TRAVEL SPEED & SPEED DIFFERENTIAL AND THEIR EFFECTS ON TRAFFIC SAFETY

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ABSTRACT

The influence of vehicle travel speed on traffic safety has attracted a lot of interests especially since the latest speed limit increases in many jurisdictions of the United States. There are different opinions regarding the effect of travel speed on traffic safety. Some previous studies found that average travel speed related to traffic accidents while others indicated that speed differentials mainly affected traffic safety. This paper examines travel speed and accident data on Saskatchewan highways. It is found that both average travel speeds and speed differentials are closely correlated with casualty accident rate. It was also found that speed differentials seem to increase as the average travel speeds increase at road sections with lower speed limits and decrease as the average travel speeds increase at road sections with the highest speed limit. This result is in contrary to findings of some previous studies. The reasons of such relationship between travel speeds and speed differentials are explored.

The paper also reviews international experience on speed limit changes. It suggests that two types of speed limit changes should be differentiated. Speed limit changes for large system and speed limit changes of individual road sections may have different impacts on traffic safety. Generally, speed limit increase (decrease) for a large system tends to lead to an increase (decrease) in travel speed and casualty accidents, while speed limit changes of individual road sections may have varying impacts on traffic safety depending on specific road situations. The safety impacts of speed limit changes for individual road sections therefore should not be generalized.
INTRODUCTION

The influence of vehicle travel speed on traffic safety has attracted a lot of interests especially since the latest speed limit increases in many jurisdictions of the United States. There are very different opinions and conflicting reports regarding the effect of vehicle travel speed on traffic safety. These include relationship between average travel speed, speed variance and traffic accidents. The effect of speed limit changes on traffic safety is also related to the controversy. This paper examines vehicle travel speed and traffic accidents on rural highways in Saskatchewan. International experiences of safety impacts by speed limit changes are reviewed. The objectives of the study are to find the relationship between travel speed and traffic accidents, and relationship between average travel speeds and speed differentials based on the data mainly from Saskatchewan rural highways. The implications of speed limit changes on traffic safety are also discussed.

TRAVEL SPEED AND CASUALTY RATE ON SASKATCHEWAN HIGHWAYS

In analyzing travel speeds and traffic accident relationship, the traffic accident data must be consistent and thus casualty accident (including injuries and deaths) data are used in this analysis. Historical travel speed data used are from nine major speed surveys on the Provincial Highways from 1969 to 1995. All of these speed surveys were conducted on both directions of more than fourteen control sections with the speed limit of 100 km/h (63% of total highway length). Average travel speeds and speed differentials are used in the analysis. Speed differentials, the differences between 85th and 15th percentile speeds, are similar to speed variances in reflecting travel speed dispersion within the traffic streams. It was found that speed differentials and speed variances were actually closely correlated to each other (1).

The historical casualty accident data and travel speed data provide a basis for cross sectional analysis of speed-safety relationship. The travel speed and traffic casualties on the Provincial Highways are closely correlated. The equation (Eq.1) shows that traffic casualties on the Provincial Highways increase linearly with average travel speed within the range of the studied data. Considering exposure (Million vehicle kilometers of travel = Mvkm), the casualty rate (casualties/Mvkm) is correlated to speed differentials, and average travel speeds. Equation (Eq.2) gives the multiple regression. The high coefficients of determination for the two equations indicate very close correlation.

\[
\text{Casualties} = -17126.1 + 190.71 \text{ Ave.Spd} \quad (R^2 = 0.81) \quad (\text{Eq.1})
\]

\[
\text{CasualtyRate} = 0.0298\text{Ave.Spd} + 0.0405\text{Diff} - 3.366 \quad (R^2 = 0.94) \quad (\text{Eq.2})
\]

where, Ave.Spd = average travel speed. Diff = speed differential, which is the difference between 85th and 15th percentile speed.
The equation (Eq.1) and (Eq.2) indicate that every 1 km/h increase in average travel speed can lead to an increase equivalent to about 190 casualties annually on the Provincial Highways. Equation (Eq.2) also indicates that every 1 km/h increase in speed differential can lead to an increase equivalent to about 270 casualties annually on Saskatchewan highways.

Some previous studies suggested that only speed differentials contributed to traffic accident involvement. A U-shaped curve is typically used for this argument, which suggested that too high or too low travel speed from the mean speed of the traffic stream would lead to higher accident rates regardless of the mean speed itself (2). More lane changing and passing maneuvers were believed to be the cause of this higher accident risk. However, traffic conditions have considerably changed over last three decades (1) and the latest study could only confirm the higher accident risk for the higher end travel speed group in traffic stream but could not find the higher accident risk for drivers using lower travel speeds (3). There have also been studies relating traffic accident increase only to the increase in average travel speeds (4). One study (5) reported that decreased accident rates were observed as the average travel speeds increased. However, the study data were from different types of highway facilities. The lower accident rates with higher average travel speeds were from highways with better geometric characteristics. In such circumstances the lower accident rates were most likely due to the higher highway standards not higher average travel speeds. The same study also reported the increase in accident rate with speed variance for both interstate and arterial highways.

The above analyses indicate that average travel speeds and speed differentials both affect traffic casualty accidents on the Provincial Highways. An increase in average travel speed or speed differential can lead to an increase in traffic casualties. There are reasonable explanations for these results. The higher average travel speed contributing to more traffic casualties can be explained by basic vehicle physics relating to driving operation aspects such as perception-reaction time, stopping distance, vehicle control, and kinetic energy. While the contribution of speed differentials to more traffic accidents is due to very different reasons. These include frictions in the traffic stream and maneuvers taken by each individual driver in reaction to various road and traffic conditions. Higher speed differentials normally reflect poor road conditions or diversified traffic compositions that require more judgements and actions by drivers. Consequently, human errors are more likely to occur because each individual driver will react to various conditions according to their own judgement and ability.

This result can be used to explain some characteristics of traffic accidents in different highway sections. For example, higher travel speeds may contribute to many single vehicle accidents and severe accidents on the Saskatchewan highways. While high speed differentials may be part of the cause for multiple vehicle accidents and an indication of poor highway conditions.

**AVERAGE SPEED AND SPEED DIFFERENTIAL**

If traffic casualty accidents increase with both average travel speeds and speed differentials, the relationship between average travel speed and speed differential becomes very important for strategies of traffic management and enforcement. Such relationship (if there is one) will help
answer questions like: Can we increase average travel speeds which is crucial for higher mobility while keeping speed differentials down and therefore without having negative impact on traffic safety?

The scatter plot of all surveyed speed differentials against corresponding average travel speeds does not seem to show any clear relationship between them (1). If the scatter plot of speed differentials against average travel speeds is performed by the speed limits of the surveyed highway sections, however, there seem to be certain general trends.

For the highway sections with the highest speed limit (100 km/h) in Saskatchewan, speed differentials seem to decrease generally as the average travel speeds increase. This can be seen from Figure 1. For the highway sections with other lower speed limits (including data from urban streets with speed limits 40-50 km/h in the City of Regina), speed differentials seem to increase as the average travel speeds increase. This can be seen in Figure 2. Although the coefficients of determination are low in both cases (about 0.30), the different trends in the two circumstances are obvious from the two scatter plots. There can be reasonable explanations for this in the author’s opinion.

![Figure 1 Average speed and speed differentials for 100 km/h speed limit zones](image)

It should be noted that the surveyed speed data were all from the “free flowing traffic” and each driver could select his own driving speed. All drivers and all type of vehicles have their limited ability to handle the highest travel speed under certain conditions. It is commonly true in reality that the rural highways with the highest speed limit in a jurisdiction also have the best geometric characteristics. When drivers using this type of facility, drivers, vehicles and highway facilities are all closer to their up-limits in handling the highest travel speed allowed in the jurisdiction. The speed limit may also have some psychological impacts on more capable drivers to not exceed the speed limit too much. Therefore, speed differentials decrease as the average travel speeds increase above the highest speed limit. While the circumstances for highway sections having speed limits other than the highest speed limit are very different. For the highway sections with lower speed limits, the geometric standards are normally lower and traffic
conditions may be more complicated. The individual vehicle’s driving speed is very much dependent on each driver’s ability and judgement, thus driving speeds can easily become more spread. For very low speed limit sections, intersections, enforcement level, high volume and safety concern can force the traffic to have a more uniform speed and thus low speed differentials.

This result is in contrary to the findings of the previous study (5), which gave a non-linear relationship showing that speed variance decreased as average speed increased. If this and the other two relationships of the study (higher average speed lead to low accident rate, and higher speed variance lead to higher accident rate) were true, then we could have simply tried to increase average travel speed to reduce accident rate. Actually, it was reported that the lower speed limit (55 mph) more than twenty years ago had lead to deceased mean speeds and lower speed variances at the same time in the United States (6).

The low level of coefficient of determination for the two scatter plot trends indicates that there must be other factors also affecting speed differential apart from average speeds. This also implies that it is not so easy and straightforward sometimes in answering speed-safety questions.

**SPEED LIMIT CHANGES AND TRAFFIC SAFETY**

Due to increased demand for mobility by society and personal liberty by individuals, there are increasing demands for speed limit increases. The impact of speed limit increases on traffic safety is often disputed over the years. For example, the latest Canadian study stated “... it can not be decisively concluded that changing the posted speed will result in a change in crashes.” (7).

To assess the impact of speed limit changes on safety, we should notice that vehicle travel speeds and speed limits of highway sections are different things. The speed limits themselves do not
cause any traffic accidents, it is the operating speeds and speed differentials that contribute to traffic accidents. Therefore, we must first understand the relationship between speed limits and operating speeds on highways.

**Speed Limits and Driving Speeds**

Some people claim that drivers just drive at the speed they feel comfortable regardless of speed limits. This is not the case according to data from Saskatchewan highways. Table 1 shows results of speed surveys in highway sections with different speed limits. The average travel speeds were always few km/h higher than the speed limits and 85th percentile speeds are always more than 10km/h higher than the speed limits. Although the compliance rate with speed limits were not so good, this does not necessarily mean that speed limits are not relevant to the prevailing operating speeds.

<table>
<thead>
<tr>
<th>Table 1 Travel Speed and Speed Limit on Sask. Highways (surveyed 1983 – 1995)</th>
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<tr>
<td><strong>Average speed</strong></td>
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<td><strong>100 km/h zone</strong></td>
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<td>CS16-13</td>
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<td>CS16-28</td>
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<tr>
<td><strong>90 km/h zones</strong></td>
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<td>CS12-05</td>
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<td>CS339-01</td>
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<tr>
<td><strong>80 km/h Zones</strong></td>
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<tr>
<td>CS40-02</td>
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<tr>
<td>CS16-14</td>
</tr>
<tr>
<td>CS39-05</td>
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<tr>
<td><strong>70 km/h zones</strong></td>
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<td>CS37-03</td>
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<tr>
<td><strong>60 km/h zones</strong></td>
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<td>CS12-16</td>
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<td>CS47-05</td>
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Actually, the table shows that the higher speed limit zones always had higher average speeds and 85th percentile speeds in every case. It is evident that driving public were clearly using the corresponding speed limits as a reference for their driving speeds. This indicates that the speed limits have been reasonably set on the provincial highways and people do take them into account when they choose their driving speeds. Therefore, there is no reason to believe that the changes in speed limits will not lead to changes in prevailing operating speeds.

**Speed Limit Changes and Traffic Safety**

After carefully reviewing international experience on speed limit changes it is not difficult to find that there have been two types of speed limit changes, which are speed limit changes for large systems and speed limit changes of individual road sections. The two types of speed limit changes may have very different impacts on traffic safety and therefore they should be differentiated.

Generally, speed limit changes for a large system tend to be accompanied by large-scale publicity and thus have greater awareness for the general public. The scope of this type of speed limit changes includes changes for the highest speed limit in a jurisdiction. The increase (or decrease) of speed limit will lead to an increase (or decrease) in travel speeds and therefore casualty accidents. There have been convincing evidences to back up this (1, 6). The most prominent examples are from the experiences in the United States.

The 55-mph national maximum speed limit was imposed in 1974 to conserve fuel during the oil crisis. Motorists slowed down on all major highway systems. Ten years later a National Research Council Committee concluded in a TRB special report (6) that up to 4000 lives were saved and about the same number of fewer serious injuries every year during the first 10 years of 55 mph limit in the United States.

In 1987, States were allowed to raise speed limits on rural interstate freeways up to 65 mph. In a report to Congress by the National Highway Traffic Administration in 1992 (8), it was found that the average speed on those highways had increased from 60.6 mph to 64.0 mph and the percentage exceeding 70 mph had increased from 6% to 19%. It was believed that almost 2000 more fatalities occurred during the first four years than would have been expected based on historical trends.

From 1995, many States further increase their speed limits on rural highways to at least 70 mph. A study (9) found that the average speeds have been gradually increasing over time and percentages of vehicles exceeding 70 mph have increased dramatically. Another study (10) concluded that the speed limit increases were associated with a 12% increase in occupant fatalities in the States where speed limits were increased when comparing with the similar facilities in States without speed limit increases.

While speed limit changes of individual road sections may have limited publicity and much less awareness to the general public. The speed limit changes normally are not systematic approach
and involve only isolated cases where the speed limits were not the highest in the jurisdiction. These changes will have varying impacts on traffic safety depending on specific road situations. In the Canadian study (7), Parker’s investigations were reviewed extensively. Parker investigated 100 experimental sites where the speed limit was either raised or lowered and 83 comparison sites where speed limits were not changed. Overall, raising or lowering speed limits did not lead to corresponding changes in travel speeds and any statistically significant changes in either total or severe crashes.

The Parker’s study results were actually consistent with the previous discussions in the way that actual travel speeds were not changed for the study sites and therefore accidents had no significant changes either. As for no travel speed changes after speed limit changes, however, we should look at the result carefully. Firstly, travel speed change following speed limit change is a gradual process, it may take some time to see the result of speed limit changes on average travel speed. Secondly, people know general speed limit in certain areas and expect certain speed limit for similar conditions, therefore they do not always look for new speed limits. Finally, the studied areas were fringe areas where changes in development and traffic called for speed limit changes, this indicates that the original speed limits were not appropriately set. If the enforcement was not adequate, it is not surprise to see no changes in travel speed after speed limit changes.

Therefore, results of speed limit changes for individual road sections should be looked at on individual case basis and not be generalized.

CONCLUSIONS

Traffic casualty accidents increase with both average travel speeds and speed differentials on Saskatchewan rural highways. The reasons for higher average travel speeds and speed differential contributing to more casualty accidents are very different. The relationship between average travel speeds and speed differentials is not clear. It seems that the relationship at the highway sections with the highest speed limit in a jurisdiction is different from the highway sections with other lower speed limits.

Speed limit changes for large systems and speed limit changes of individual road sections may have very different impacts on traffic safety. Generally, speed limit changes for a large system tends to lead to changes in travel speed and the travel speed changes will lead to changes in casualty accidents. While speed limit changes of individual road sections may not lead to immediate significant changes in travel speeds and thus changes in traffic safety may also be insignificant. The impacts of speed limit changes on traffic safety depend on specific road and traffic situations. Therefore, results of speed limit changes for individual road sections should not be generalized.

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