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Investigation of traffic and safety behavior of pedestrians while talking on mobile phone

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Introduction

- An important aspect of road traffic injuries' problem is vulnerable road users such as pedestrians, cyclists and motorcyclists.
- Pedestrians suffer, due to their vulnerability to the speed of vehicles and increased exposure to multiple vehicles in high traffic volumes.
- In 2019, there were 145 pedestrian fatalities in Greece (21% of all road fatalities).
- Pedestrian actions and behavior may account for 15% of pedestrian fatalities (Thompson et al., 2013).
- The expansion of mobile phones has caused a rising number of pedestrians who use mobile phones in their daily traffic activities by the roadside or even when crossing the street.

Objectives

- To investigate the impact of hand-held cell phone conversation on pedestrians' traffic and safety behavior, when crossing signalized intersections.
- Examine the differences between the behavior of distracted and non-distracted pedestrians.
- Analyze data derived from an experimental process through video recording in real road conditions.

Data Collection (1/2)

- An experimental process through video recording was carried out in real road conditions, in three signalized intersections in the center of Athens in Greece, in spring 2019 (daylight, peak hours, good weather conditions).
- The selection of the pedestrian crossings was based on the high pedestrian volumes typically found in the area, ensuring sufficient sample size, and the presence of a pedestrian traffic light on each crossing.
- Pedestrian crossings chosen:
  - Akadimias Street (3 lane road) at intersection with Ippokratous Street
  - Ippokratous Street (2 lane road) at intersection with Akadimias Street
  - Skoufa Street (1 lane road) at intersection with Filikis Eterias Square

Data Collection (2/2)

- The extracted data used for this study were:
  - Pedestrian distraction
  - Pedestrian gender
  - Pedestrian age estimate 0-17 (child), 18-34 (young), 35-64 (middle) and 65+ (old)
  - Pedestrian crossing length and width
  - Crossing time
  - Pedestrian speed
  - Number of road lanes
  - Pedestrian volume
  - Pedestrian accompanied by someone else
  - Pedestrian traffic lights
  - Pedestrians' trajectory
  - Conflict with other pedestrian
  - Illegal vehicle passing
  - Vehicle on crossing
  - Weekday
  - Waiting time for pedestrian green light
  - Near miss (temporal headway between pedestrian and vehicle less than two seconds)

- The videos were examined frame by frame with the ability to pause and rewind all the pedestrian times and the calculation of pedestrian speed (m/s) was cross-checked by multiple researchers.

Distraction	Count	Percentage
Texting or web-surfing	142	6.2%
Music (headphones)	124	5.4%
Talking	113	5.0%
No distraction	1,901	83.4%
Total	**2,280**	**100.0%**

Methodological Approach

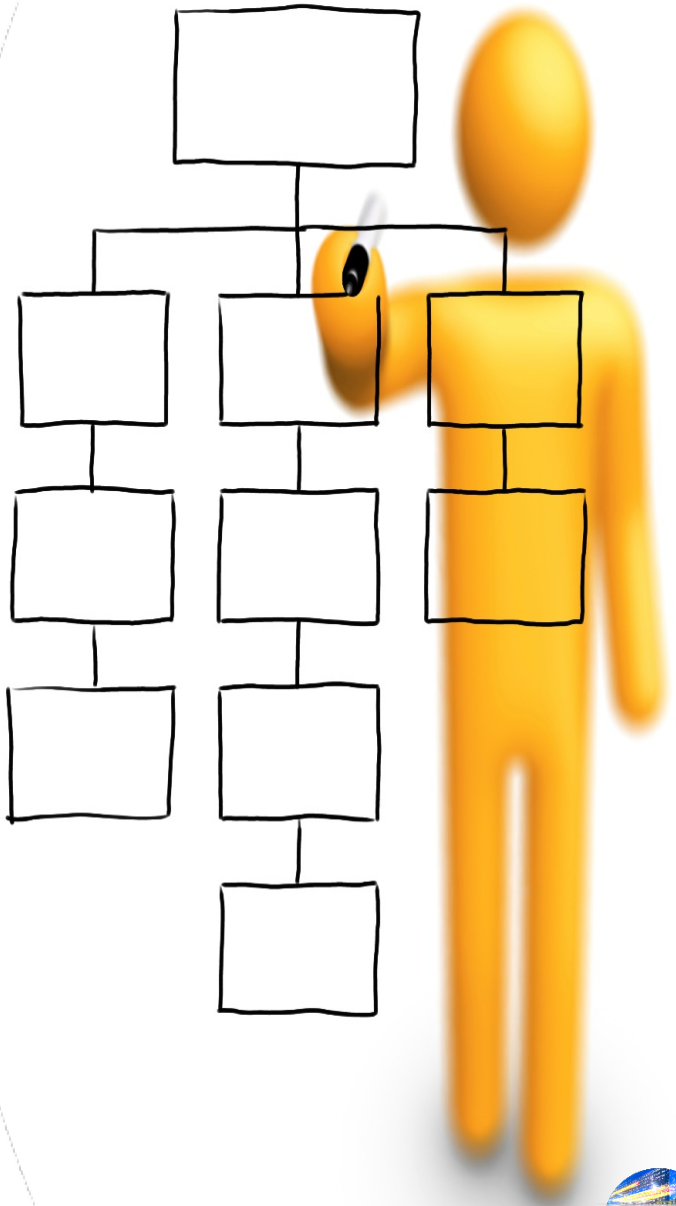
- Statistical analyses were carried out using two modelling approaches; multiple linear regression and binary logistic regression models.

- The basic equation of the multiple linear regression model is $Y_i = \beta_0 + \beta_1*X_{1i} + \beta_2*X_{2i} + \ldots + \beta_v*X_{vi} + \varepsilon_i$ and the accuracy of the model is assessed through the coefficient of determination R squared.

- Where the dependent variable is binary, binary logistic regression is the statistical technique used to predict the relationship between predictors and a predicted variable.

- If the "utility function" is given by $U=\beta_0+\beta_i*X_i$, then the probability P is given by $P=e^U/(e^U+1)$.

- The goodness of fit of the logistic regression model can be assessed with the Hosmer & Lemeshow Test.



Models for Pedestrian Speed (1/3)

Independent Variables	β_i	t	Sig.
(Constant)	0.150	6.071	0.000
Distractionhand-yes	-0.021	-2.037	0.042
Gender-male	0.023	2.845	0.005
Age	-0.034	-6.992	0.000
Accompanied-yes	-0.060	-6.266	0.000
Trajectory-direct	0.029	3.160	0.002
Pedestrian light-green	-0.057	-6.125	0.000
Pedestrian volume	-0.002	-3.302	0.001
Number of lanes	0.013	7.434	0.000
Adjusted R^2		**0.363**	

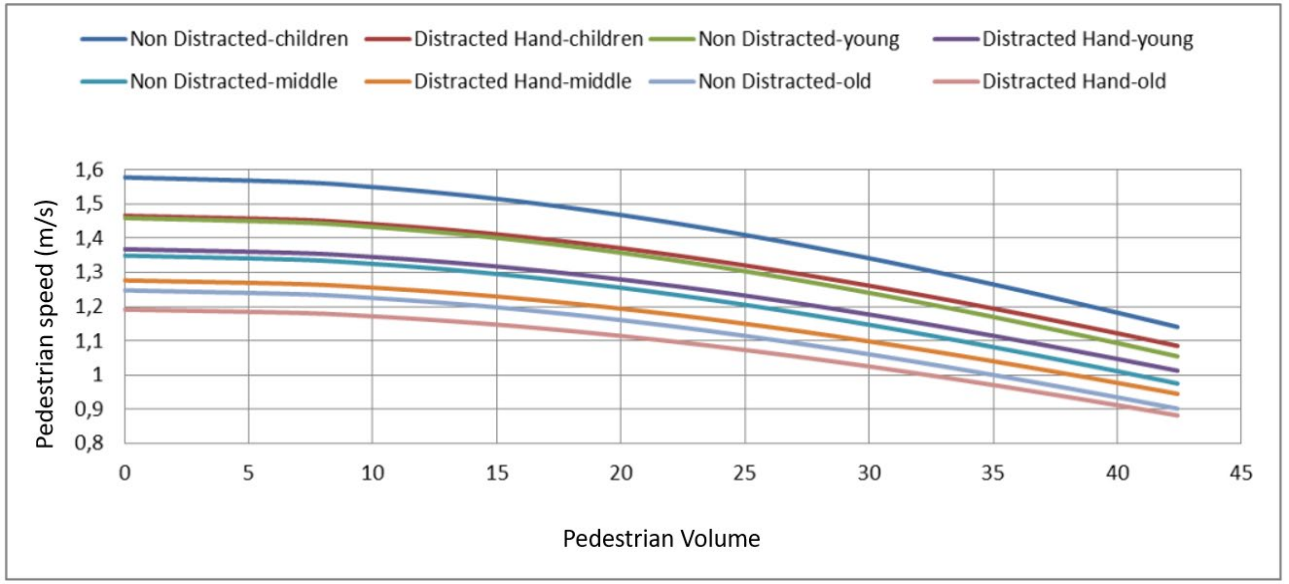
- Initially, a linear regression model was developed for the logarithm of pedestrian speed including distraction caused by hand-held phone conversation as one of the independent variables.
- Distraction caused by hand-held mobile phone conversation decrease the average pedestrian speed.
- However, including "distraction" as one of the independent variables in the statistical models reveals general results focused on the traffic characteristics of both distracted and non-distracted pedestrians, which was not the primary objective of this study.

Models for Pedestrian Speed (2/3)

	Distracted Pedestrians			Non-Distracted Pedestrians		
Independent Variables	**β_i**	**t**	**Sig.**	**β_i**	**t**	**Sig.**
(Constant)	0.196	5.517	0.000	0.232	13.067	0.000
Conflict-yes	-0.044	-1.749	0.083	-0.032	-2.491	0.013
Age	-0.030	2.261	0.026	-0.034	-5.841	0.000
Accompanied-yes	-0.068	1.940	0.055	-0.063	-5.759	0.000
Pedestrian volume^2	$-7.255*10^{-5}$	2.728	0.007	$-7.831*10^{-5}$	-6.226	0.000
Adjusted R^2	**0.179**			**0.243**		

- Therefore, a different approach was chosen. More specifically, the selected approach involved calibrating statistical models separately for distracted and non-distracted pedestrians.
- The independent variables affect similarly the speed of distracted and non-distracted pedestrians, as the signs of the β coefficients are the same in both cases.
  - The negative sign of "Conflict" variable shows that if a conflict occurs between the examined and another pedestrian, pedestrian speed decreases.
  - The variable "Age" has a negative relationship with the dependent variable, indicating that as pedestrian age increases, the speed of the pedestrian decreases.
  - The negative sign of "Accompanied" variable demonstrates that if someone else accompanies the examined pedestrian, pedestrian speed decreases.
  - Pedestrian speed is lower for higher pedestrian volumes.

Models for Pedestrian Speed (3/3)



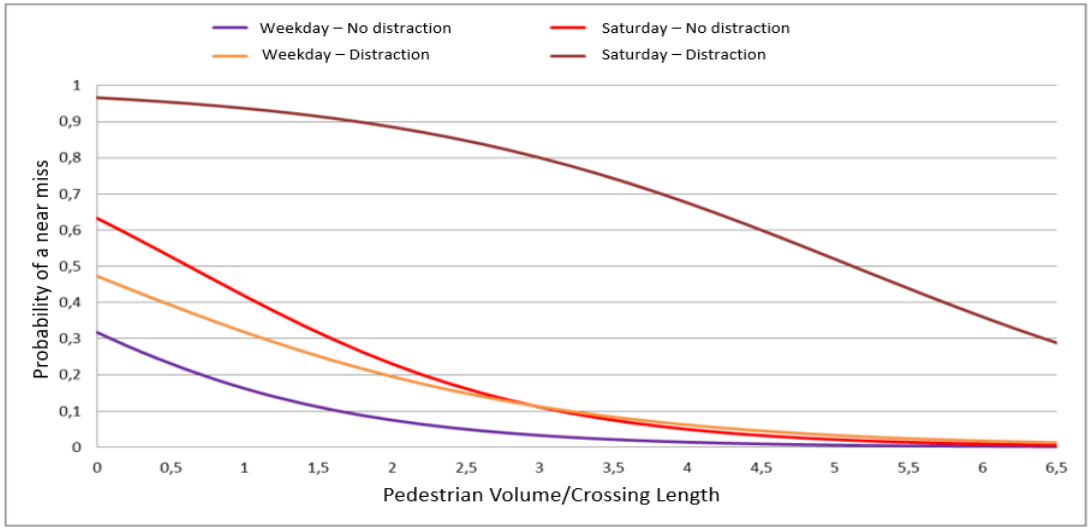
- In order to complement the results of the statistical models and visualize the influence of the examined explanatory variables on the speed of distracted and non-distracted pedestrians, sensitivity analysis was also conducted.
- In case of non-accompanied pedestrians and without conflict among examined pedestrians, for all age groups, non-distracted pedestrians present higher speeds than distracted pedestrians regardless of the pedestrian volume, indicating clearly that distraction due to hand-held phone conversation leads to a reduction in pedestrians' speed.

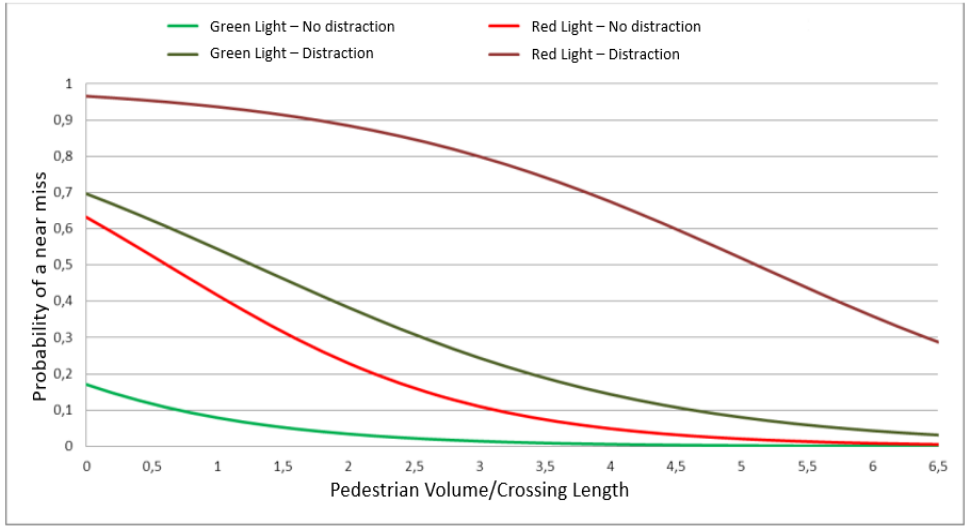
Models for Near Misses (1/2)

	Distracted Pedestrians			Non-Distracted Pedestrians		
Independent Variables	**β_i**	**Wald**	**Sig.**	**β_i**	**Wald**	**Sig.**
Weekend	3.458	4.641	0.031	1.311	2.773	0.096
Vehicle on crossing-no	-3.989	8.201	0.004	-2.437	8.518	0.004
Red pedestrian light	2.514	5.075	0.024	2.119	6.620	0.010
Ped.Volume/Cross.Length	-0.654	3.857	0.050	-0.876	15.152	0.000
Crossing Length^2	-0.040	7.327	0.007	-0.044	12.066	0.001
Hosmer & Lemeshow Test		**0.996**			**0.638**	

- The p-value of Hosmer & Lemeshow Test for goodness of fit is higher than 0.05 indicating that one cannot reject the null hypothesis of the test for both models, which means that these models can be considered as acceptable.
- The results indicate for both models the following:
  - The positive sign of the variable "weekend" shows that there is an increase in the probability of a near miss on weekends.
  - There is a decrease in the probability of a near miss when there is no vehicle on the pedestrian crossing.
  - Both distracted and non-distracted pedestrians who started walking through the pedestrian crossing when the pedestrian traffic light was red present higher probability of a near miss.
  - The sign of pedestrian volume divided by the pedestrian crossing length is negative indicating that an increase in this variable leads to lower probabilities of a near miss.
  - The probability of a near miss is higher for pedestrian crossings with lower crossing length.

Models for Near Misses (2/2)





- Two additional sensitivity figures have been developed in order to better understand the influence of the independent variables to the probability of a near miss occurrence.
- It can be observed that distracted pedestrians are most likely to be involved in a near miss on weekends when there is a vehicle on the crossing and the pedestrian traffic light is red.
- Moreover, on weekends, when there is a vehicle on the pedestrian crossing, distracted pedestrians are more likely to get involved in a near miss compared to non-distracted pedestrians regardless of whether they are crossing the road legally or not.

Conclusions

- Distraction caused by hand-held cell phone conversation **affects negatively** pedestrians' main traffic and safety characteristics.
- For all age groups, distracted pedestrians who were talking on their mobile phone present **lower speed** than non-distracted pedestrians, regardless of the pedestrian volume, and therefore they have **higher crossing times.**
- Moreover, mobile use not only decreases pedestrians' speed but also **increases their probability** of being involved in a crash with an oncoming vehicle.

Recommendations

- Educational campaigns aiming to sensitize pedestrians to the risks of talking on the mobile phone while crossing the street.
- A type of restriction on walking while using a mobile phone (as compared to the driver mobile phone prohibition) might be foreseen in busy roads where road collisions involving pedestrians are a frequent phenomenon.
- Mobile applications warning pedestrians that they are moving towards a pedestrian crossing or that a vehicle is approaching them.
- Engineering solutions in the design of road crossings and public places (e.g. green and red lights on the ground).

Future Research

- More results could be obtained by observing the same variables on a larger sample of pedestrians.
- Expand the experiment in signalized intersections located in different areas and conduct a comparative analysis to identify which pedestrians incur higher risks.
- Carry out the same experiment during the nighttime in order to identify the differences in pedestrians' behavior between nighttime and daylight hours.
- Take into account traffic volume.

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