Unrevealing Nonlinear Effects of Travel Behaviors on Subjective Well-Being via Explainable Artificial Intelligence

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ABSTRACT:

Subjective well-being (SWB) reflects the quality of life and has long been considered a societal goal. Recently, SWB has attracted increasing attention in promoting public health and sustainable transportation. Researchers have examined pathways highlighting the relationships between SWB and travel behaviors. However, studies often focus on selected trip characteristics such as travel mode, duration, and distances, but ignore the interrelationships between activities and trips in one's daily schedules and their combined impacts on SWB. Further, to quantitatively examine the associations between travel and SWB, most studies apply descriptive statistics and regression models, which may fail to capture their intricate, nonlinear patterns. To address these gaps, this study applies the sequence alignment method (SAM) to extract activity-travel patterns and employ explainable artificial intelligence (XAI) methods to provide novel insights into the complex associations between travel and SWB. First, this study extracts activity-travel patterns using SAM and includes them as an input for XAI methods in addition to trip characteristics and social-economic characteristics of participants. By representing each person's daily schedules as ordered sequences of activities and trips, SAM can capture the spatial-temporal interdependency of activities and trips in everyday task scheduling. Second, we apply the gradient boosting model (GBM) to examine nonlinear relationships between behavior indicators and SWB. We add SAM results as random effects in the GBM to capture the unobserved behavior indicators beyond trip characteristics. Given the GBM results, we use Shapley Additive Explanations (SHAP) to interpret the important factors contributing to the SWB outcomes and their detailed relationship. To demonstrate the methods, this study uses the travel survey data collected in Minnesota in 2021 as a study case. The survey collects the activities and trips of each participant and the emotions accompanying each activity and trip, including happy, meaningful, safe, sad, tired, stressed, and painful. We find several nonlinear relationships that have rarely been addressed in the literature. For instance, discretionary activities tend to improve SWB outcomes but too many of them can have negative impacts on SWB. These novel findings can inform policymakers, urban planners, and transportation experts on the complex dynamics between travel behavior and well-being, ultimately leading to more effective strategies for enhancing overall well-being and sustainable travel patterns.

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