EFFECTIVENESS OF A PEDESTRIAN MEASURE IN AN ARTERIAL STREET IN THESSALONIKI , GREECE: FIRST RESULTS

Pantelis Kopelias, Panos Papaioannou, Joanna Vasiliadou

Civil Engineering Department, Transport Section, Aristotle University of Thessaloniki
54006 Thessaloniki, Greece
Fax: +30-31-995789
e-mail: Kopelias: kope@civil.auth.gr
Papaioannou: papa@vergina.eng.auth.gr
Vasiladou: jane@civil.auth.gr

ABSTRACT

According to National Statistical Data, pedestrians are responsible for 70% of the number of accidents involving a pedestrian in Greek urban areas. Pedestrians often reveal offensive behaviour (crossing roads away from the pedestrian crossings, violating red signals) as well as other dangerous manners like walking across the streets, sudden direction changing, careless road-entering etc.

The purpose of this paper is to present the first results of a study on the behaviour of pedestrians at a city-centre main arterial road in Thessaloniki Greece. The pedestrian behaviour is examined against measures implemented to improve pedestrian safety at that area where both high traffic and pedestrian volumes occur.

The study results show that even after the implementation of restraint measures, the risk undertaken from the pedestrians seems to remain the same: no significant reduction of the number of illegal crossings has been observed. On the contrary, due to the nature of the specific measure, the exposure time after the implementation of the safety measure almost doubles.

INTRODUCTION

According to relevant bibliography, safety effects for pedestrians are significantly related to perceived risk and exposure to traffic. Of course, road characteristics, traffic volumes and pedestrian - driver behaviour have an effect on safety too. But in case of comparing two sites of similar traffic conditions and pedestrian behaviour patterns, differences in safety may be measured by the pedestrian exposure to traffic.

Based on this theory, this paper attempts to give a picture of the most common pedestrian behaviour with and without measures to improve pedestrian safety in central city areas and to estimate the impacts of the safety measures to the expected safety level. The total exposure time for pedestrians is calculated for areas with and without the implementation of specific safety measures. In doing so, a number of indices and estimators are used, based on collected data for this purpose.

DESCRIPTION OF THE CASE STUDY

In the city of Thessaloniki in Greece, as in any other cities in the country, the safety problem, especially for the pedestrians, is an increasing one. The rapid increase of motor vehicles

coupled with the increased mobility of the population results in high levels of exposure for both the vehicles and the pedestrians. The so-called traffic problem is ranked among the first priority problems in most of the Greek cities and in Thessaloniki too. Regardless of the reasons for not having a concrete and effective city transport plan, there is a pressure for improving the overall situation by implementing small scale measures such as physical, reconstruction of sidewalks, pedestrianisations where possible etc. This trend also caters for improving the aesthetics of the build areas especially in the commercial and local centres where a lot of people are gathered.

In this manner, an ambitious program began some time ago by the Local Authority of the Municipality of Thessaloniki to upgrade the biggest part of Tsimiski str., one of the most important and central streets in the historical city centre.

Tsimiski str. is an arterial one-way road with four lanes and a total length of approximately 2,4 kms. The right lane is a reserved bus lane for most of the road length. Tsimiski str. is located at the most commercial area of the city centre. In the morning peak it accommodates approximately 5500 vehicles per hour, serving some 7 different bus lines. Most of them cover a great geographical area in the east since the direction of the road is from the east to west.

The sidewalks of the street are usually full of pedestrians who either visit the shops or the other commercial areas, not forgetting that many recreation areas are also located in the area. From filed data it has been found that approximately 3600 pedestrians per hour in the peak periods make use of each sidewalk on Tsimiski everyday.

Tsimiski Street is crossed by several streets (see Figure 1), most of which are controlled by traffic signals. Thus a number of designated pedestrian crossings exists along the road. However, a common phenomenon is the crossing of the road by the pedestrians at any point of the road and regardless of the fact that after a few meters a pedestrian crossing may be available.

Many efforts had been undertaken in the past, to restrain pedestrians from crossing (jaycrossing) the street, including strict enforcement with pedestrian booking, predictive enforcement etc. However none of them really worked. Since some locations of the road seem to be black spots, the Municipal authority decided to put sidebars along the street taking chance of the reconstruction project of the sidewalks. The idea has been to prevent pedestrians from crossing the road at any point and channel them to the designated crossings. The installation of these sidebars has started since the summer of 2000 and is still on progress.

According to the detailed design of this project, certain gaps along the sidebars exist for two different purposes. First to facilitate the litter vehicles to collect the litter from the litter baskets and second to allow taxis boarding and disembarking at designated taxi lay-bys along the right lane, since that is a bus-only lane.

METHODOLOGY

Site description

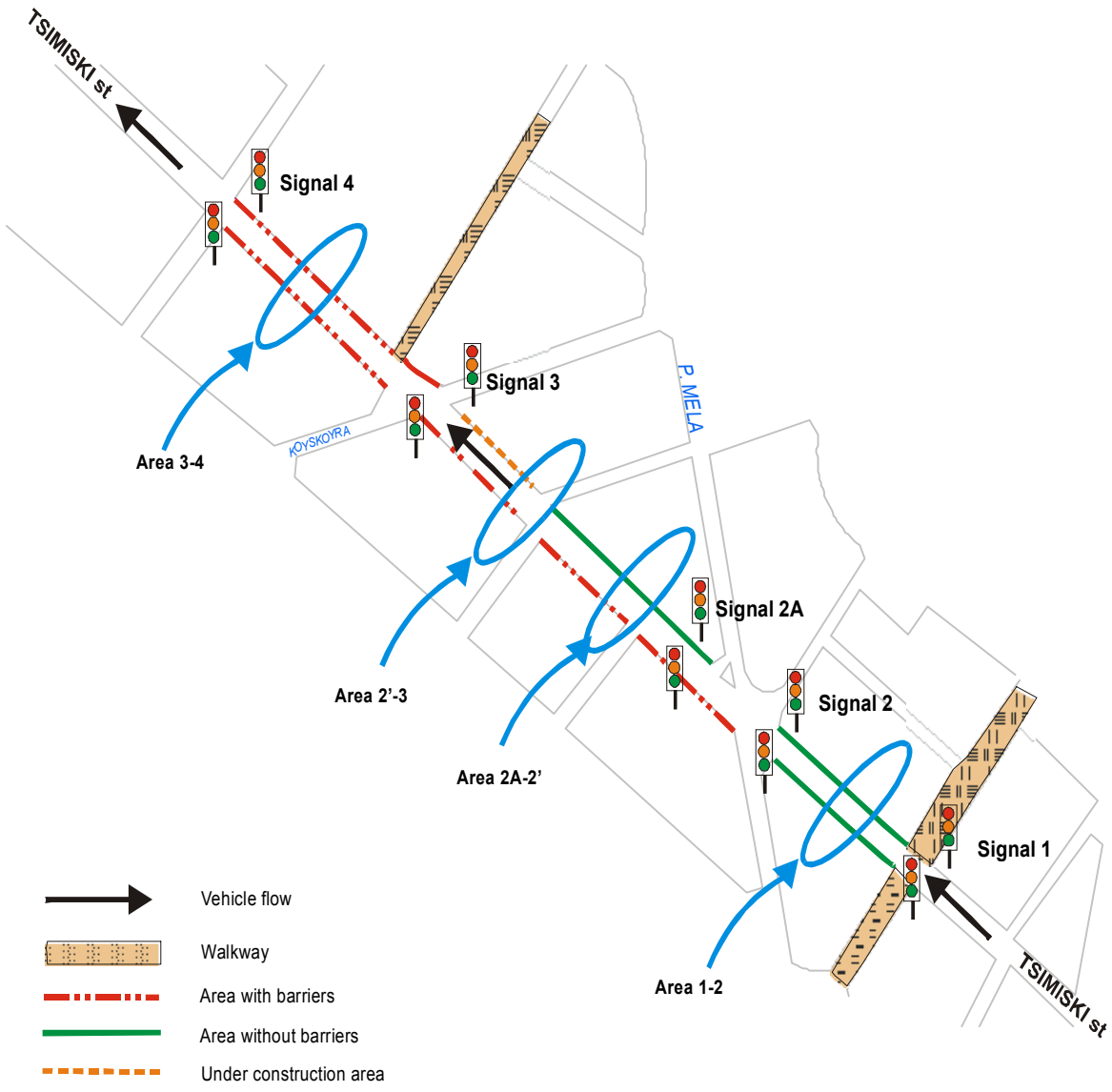
The selected road segment has a total length of 400 meters and contains 10 different block sides. The study was conducted during the implementation phase of the measure, in order to examine every possible case: road segments with no sidebars on the sidewalks, road segments with sidebars on one sidewalk and road segments with sidebars on both sidewalks (Figure 1).

The methodology adopted within this study consisted of two main parts: observations and questionnaire survey that took place during the afternoons of 2 summer days. During the summer evenings, while the stores are closed, Tsimiski is a street of low traffic and

pedestrian volumes and no parked cars on the sidewalks. Therefore, the selected time and days secure the most unobstructed conditions for the pedestrian behaviour i.e. the pedestrians are not forced in their acting on the street.

As shown in Figure 1, each area is served by two signalised (the two nearest) intersections or crossings. Each midblock area is named after the two closer signals.

***Figure 1**. The study area*



The geometric and traffic characteristics of the sidewalks are described in Table 1 and refer to the conditions of the day and time of observations.

***Table 1**. Geometric and traffic characteristics of the sidewalks*

Area	Sidewalk *(based on the way of traffic flow)*	Length (m)	Effective width* (m)	Pedestrians / 15min	LOS*
1-2	Left	85	4,5	43	***A***
	Right	85	4,25	67	A
2A-2'	Left	125	2,00	58	A
	Right	115	3,00	72	A
2'-3	Left	85	4,25	85	A
	Right	60	3,50	104	A
3-4	Left	115	2,5	120	B
	Right	140	3,0	170	B

** Calculated according to HCM method [1]

The observations

To identify the violation behaviour and the exposure time of pedestrians, the pedestrian flows on the sidewalks were measured and the number of crossings at signals and crossings in the mid-blocks areas were recorded. For each pedestrian, the sex and the age were recorded in three main categories: Y-young (<18), M-middle age (18-60), O-Older (>60).

The total exposure time of pedestrian crossings composed by three different factors:

1. The *waiting time on the road (WT)*, which is the time standing on the edge of road, after the pedestrian's decision to cross the road from a specific point and before he starts crossing the road. This time depends, among others, on the road's traffic and parking conditions.

If there are parked cars along the sidewalks, the waiting area (or hold area [1]) for pedestrians extends to the road for a length equal to the parked car width. In the case of our study, there were no parked cars on either side of the street. Additionally, the right lane of the road is used as a bus lane. Therefore, the observed average waiting time in all areas was quite short.

2. The *crossing time (CT),* which is the time that the pedestrian uses to cross the road from one side to the other. A lot of researchers have studied this specific matter in relation to pedestrian behaviour on crossings and the time of pedestrian crossing. They have observed the tactics [2,3], determined the subjective risk and the abilities of some groups of population [4], analysed the accidents on pedestrian crossings in relation with the complexity of traffic environment, the type of pedestrian facilities and personal characteristics of pedestrians [4,5] and suggested the crossing speed of average, older adult and mobility impaired pedestrians [6].

In this case, the main hypothesis is that the combination of population using the sidewalks of this road is similar at all sites. Additionally, the selected traffic conditions (low traffic volumes, big gaps between oncoming vehicles) that allow a significant degree of freedom to pedestrian to cross the street without interruptions (like change of direction, stops in the middle of the road, walking in direction of the vehicles etc) remained the same along the study area.

3. The walking on the road-edge time (WET), which is the time after the pedestrian crossing and before he enters in the sidewalk. This move refers only to the pedestrians who ended their crossings at a point with no possible entrance to the sidewalks. In fact, this time has been measured only for the pedestrians who crossed the road to a side with sidebars and walked until they reached the first gap of the sidebars. WET precedes WT in the case when the pedestrian starts walking on the road before crossing.

The age distribution of the observed pedestrians at each point (signal or mid-block) followed the actual age distribution of the pedestrians at the respective point.

Table 2 shows the total number of pedestrian crossings per hour by sex and age[1].

***Table 2**. Total number of pedestrian crossings, by sex and age*

	Sex		Age		
	M	*F*	*Y*	*M*	*O*
Signal 1,2 and area 1-2	373	306	95	385	199
Signal 2A,3 and area 2A-2', 2'-3	421	320	89	389	263
Signal 3,4 and area 3-4	667	503	140	580	450

The questionnaire survey

A questionnaire survey was conducted along with the observations survey, in order to investigate the pedestrians' opinion about the measure and the possible effect on their behaviour. The sample consisted of 128 pedestrians, which were interviewed while the observations were taking place. The sample sex and age distribution was:

- 41% women-59% men
- 15% younger than 18 years old, 67% between 18-60 and 18% over 60 years old

RESULTS

Observations results

One main result is that pedestrians tend to cross the street illegally, regardless of the existing barriers. When barriers were covering the point at which pedestrians ended their crossing, pedestrians either walked on the street in order to find a gap to enter the sidewalk or passed over the barriers (jumped). This action was observed for 94% of the young or middle age male pedestrians.

Waiting time

Table 3 shows the changes of waiting time for pedestrian crossings at each mid-block taking into account two hypothesises:

- Area 1 is similar to the situation before the barriers installation (no barriers yet at this area)
- The population combination is homogeneous in the study area

As shown, the waiting time in area with barriers on both sidewalks is 48% longer than at the area with no barriers. The statistical differences are significant at the 95% Confidence level.

[1]The number of pedestrians on the right sidewalk of area 2'-3 was impossible to be recorded because of the constructions

Table 3. *Changes in waiting time*

	Before (without barriers)	After (with barriers) on one side		on both
	Area 1-2	*Area 2A-2'*	*Area 2'-3*	*Area3-4*
WT (sec)	5,8	6,36	7,10	8,54
change		+10%	+22%	+48%
		t=2,84	***t=4,76***	***t=5,12***

Crossing time

Table 4 shows the changes in clear crossing time for each area. The crossing time at the area with barriers increases significantly compared to the area with no barriers, because pedestrians tend to cross the street diagonally instead of vertically in order to enter the sidewalk from the nearest gap.

Table 4. *Changes in crossing time*

	Before (without barriers)	After (with barriers) on one side		on both
	Area 1-2	*Area 2A-2'*	*Area 2'-3*	*Area3-4*
CT (sec)	10,56	12,68	11,25	12,39
change		+20%	+6,5%	+17%
		t=4,39	***t=1,25***	***t=4,01***

Walking time

The most significant changes have been observed in walking time. The pedestrians while starting or ending their movement seem to be trapped on the roadway and cannot get back on the sidewalk, because of the barriers. So they have to walk on the road until they find a chance to cross the street or until they find a gap to enter the sidewalk after their crossing.

As shown in Figure 2, the walking time in the area with no barriers is zero. At the other areas the walking time can rise up to 10,7 sec. The number of gaps among the barriers explains the fact that in those areas the time is longer (Table 5). Area 4 has more barrier gaps, therefore pedestrians have to walk for shorter times until they find a chance to enter the sidewalks.

Figure 2. *Walking time at each point of study area*

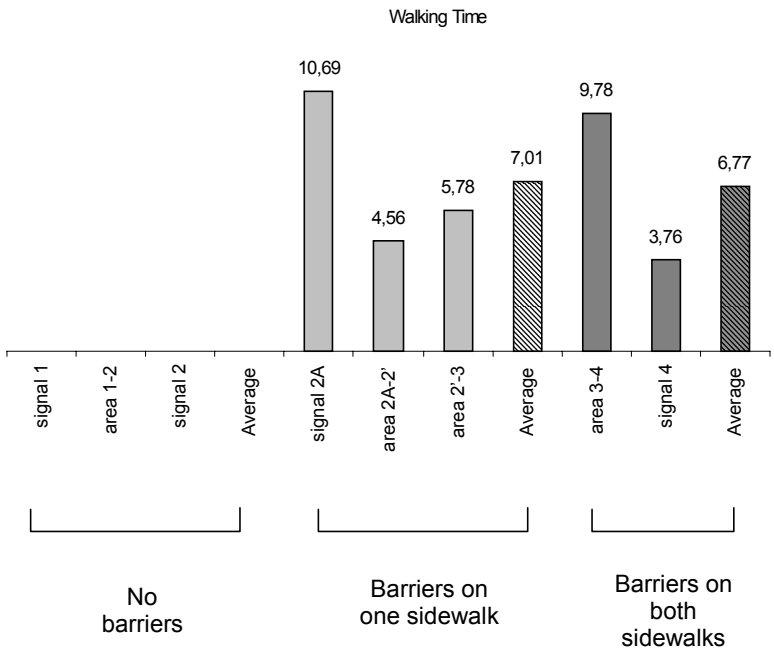


Table 5. *Number of barrier gaps at each block*

Area	Sidewalk	No of gaps
1-2	Left	no barriers
	Right	no barriers
2A-2'	Left	4
	Right	3
2'-3	Left	4
	Right	Under construction
3-4	Left	5
	Right	7

Total times

Table 6 shows the total time needed to cross the street at each point of the study area. The main result of the calculated total exposure time is that the time of exposure to traffic flow at the area with barriers is approximately two times greater than the respective time at the area without barriers (change 93,6%). The following Table shows the average waiting, crossing and walking time at each point and the number of pedestrians observed waiting, crossing and walking on the road within one hour.

Table 6. *Total pedestrian crossing times by area*

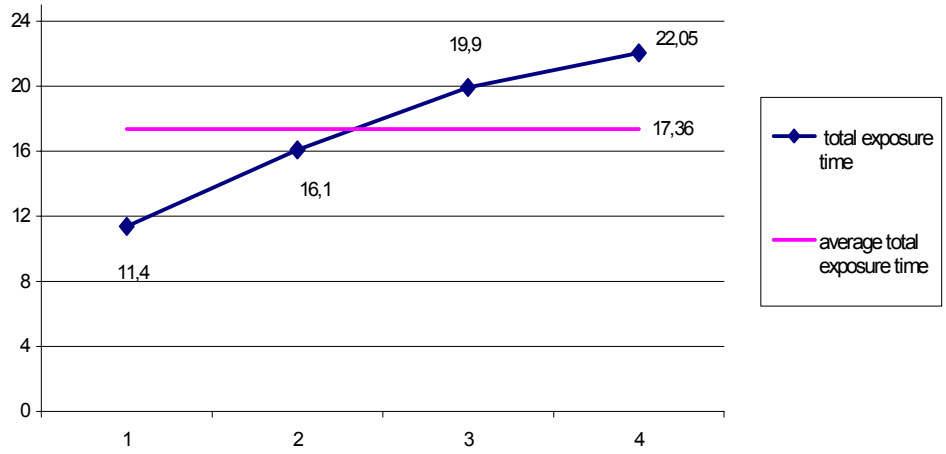
	WT (sec)	N	Subtotal 1	CT (sec)	N	Subtotal 2	WET (sec)	N	Subtotal 3	total	Average time of crossing/pedestrian	Changes (based on area 1-2)
signal 1	7,23	67	484	10,86	534	5799	0,00	0	0	6284	11,77	
area 1-2	5,80	6	35	10,56	42	444	0,00	0	0	478	11,39	0
signal 2	6,54	15	98	10,16	103	1046	0,00	0	0	1145	11,11	
signal 2A	5,76	22	127	10,03	171	1715	10,69	12	128,28	1970	11,52	
area 2A-2'	6,36	24	153	12,68	84	1065	4,56	29	132,24	1350	16,07	+41,1%
area 2'-3	7,10	124	880	11,25	156	1755	5,78	82	473,96	3109	19,93	+67,6%
signal 3*	-	-	-	9,57	330	3158	-	-	-	-	-	
area 3-4	8,54	210	1793	12,39	372	4609	9,78	184	1799,52	8202	22,05	+93,6%
signal 4	3,50	52	182	10,88	468	5092	3,76	116	436,16	5710	12,20	

* Area under construction

As shown in the Figure 3, the average total crossing time is proportionally increasing from the area with no barriers to the one with barriers on both sides. This result indicates that pedestrian behaviour remains the same for every segment.

Compared to the time that pedestrians need to complete their crossings at the area with no barriers, pedestrians at the area with barriers on one side need 50% more time and, moreover, pedestrians at the area with barriers on both sides need 100% more time (see Table 6). Rationally, the fact that pedestrians can see the obstacle (barriers) at the end of their crossing would have an effect on the final route choice or the total crossing time. To the contrary, pedestrians tend to choose the shorter - and unsafe - route than to walk until the nearest crosswalk.

Figure 3. *Average total crossing time and total exposure time for each study area*



Number of violations

A comparison between the number of violations before and after the implementation of the measure is possible only in ***Area 4*** of the study area, since this is the only area where the barriers are placed on both sidewalks.

Observations made 16 months before the measure implementation at this area gave a total number of 397 illegal crossings (Table 7). These "before" observations were made during similar traffic conditions, days and time as those of the "after" observations.

The rather small reduction of illegal crossings (6,7%) is probably due to random changes of the pedestrian flows. Even if this small reduction is a measure impact, the pedestrians' total exposure time in traffic flow has been increased (81,6 %). Based on that result, a total 94% decrease in the number of illegal crossings must be achieved with the barriers' implementation in order to have a reduction to the total pedestrian exposure time.

Table 7. *Before –after comparison of illegal crossings and exposure*

	No of pedestrians	Total crossing time	Exposure (ped x time)
Before (16 months)	397	11,38	4518
After (today)	372	22,05	8203
Change (%)	*-6,70*	*93,7*	*81,6*

There is no significant correlation between the number of illegal crossings at mid-blocks and the crossings at the signals (Table 8) or the traffic flow on the sidewalks. The results in Table 9 show that the number of illegal crossings at the area 4 is significantly greater than it is at the other areas. What is remarkable is that although the pedestrian flow of Area 1-2 is 37,9% of the pedestrian flow at Area 3-4, the number of illegal crossings in Area 1-2 is only 11.3% of the respective number in Area 3-4.

Table 8. *Crossings at signals*

	No of crossings		
	legal	illegal	total
signal 1	432	102	534
signal 2	78	25	103
signal 2A	150	21	171
signal 3	312	18	330
signal 4	444	24	468

Table 9. *Figure comparisons between the study areas*

Area	*1*	*2*	*3*	*1/3*	$2_i/2_{3\text{-}4}$	$1_i/1_{3\text{-}4}$
	Crossings (in mid-block)	*Flow on sidewalk*	*Crossings at signals (total of 2 signals)*			
1-2	42	440	637	6,6%	37,9%	11,3%
2A-2'	84	520	501	16,8 %	44,8%	22,6%
2'-3	156	756	501	31,1 %	65,2%	41,9%
3-4	372	1160	798	46,6 %	100,0%	100,0%

The large number of pedestrian crossings at the area with barriers can be explained as follows: First, a walkway of a high pedestrian flow ends within this area (see Figure 1) unlike the other areas which contain only small cross roads or no cross roads at all (i.e. area 1-2). The second and more important reason is that the time that pedestrians have to walk to the nearest signals at the area 3-4 is 1.54 and 1.23 times the respective times for areas 1-2 and 2-3 (Table 10). This time has been calculated for an average walking speed of 1,2 m/sec.

Table 10. *Time to the nearest signalised crossing for each area*

Area	Time (sec)
1-2	48,27
2A-3	61,54
3-4	75,93

The questionnaire survey results

The general opinion about the measure was extremely positive. The average rating of the measure was 4,2 in a scale from 1 (negative) to 5 (positive). The respective rating for women was 4,3 and for men 3,95. Older people had significantly positive opinion about the measure - 75% of them rated the measure with 5.

The results related to the pedestrians' opinion about the effect of the measure to pedestrian safety were almost the same. The average rating was - even higher - 4,3 (see Table 11). The responses to this question had no significant variations among the different population groups.

Table 11. *Pedestrian responses regarding the measure*

	Average score*
General Opinion	4,2
Effects on safety	4,3

* scale *1* to *5* : 1-negative, 5- positive

When people were asked which – in their opinion – was the measure's most important effect on the sidewalk conditions (see Table 12), a significantly high percentage of the sample expressed the fact that cars cannot park on the sidewalks anymore. This situation is a very common one in almost every Greek city and the fact that the interviewed pedestrians pointed it out shows the degree of dissatisfaction about this situation.

Furthermore, the opportunity to have a pleasant walk and the feeling of order on the walkway came up to a significant number of the pedestrians' responses.

Table 12. *Most important effect on the sidewalk conditions*

Effect*	% of responses
no parked cars	84
pleasant travel –environment improvement	79
other	18

*free answer

Regarding the measure's possible effect on their future behaviour (i.e. if from now on they intend to use the crosswalks), only 26% said that it would chance their behaviour, while another 36% said that it would have no effect on their behaviour (Table 13). Positive answers came mostly from elderly pedestrians (one out of every two). There was no significant response variation among men and women.

Table 13. *Effect on pedestrian behaviour*

Do you believe that this measure is going to change your behaviour in the future?	%
Yes	26
Maybe/I don't know	48
No	36

As far as public awareness is concerned, a significant part of the surveyed people stated that they were not informed about the measure implementation. This is a fact, since no awareness campaign or any other form of publication had been launched prior to the implementation of the measure.

Table 14. Information about the measure implementation

Have you heard or been informed about the implementation of this measure?	%
Yes	9
No	91

CONCLUSIONS

According to traffic accident data, pedestrians are responsible for 70% of the traffic accidents including pedestrians in Greek urban areas because they either cross the streets away from the crosswalks or walk on the road [7]. Even after the implementation of restraint measures, the risk undertaken from the pedestrians seems to remain the same: no significant reduction of the number of illegal crossings has been observed. On the contrary, due to the nature of the specific measure, for a certain number of crossings the exposure time after the implementation of the measure is almost twice the respective number before the implementation of the measure.

The general rule that “the shorter the better” for pedestrians, is supported by the pedestrian statements that a generally accepted measure is not necessarily causing the expected responses. It most likely will cause the pedestrians to adjust their behaviour so as to maintain the previous level of risk. Regardless the fact that the measure is seen as significantly positive one, only one out of five pedestrians is willing to change their behaviour.

Finally, the overall design of the measure is wrong, since it gives the pedestrians the opportunity to cross the street illegally from the several gaps between the barriers. This fact combined with the pedestrians’ stable trend to cross the street away from the crosswalks, make the whole effort ineffective.

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