



# The impact of weather conditions and driver characteristics on road safety on rural roads

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# Introduction

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- Weather is an **environmental risk factor** which partly determines the road conditions and the safe driving behavior
- **Adverse weather conditions** encompass rain, fog, snow, strong wind or high temperatures which significantly affect collision, casualty rates, road safety and efficiency in the road transportation system
- **Rainfall** can lead to an increase in road crashes and serious injuries by 45%
- **Dense fog** and inclement weather can reduce visibility and, thus cause more or severe crashes, while **snow** immediately after clear weather significantly increases certain types of crashes



# Objectives

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- The **quantification of the impact of weather conditions** (i.e. sun, rain, fog, snow) and time pressure on road safety in rural roads, through a driving simulator experiment
- Examination of the key **driving performance indicators**:
  - ✓ driving speed
  - ✓ headway distance
  - ✓ lateral position
  - ✓ steering angle variability
  - ✓ reaction time to the unexpected event
  - ✓ crash probability
  - ✓ other variables (gender, age, driving experience)

Independent Variables	Description
Mean driving speed	Mean speed of the driver's vehicle along the route, excluding the small sections in which incidents occurred, and excluding junction areas
Headway distance	Time distance between the front of the simulator vehicle and the front of the vehicle ahead
Reaction time at unexpected incidents	Time between the first appearance of the incident on the road and the moment the driver starts to brake in milliseconds
Lateral position	Vehicle's distance from the central road axis in meters
Lateral position variability	The standard deviation of lateral position
Wheel steering angle	The mean wheel steering angle in degrees
Steering angle variability	The standard deviation of steering angle





# Data Collection

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## Driving simulator experiment

- An experimental procedure was performed on a driving simulator certified by Foerst Driving Simulator FPF
- 42 young drivers aged 20-30 years, 25 men (60%) and 17 women (40%)
- Driving on an urban driving environment under:
  - ✓ Good weather conditions
  - ✓ Heavy rainfall
  - ✓ Fog
  - ✓ Snowfall (heavily slippery road)

## Questionnaire

- Overall driving experience
- Event history
- Driver self-assessment
- Attitude and behavior toward road safety



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# Methodology

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- **Multiple Linear Regression** models, for continuous variables, were applied
- **Binomial Logistic Regression** models, if the dependent variable was discrete, were developed
- **Six regression models** were implemented:
  - ✓ Model 1: Prediction of average speed
  - ✓ Model 2: Prediction of average headway distance
  - ✓ Model 3: Prediction of reaction time to an unexpected event
  - ✓ Model 4: Prediction of lateral position
  - ✓ Model 5: Prediction of steering angle variability
  - ✓ Model 6: Prediction of crash probability at a dangerous event



# Results - Linear Regression Models

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- In rainy, foggy and snowy conditions, drivers reduce their **average driving speed** in order to spot the potential hazards of the road
- Women drive more safely compared to men, as the former manage to keep a **safer gap and a greater distance** from the vehicle in front
- The more frequently the user is driving under time pressure, the higher the **average reaction time** is, probably due to the increased attention
- Older drivers tend to have less variation of the **steering wheel rotation**, probably due to the fact that they have more driving experience, so it is easier for them to operate the vehicle and perform a maneuver, when necessary

Independent Variables	Average Speed			Average Headway			Average Reaction Time			Lateral Position			Std Average Wheel		
	b <sub>i</sub>	e	e*	b <sub>i</sub>	e	e*	b <sub>i</sub>	e	e*	b <sub>i</sub>	e	e*	b <sub>i</sub>	e	e*
TimePressure	9.902	0.19	8.5	384.245	0.63	6.9				-0.073	-0.13	-1.4	26.067	0.76	4.0
Fog	-2.703	-0.05	-2.3							0.051	0.09	1.0			
Rain	-4.901	-0.10	-4.2							0.071	0.13	1.4			
Snow	-20.463	-0.40	-17.6	277.559	0.46	5.0	-123.723	-0.07	-2.4	0.132	0.23	2.6	17.090	0.50	2.6
AgeGroup													-6.516	-0.19	-1.0
AverageSpeed							5.049	0.00	-	0.004	0.01	-			
Gender	-3.624	-0.07	-3.1	100.100	0.16	1.8	52.453	0.03	1.0						
DrivingExperience				-55.628	-0.09	-1.0									
DrivingRuralWeekly	-0.008	0.00	-												
CrashesWithDamage	1.162	0.02	1.0												
DriveUpTheLimits				-96.607	-0.16	-1.7									
OtherCrashes				-88.791	-0.15	-1.6									
TimesDrivingWithSnow Year				67.383	0.11	1.2									
DriveUnderPressure							-123.368	-0.07	-2.4						
TotalCrashes							68.615	0.04	1.3				8.693	0.25	1.3
ReduceSpeedWithSnow							55.767	0.03	1.1						
DriveDangerously										0.081	0.14	1.6			



# Results - Binomial Logistic Regression Models

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- **Time pressure** significantly decreased the likelihood of a collision at an unexpected incident
- Rain and snow **increased the likelihood of a collision** at an unexpected incident in a great extent, probably due to low visibility, slippery or wet road surface, braking difficulties
- As far as **gender** is concerned, women seemed to be involved in fewer crashes compared to men
- **Drivers who self-declared** that they avoid driving in rainy conditions were more likely to cause a crash, while those who answered that they usually reduce their average driving speed during rain were involved in less crashes, probably due to their driving experience in adverse weather conditions
- Lastly, drivers who said that they often drive under time pressure were less **likely to be involved in a crash**

Independent Variables	Crash probability at a dangerous event			
	B	Wald	e	e*
TimePressure	-1.922	37.577	-0.42	-4.1
Rain	1.511	21.180	0.45	4.3
Snow	4.079	67.977	1.23	11.8
AvoidDrivingWithRain	0.334	3.429	0.10	1.0
ReduceSpeedWithRain	-0.223	4.219	-0.05	-0.5
DriveDangerously	-0.725	4.871	-0.16	-1.6
Gender	0.607	4.248	0.20	1.9





# Discussion

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- Rain led to a **significant increase in the probability of a crash**, while time pressure was a fact of concern for the drivers
- Snow had the **greatest impact on the crash probability** at a dangerous event, as well as fog had a considerable effect on mathematical models as well
- In the absence of an unexpected event, crash probability was increased by **rush/time pressure** due to loss of vehicle control
- Snow resulted in a **decreased reaction time**, while participants who were driving under time pressure had an increased reaction time, probably due to the much more attention paid in the driving task
- Male drivers exhibit **more aggressive behavior**, drive at higher speeds and maintain shorter headway distance from the vehicle in front compared to female drivers in all weather conditions





# Conclusions

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- Findings of this study can contribute to a great extent to the **effective traffic control and management** to enhance road safety under hazy weather conditions
- The application of **Intelligent Transportation Systems** (ITS) in vehicles seems to be necessary, especially in difficult driving conditions (i.e. under heavy rain, fog or snow) in order to protect the driver from a very probable driving error
- This research can also provide **considerable gains to the society**, since the stakeholders including policy makers and industry could rely on the results and recommendations regarding risk factors that appear to be critical for safe driving under adverse weather conditions and time pressure



# Future Research

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- **Real-time traffic data** could allow for identification of the impact of weather conditions and driver characteristics on road safety
- Future research efforts could consider additional **drivers' age groups** and extend the experiment to on-road driving conditions
- The investigation of other **significant risk factors** (such as the presence of a passenger, the drug abuse, the alcohol consumption or the seat belt use) could be also included
- As per future research directions, the examination of additional **methods of analysis** could be applied





*Thank you!*

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