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CONSIDERING SPATIAL HETEROGENEITY AND TIME OF DAY IN SELF-REPORTED SEAT BELT USE

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Order of Authors:	Amin Mohamadi Hezaveh
	Trond Nordfjærn, PhD
	Jerry Everett, PhD
	Christopher R Cherry

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CONSIDERING SPATIAL HETEROGENEITY AND TIME OF DAY IN SELF-REPORTED SEAT BELT USE

Amin Mohamadi Hezaveh
University of Tennessee, Knoxville
311 JD Tickle Building, TN 37996
Phone: (385) 259-5148; Email: amohamad@vols.utk.edu

Trond Nordfjærn
Norwegian University of Science and Technology, Department of Psychology
Dragvoll, Building 12, Level 5, N-7491, Norway
Phone: +47 959 34 766
Fax: +47 735 91 960; Email: trond.nordfjarn@ntnu.no

Jerry Everett
Center for Transportation Research, University of Tennessee, Knoxville
309 Conference Center Bldg., Knoxville, TN 37996-4133
Phone: (865) 974-8275
Fax: (865) 974-3889; Email: jeverett@utk.edu

Christopher R. Cherry
University of Tennessee, Knoxville
321 JD Tickle Building, TN 37996
Phone: (865) 974-7710
Fax: (865) 974-2669; Email: cherry@utk.edu

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There are approximately 1,000 fatalities on the roads in Tennessee every year. One known solution that reduces the fatality rate of the vehicle occupants is proper use of seat belts. Several studies have reported the importance of wearing a seat belt in reducing crash fatalities and injury rates. Despite the proven effectiveness of these protective devices, some high-risk populations still neglect using them. A ten-year trend of the crashes in Tennessee shows that 30% of Tennesseans who died in traffic crashes failed to wear their seat belt properly at the time of the crash (*1; 2*). National Highway Traffic Administration (NHTSA) reported on average that Tennesseans have lower seat belt use compared to the average in the United States (*3*). Despite a few studies that aim to understand lower seat belt use rate in South and specifically Tennessee, little is known about the factors correlating with low seat belt use rate in this area. As a result, it is challenging to deploy effective countermeasures.

Not using safety equipment could be attributed to human factors such as forgetfulness, laziness, perceiving a low risk of injury, and discomfort (*4*); attitudes, beliefs, and intentions (*5; 6*); and habits (*7; 8*). Roadside observations also indicated that driving context and time of the day impact seat belt use. Researchers reported that those who drive in urban areas or expressways have a higher compliance rate (*9; 10*). A naturalistic driving study also showed that people are more likely to use seat belts while driving on high-speed roads (*11*). Regarding seat belt use by time of the day, Gkritza and Mannering (*12)* found that single-vehicle occupants are less likely to be restrained in the morning, while multi-vehicle occupants are less likely to be restrained in the afternoon. A number of studies have also shown that nighttime seat belt use rates are significantly lower compared to daytime rates (*13*). However, most studies to date tended to not stratify the analyses across driving during daytime and nighttime.

In this study, we developed a questionnaire that considers the role of Education, Engineering, and Enforcement as well as sociodemographic variables and seat belt use. Nighttime seat belt use is usually lower than daytime use (*13-15*). As a result, we focused on seat belt use during nighttime and daytime by using separate questionnaires that consider self-reported behavior for daytime and nighttime. Moreover, another contribution of this study is that it explicitly includes spatial heterogeneity in the model for self-reported seat belt use. We hypothesize that there will be spatial heterogeneity in different areas of the Knoxville region, given the diversity in land use, transportation systems, demographics, and culture. We considered the issue of spatial heterogeneity in the modeling process by recording respondents residential zip codes.

Spatial heterogeneity exists when exogenous variables do not vary identically across space (*16*). A large portion of road safety literature in the area of macroscopic crash prediction models and safety performance function estimation is dedicated to the role of spatial heterogeneity and addressing it in count data modeling. However, this issue has received less attention in self-reported studies concerning the use of safety equipment. One reason for the presence of unobserved heterogeneity in the data is the presence of factors that are not likely to be available for the analysis (*17*). This phenomenon impacts the relationship between exogenous variables and dependent variables; therefore, this relationship may not be constant across the observation. Failing to address unobserved heterogeneity in the modeling process would lead to biased estimation and drawing incorrect inferences (*17*). There are different methods for addressing heterogeneity in modeling. Mixed Logit Models (e.g., random parameters) and geographically weighted regression (GWR) are two common methods to address this issue. Random parameters models are drawn from some random distribution and are assumed to vary randomly over observations (*18*). One of the shortcomings of the random parameter model is that

it usually fails to consider the location of observation. On the other hand, spatial models such as GWR consider the location of the observations to capture spatially structured variability in the effect of contributing factors (*16; 18*). Several studies in other fields in road safety showed the advantage of GWR models with regards to improvement in model goodness of fit and capability to explore the spatially varying association among dependent variables and exogenous variables (*16; 19*).

In this study, we developed a questionnaire that considers the role of Education, Engineering, and Enforcement as well as sociodemographic variables and seat belt use. Nighttime seat belt use is usually lower than daytime use (*13-15*). As a result, we will focus on seat belt use during nighttime and daytime by using separate questionnaires that consider self-reported behavior for daytime and nighttime. Moreover, another contribution of this study is that it explicitly includes spatial heterogeneity in the model for self-reported seat belt use. We hypothesize that there will be spatial heterogeneity in different areas of the Knoxville region, given the diversity in land use, transportation systems, demographics, and culture. We used a global binary logit model and a geographically weighted regression logit model to examine the factors influencing seat belt use in the daytime and nighttime. Results of self-reported seat belt use in this study closely resemble findings in roadside observations conducted in the study area (*2*). Comparison of self-reported seat belt use across demographics indicates that male respondents have lower seat belt use rates both in daytime and nighttime. Moreover, respondents with a higher education degree and driving exposure at nights have higher self-reported nighttime seat belt use rates. The result of the non-stationary test indicates that the estimated coefficients in the GWR model have no substantial local effect, which yields the conclusion that the estimated parameters in the model are independent of respondents' locations. Accordingly, using the global effect for the testing hypothesis in this study is appropriate, and the findings of the global model are not affected by spatial heterogeneity.

Findings of the models indicate that self-reported seat belt use rate for both daytime and nighttime have a significant association with perception of enforcement, driving exposure, attitude toward seat belt use, and individuals' reasons for seat belt non-use. Whereas, for the nighttime seat belt use, exposure to educational materials has a significant effect on self-reported seat belt use. The designed framework for self-reported seat belt use for daytime and nighttime have a similar performance in terms of the relationship between significant variables and their association with self-reported seat belt use for daytime and nighttime. Findings of this study could be used by policymakers and road safety practitioners to design better educational, enforcement, and engineering countermeasures and interventions by prioritizing groups that have lower seat belt use.

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