Traffic safety has become the first concern in the transportation area. Crashes have cause extensive human and economic losses. With the objective of reducing crash occurrence and alleviating crash injury severity, major efforts have been dedicated to revealing the hazardous factors that affect crash occurrence at both the aggregate (targeting crash frequency per segment, intersection, etc.,) and disaggregate levels (analyzing each crash event).

In this study, first, aggregate safety performance functions were estimated to unveil the different risk factors affecting crash occurrence for the snow and dry seasons on a mountainous freeway. Then, disaggregate real-time crash risk evaluation models have been developed for the total crashes with both the machine learning and hierarchical Bayesian models. Considering the need for analyzing both aggregate and disaggregate aspects of traffic safety, systematic multi-level traffic safety studies have been conducted for single- and multi-vehicle crashes, and weekday and weekend crashes. Finally, the feasibility of utilizing a variable speed limit (VSL) system to improve traffic safety on freeways has been investigated.

Through the safety analysis models, hazardous factors and crash precursor conditions were identified. Moreover, the proposed VSL system was proved to be capable of decreasing crash risk, enhancing speed homogeneity, and reducing travel time. In addition, recommendations were made for future system implementations and possible research topics.