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The Impact of Nighttime Driving on Young Drivers' Behavior and Safety in Cities Using a Driving Simulator

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Introduction

- Nighttime driving is associated with increased **crash risk** and **severity**.
- Reduced visibility affects hazard detection and reaction time.
- **Young drivers** are particularly vulnerable.
- Need to **quantify the impact of nighttime** driving on:
 - Driving behavior
 - Crash probability



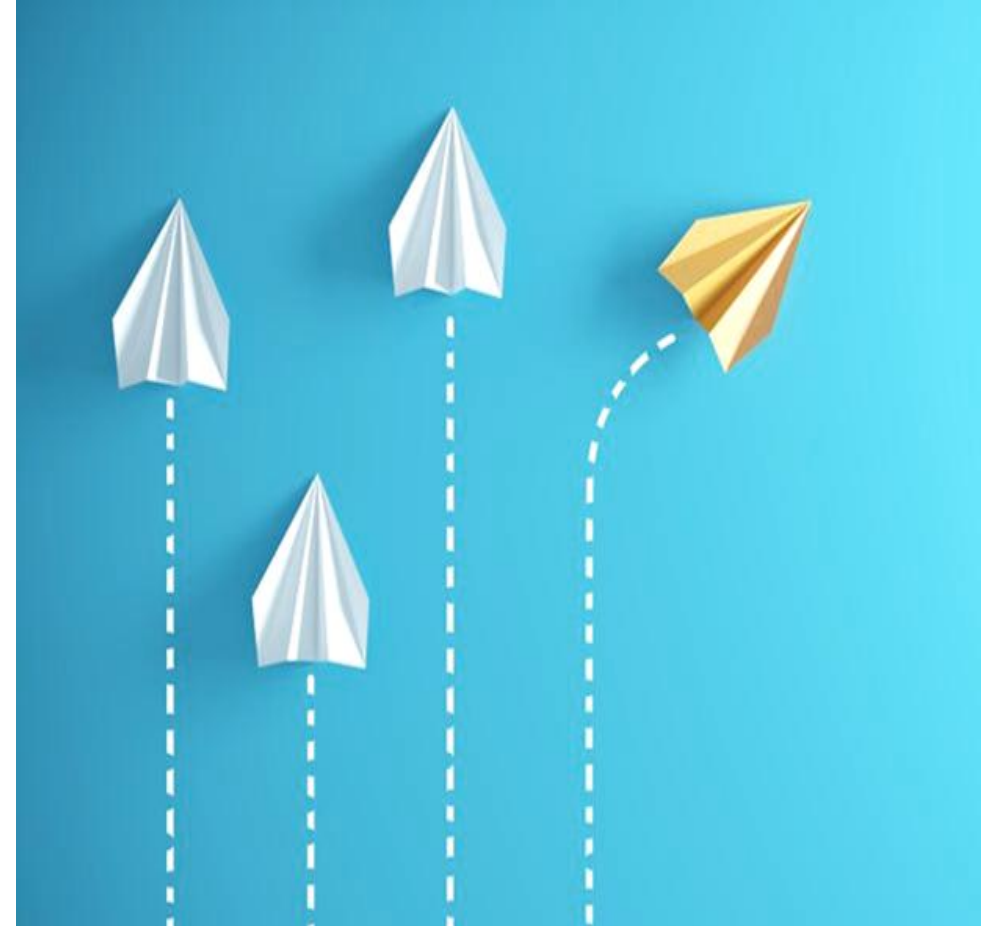
Objective

Research Objective

- Investigate the effect of nighttime driving on young drivers' behavior and safety in an urban environment using a driving simulator.

Research Questions

- Does nighttime driving affect mean speed?
- Does nighttime driving affect reaction time?
- Does nighttime driving increase crash probability?



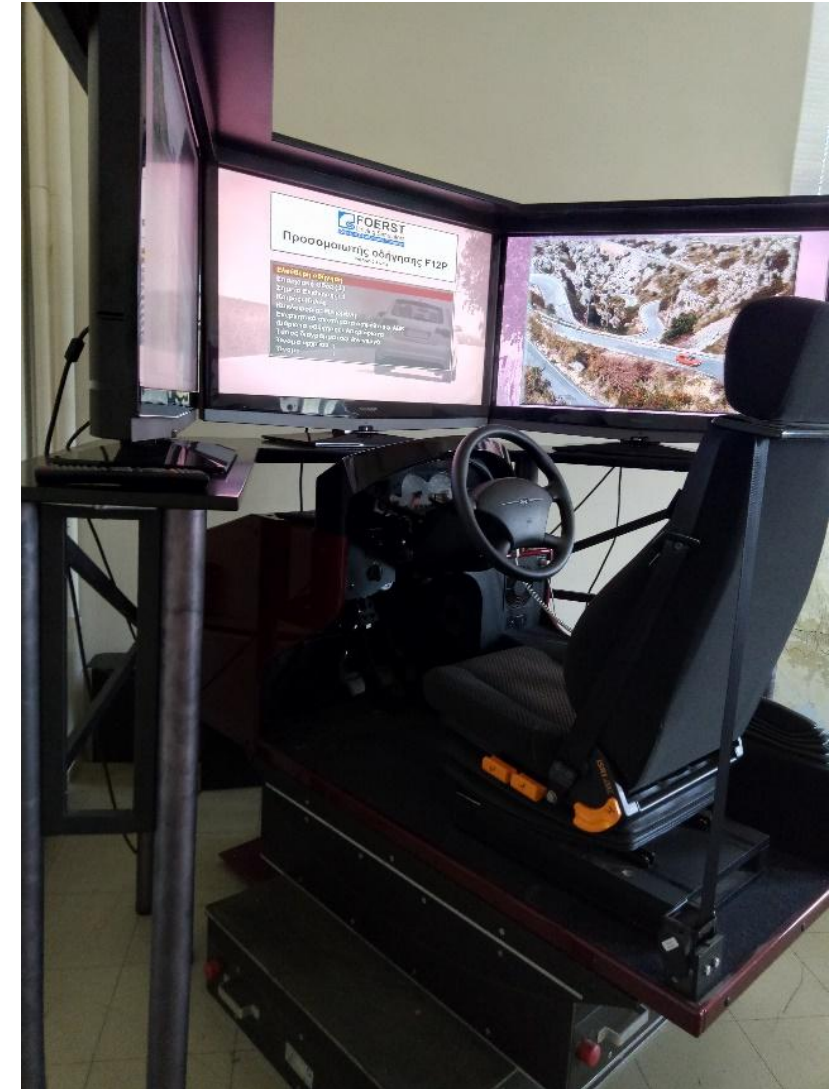
Participants & Driving Simulator

Participants

- 35 young drivers (18–30 years old)
- 23 males and 12 females
- Average driving experience: 5 years
- Valid driving licence holders
- Questionnaire on demographics and driving habits

Driving Simulator

- NTUA fixed-base driving simulator
- 3 × 40" Full HD screens
- 170° field of view
- Manual transmission (5 gears + reverse)
- Steering wheel, pedals, lights and horn controls



Experimental Design

- **Within-subject** experimental design
- Road Environment: **urban route** (1.7 km, guardrail-separated roadway)
- **Unexpected Events**
 - Sudden pedestrian appearances
 - Used to assess reaction time and crash involvement
- **Experimental controls**
 - Counterbalanced order of scenarios
 - Familiarization session before testing
 - Rest period between sessions



Scenarios	Lighting	Traffic
	Daytime	Low traffic (300 veh/h)
	Daytime	High traffic (600 veh/h)
	Nighttime	Low traffic (300 veh/h)
	Nighttime	High traffic (600 veh/h)

Methodology

- **Statistical models** were estimated for mean speed, reaction time and crash probability.
- Driver characteristics, traffic conditions and behavioural indicators were included as **explanatory variables**.
- **Linear regression** was applied to continuous outcomes, while **logistic regression** was used for crash occurrence.
- **Sensitivity analyses** were performed to investigate the effects of nighttime driving across different driver groups and conditions.



Descriptive statistics

- **31%** of participants reported involvement in a nighttime property-damage crash.
- **11%** reported involvement in a nighttime injury crash.
- **42%** did not reduce their speed when driving at night, despite reduced visibility.
- Although most participants considered nighttime driving riskier, only **9%** would avoid driving at night.

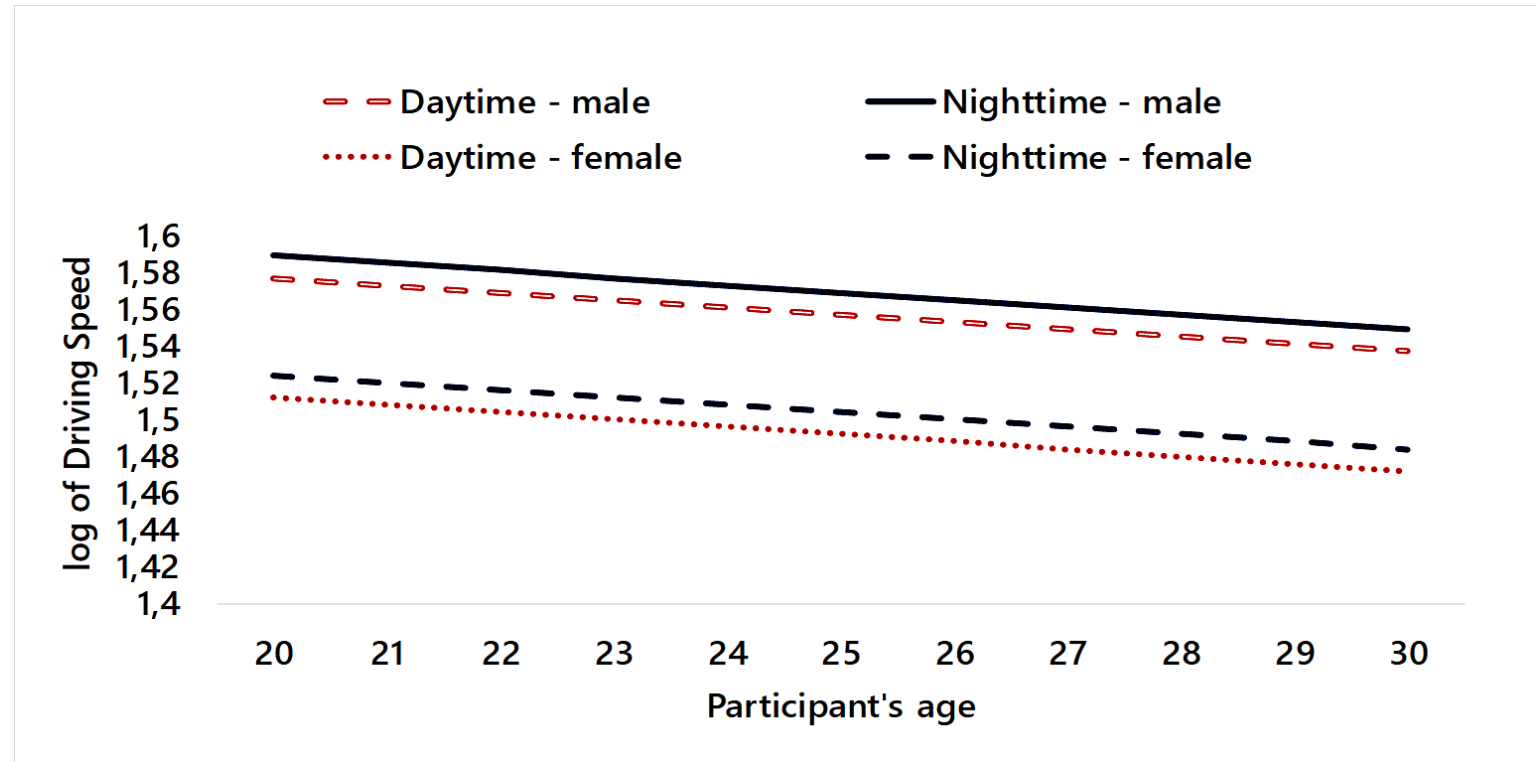


Results - Mean Speed (1/2)

Independent variables	β_i	t	p value	Elasticity (ei)	Rel. elasticity (ei*)
Constant	1.682	39.849	<0.001		
Nighttime driving	0.012	1.842	0.042	-0.004	1
Traffic conditions	-0.044	-4.030	<0.001	-0.015	-3.752
Average of the distance from central axis	-0.019	-3.231	0.002	-0.038	-9.527
Age	-0.004	-2.764	0.007	-0.067	-16.753
Gender	-0.018	-2.127	0.035	-0.016	-4.000
Driver Avoids Driving At Night	-0.047	-4.299	<0.001	-0.007	-1.753
Self-reported crash during daytime	0.023	2.855	0.005	0.007	-1.753
R ²	0.615				

Results - Mean Speed (2/2)

- Sensitivity analysis confirmed the stability of the estimated effects across participant characteristics.
- Driving speed decreased with age for both genders.
- Nighttime driving and male gender were associated with higher driving speeds.

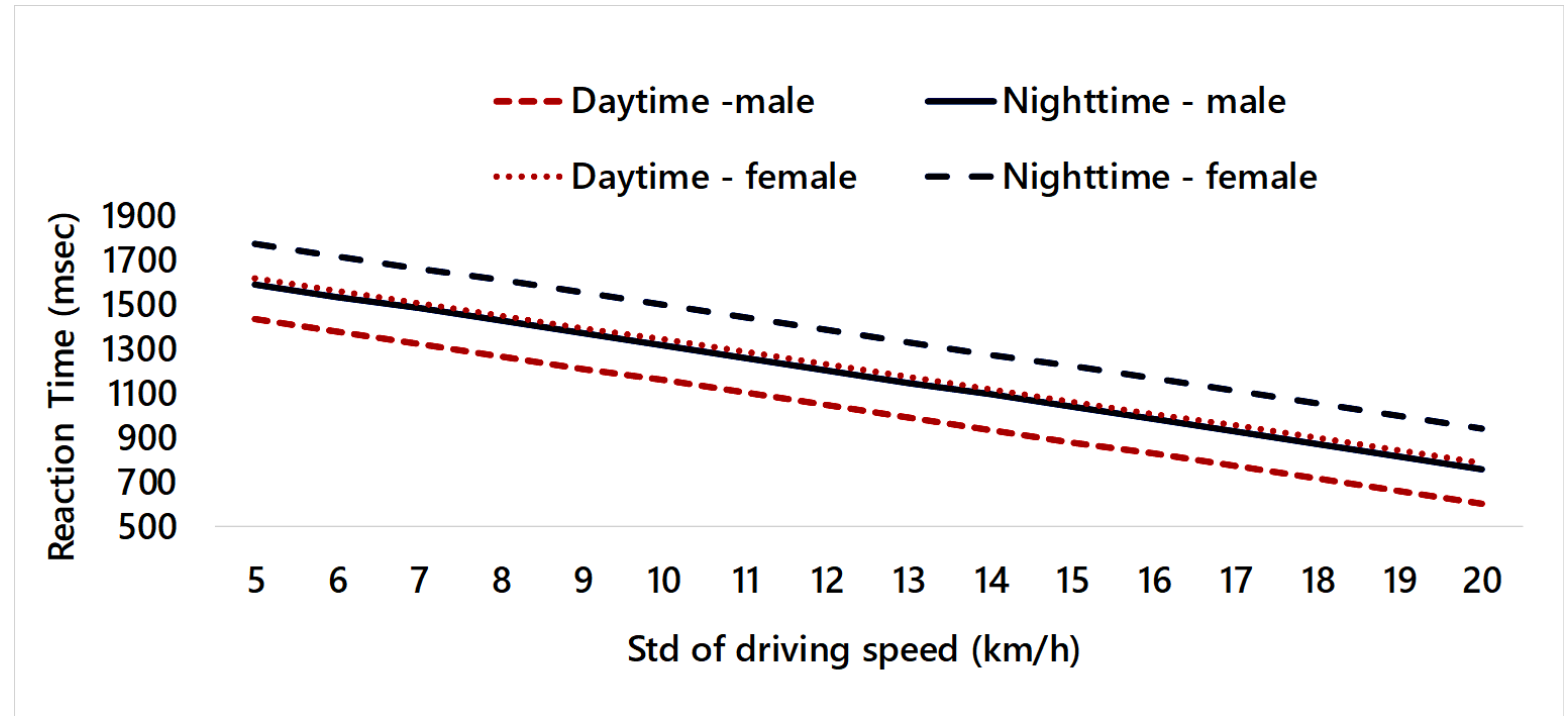


Results - Reaction Time (1/2)

Independent variables	β_i	t	p value	Elasticity (ei)	Rel. elasticity (ei*)
Constant	1526.670	5.969	<0.001		
Nighttime driving	157.475	2.143	0.035	0.116	1
Gender	182.622	2.415	0.018	0.338	2.917
Std of Driving Speed	-55.343	-3.539	0.001	-1.030	-8.910
Speed reduction at nighttime driving	-192.357	-2.634	0.010	-0.428	-3.693
R ²	0.420				

Results - Reaction Time (2/2)

- Sensitivity analysis supported the stability of the estimated effects.
- Higher speed variation was associated with shorter reaction times.
- Both male and female drivers demonstrated quicker reactions during daytime than nighttime driving.

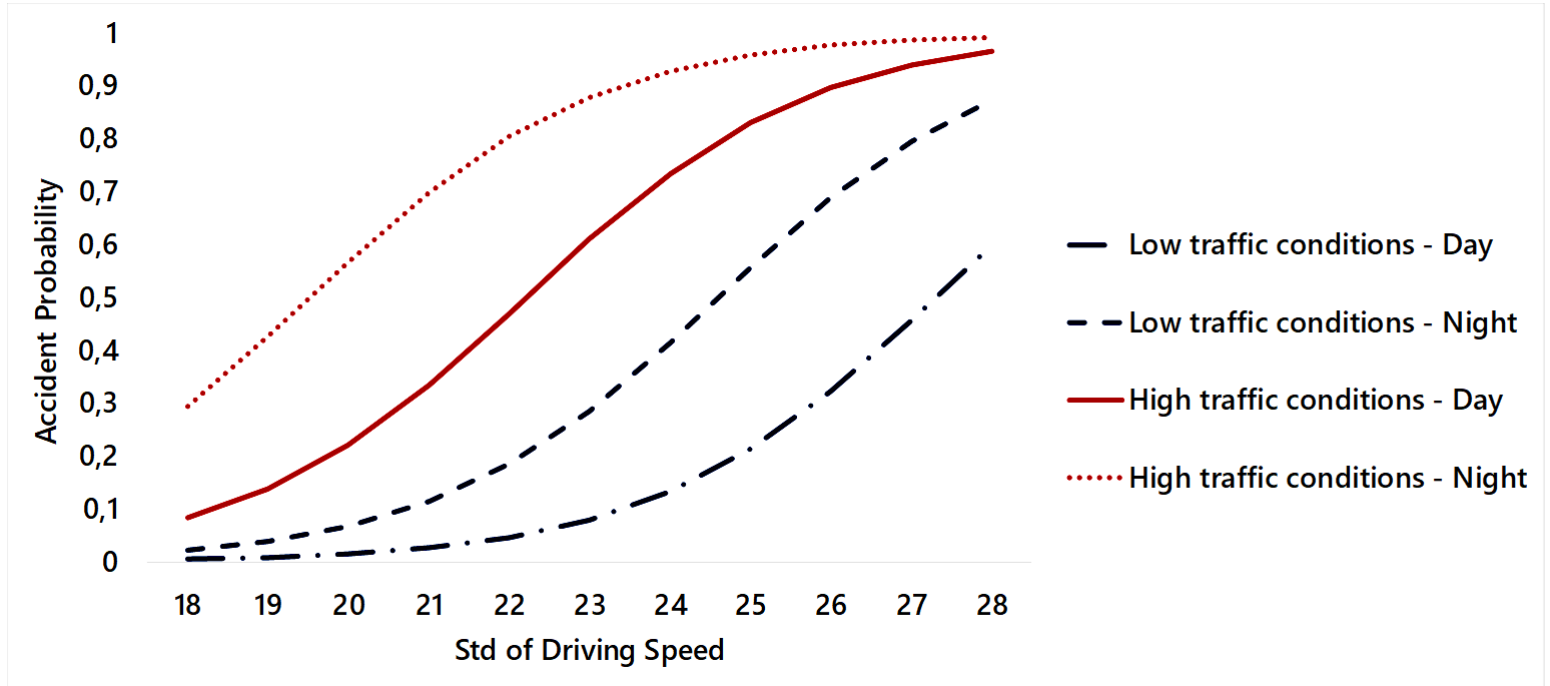


Results - Crash Probability (1/2)

Independent variables	β_i	Wald	p value	Elasticity (ei)	Rel. elasticity (ei*)
Constant	-22.304	12.530	<0.001		
Nighttime driving	1.531	4.567	0.035	1.860	2.623
Traffic conditions	2.897	5.726	0.017	8.254	11.626
Gender	2.853	7.075	0.008	1.363	1.925
Standard Deviation of Driving Speed	0.570	7.029	0.008	4.910	6.919
Average of the distance from central axis	1.297	4.172	0.040	2.447	2.570
Driver's reduced perception of real distances when driving at night	4.993	8.691	0.003	0.715	1
Hosmer & Lemeshow test	0.611				

Results - Crash Probability (2/2)

- Sensitivity analysis supported the stability of the estimated crash-risk effects.
- Crash probability was consistently higher during nighttime driving.
- The highest crash probabilities were observed under high traffic conditions, highlighting the combined effect of traffic density and reduced visibility.



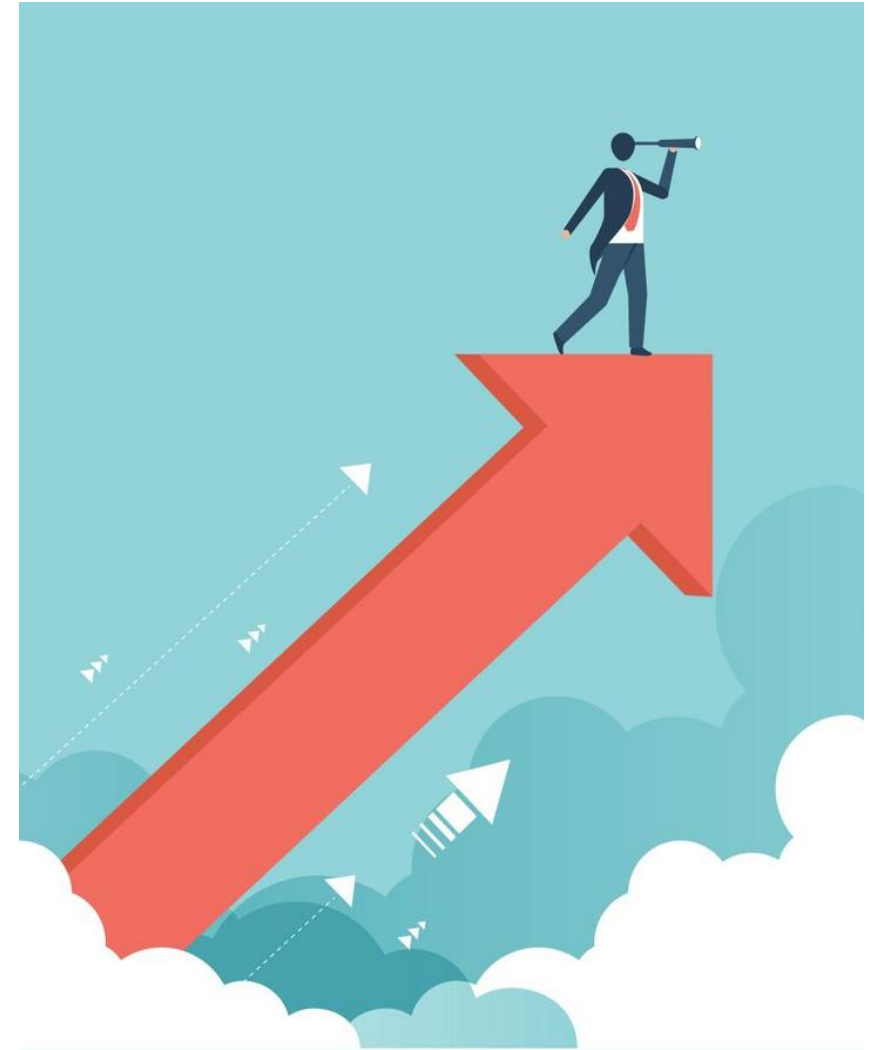
Conclusions

- **Nighttime driving significantly affected** the behaviour and safety of young drivers.
- Drivers tended to travel at **higher speeds under nighttime** conditions than during daytime driving.
- **Reaction times increased** at night, indicating slower responses to unexpected events.
- Nighttime driving was associated with a significantly **higher probability of crash** occurrence.



Future research

- Investigate **larger and more representative** samples across different age groups.
- Examine the effects of nighttime driving in **different road environments**, including rural roads and motorways.
- Assess the combined impact of nighttime driving and **adverse weather conditions** on driver behaviour and safety.
- Validate the findings using **naturalistic driving data** and additional statistical modelling approaches.





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