical trial data, promoting more informed decision-making and improved patient outcomes.

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