TRAFFIC MANAGEMENT MEASURES IN GREEK URBAN AREAS. EVALUATION OF THEIR IMPLEMENTATION IN SAFETY THROUGH A QUANTITATIVE AND QUALITATIVE PERSPECTIVE

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ABSTRACT

During the last decades road traffic has grown considerably in major urban areas, leading to negative impacts especially as far as the road safety is concerned. Various traffic management measures implemented in Greek urban areas, had as a primary objective the improvement of level of service, as well as the quality of life in general (creation of user-friendly areas with less traffic and better landscape), while road safety was not taken into consideration.

The objective of this research is to evaluate the effectiveness of various traffic management measures which were implemented in Greek urban areas in terms of road safety, through before-and-after accident studies, as well as through a traffic behaviour and risk perception analysis of the drivers and the residents living in these areas.

In this framework, two characteristic urban areas in the Thessaloniki Metropolitan Area had been chosen as case studies and quantitative accident analysis was taken place, in order to evaluate their effectiveness in terms of road safety. Furthermore, a questionnaire survey was carried out to people who influenced by these measures (residents, employees, drivers, etc.), in order to investigate their perception concerning the effectiveness of the implemented measures in terms of safety, as well as possible changes in their driving attitude. From the above methodology interesting results were derived and useful conclusions were drawn.

1. INTRODUCTION

Residential areas in big cities, especially those close to the Central Business District (CBD), tend to have increased road accident rates and road traffic plays an important role to this. In most cases, the road network carries greater traffic volumes than its capacity and some residential streets suffer from through traffic, especially during rush hours. For this reason during the last decades, various traffic management schemes including traffic calming measures have been implemented in a great number of European cities, with main objectives either to increase the road capacity or to reduce the number of accidents and to improve the quality of life in urban areas (1). More specifically, their objective may be the overall improvement of road safety (protection of VRU, implementation of 30Km/h speed limit zones, etc), as well as the creation of environmental-friendly areas (reduction of visual intrusion, reduction of vehicle noise and emissions, etc.).

The type of the traffic management schemes depends mainly on the size of the area where they are implemented and on their major focus. Thus, the overall improvement of road safety
can be achieved either by the separation of all road users (especially the separation of vehicle and pedestrian movements), where the geometrical characteristics permit this, or by reducing vehicle speed and the space occupied by vehicles. The latter can be achieved by the implementation of physical measures like speed humps, warning and speed reduction signs, street narrowings, as well as of extended pedestrianised streets (2), (3).

For the evaluation of the implemented traffic management schemes, as far as the road safety is concerned, the number of road accidents “before” and “after” the implementation can be used as a useful index (1). This quantitative evaluation is a quite difficult task due to the limited data (i.e. small number of accidents in residential areas) - which requires a long study period - on one hand, and to the isolation of the accident causes from other exogenous parameters on the other.

In addition, the risk perception of the road users is an important factor in evaluating such schemes. Studies have found (4) that there are streets with mixed and heavy traffic which although present a good level of safety according to statistical accident analysis, however they are perceived by the users as highly dangerous ones, as the users are forced to move very carefully and under psychological pressure.

Taking into consideration the above and in particular the difficulty of accident data collection in Greece, the evaluation of the implementation of traffic management schemes in Greek urban areas was based both on an accident statistical analysis and on a questionnaire survey, so that the evaluation could be done through a qualitative and a quantitative perspective.

2. TRAFFIC MANAGEMENT AND SAFETY IN GREECE

Traffic safety is one of the major social problems in Greece. Every year, more than 2,000 people are killed and more than 30,000 are injured, in 24,000 accidents. As shown in Table 1, the number of accidents has been increased during the period 1989 - 1999 by more than 16% (from 20,299 to 24,231), while the number of deaths has been increased by more than 20% (from 1,699 to 2,131) at the same period (5).

Table 1. Number of accidents, fatalities and injuries in Greece. Period 1989 - 1999.

<table>
<thead>
<tr>
<th>year</th>
<th>total no. of accidents</th>
<th>accidents invol. fatalities</th>
<th>Accidents invol. Injuries</th>
<th>no. of deaths</th>
<th>no. of heavy injuries</th>
<th>no. of light injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>20299</td>
<td>1462</td>
<td>18837</td>
<td>1699</td>
<td>3465</td>
<td>25448</td>
</tr>
<tr>
<td>1990</td>
<td>19609</td>
<td>1533</td>
<td>18076</td>
<td>1737</td>
<td>3499</td>
<td>23892</td>
</tr>
<tr>
<td>1991</td>
<td>20764</td>
<td>1557</td>
<td>19207</td>
<td>1790</td>
<td>3318</td>
<td>25631</td>
</tr>
<tr>
<td>1992</td>
<td>22006</td>
<td>1610</td>
<td>20396</td>
<td>1829</td>
<td>3597</td>
<td>26687</td>
</tr>
<tr>
<td>1993</td>
<td>22165</td>
<td>1634</td>
<td>20531</td>
<td>1830</td>
<td>3116</td>
<td>26794</td>
</tr>
<tr>
<td>1994</td>
<td>22222</td>
<td>1671</td>
<td>20551</td>
<td>1909</td>
<td>3372</td>
<td>26925</td>
</tr>
<tr>
<td>1995</td>
<td>22798</td>
<td>1798</td>
<td>21000</td>
<td>2043</td>
<td>3475</td>
<td>27705</td>
</tr>
<tr>
<td>1996</td>
<td>23775</td>
<td>1870</td>
<td>21905</td>
<td>2157</td>
<td>3327</td>
<td>29426</td>
</tr>
<tr>
<td>1997</td>
<td>24319</td>
<td>1889</td>
<td>22430</td>
<td>2199</td>
<td>4287</td>
<td>28380</td>
</tr>
<tr>
<td>1998</td>
<td>24836</td>
<td>1929</td>
<td>22907</td>
<td>2226</td>
<td>4806</td>
<td>28611</td>
</tr>
<tr>
<td>1999*</td>
<td>24231*</td>
<td>1882*</td>
<td>22349*</td>
<td>2131*</td>
<td>4626*</td>
<td>27685*</td>
</tr>
</tbody>
</table>

* temporary data.

Source (5)

The comparison of accident statistics in Greece with those from other E.U. countries (Table 2), shows the severity of the problem. More specifically, Greece presents the highest ratio of fatalities per 100,000 inhabitants, 1.83, while the respective value for UK is three times lower, i.e. 6.1 (6).
Table 2. National numbers of traffic fatalities (within 30 days) and the percentage of injury accidents in built-up areas (year 1995).

<table>
<thead>
<tr>
<th>Country</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>% injuries in built-up areas</th>
<th>population (1,000)</th>
<th>ratio (fatal./popul.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1216</td>
<td>51974</td>
<td>60</td>
<td>8050</td>
<td>15,1</td>
</tr>
<tr>
<td>Cz Republic</td>
<td>1588</td>
<td>36967</td>
<td>69</td>
<td>10330</td>
<td>15,4</td>
</tr>
<tr>
<td>Denmark*</td>
<td>546</td>
<td>9757</td>
<td>62</td>
<td>5230</td>
<td>10,4</td>
</tr>
<tr>
<td>France</td>
<td>8412</td>
<td>181403</td>
<td>68</td>
<td>58140</td>
<td>14,5</td>
</tr>
<tr>
<td>Germany*</td>
<td>9814</td>
<td>516400</td>
<td>63</td>
<td>81640</td>
<td>12,0</td>
</tr>
<tr>
<td>Greece*</td>
<td>1909</td>
<td>30297</td>
<td>72</td>
<td>10460</td>
<td>18,3</td>
</tr>
<tr>
<td>Italy</td>
<td>6512</td>
<td>259571</td>
<td>73</td>
<td>57270</td>
<td>11,4</td>
</tr>
<tr>
<td>NL</td>
<td>1227</td>
<td>10210</td>
<td>54</td>
<td>15460</td>
<td>7,9</td>
</tr>
<tr>
<td>UK*</td>
<td>3560</td>
<td>315189</td>
<td>74</td>
<td>58605</td>
<td>6,1</td>
</tr>
</tbody>
</table>

*year 1994.

Source (6)

Another important conclusion drawn from Table 2 is that the majority of injury accidents take place in urban areas, revealing the necessity of the implementation of traffic management and safety measures in such areas.

During the last decade, various traffic management schemes have been implemented in a number of Greek cities, such as the cities of Larissa, Katerini and Rhodes, as well as in big municipalities of the Greater Metropolitan Areas of Athens and Thessaloniki. These schemes mainly included traffic calming measures like speed humps, street narrowings, as well as pedestrianised streets accompanied by a number of traffic management measures (one-way streets, improvements of signing and signalisation, etc.) (7), (8). The results of the evaluation of the schemes implemented in cities of Larissa and Katerini - where extensive pedestrianisation was carried out - were positive, not only in terms of the primary purpose of improving environment, but also in safety terms (a significant reduction of pedestrian accidents was observed) (9), (10).

3. THE CASE STUDIES OF TWO MUNICIPALITIES IN THESSALONIKI

3.1. Description of the study areas

Traffic management and calming measures have been recently designed and implemented in various municipalities in the Thessaloniki Greater Metropolitan Area (TGMA), like the municipalities of Thessaloniki, Kalamaria, Stavroupolis, Neapolis, Pylea, etc. (7), (8). Most of the designed measures were implemented in different time periods between 1991 and 1999. Although each municipality had somehow different priorities, the concluding result was more-or-less the same, i.e. the reduction of congestion by forcing car users to follow specific routes, and making this way “sensitive” built-up areas more environmental friendly.

The objective of this paper is to evaluate the implementation of traffic management schemes in two municipalities in TGMA, i.e. the municipality of Kalamaria and the municipality of Thessaloniki (focused on the city centre).

3.1.1. Municipality of Kalamaria

The Municipality of Kalamaria is one of the first Municipalities in the TGMA, where traffic management measures were implemented, with main objective the encouragement to reduce car use in the study area and to improve the safety especially for VRU.
The area chosen for the survey is mainly a residential area, mixed with shopping activities, carrying a significant number of pedestrian movements, especially towards the CBD of Kalamaria. Safety problems were observed along its main arterials as well as at major intersections, where high traffic and pedestrian volumes were conflicted, especially during peak hours.

For the solution of this problem, a calming and safety study was designed and implemented (11) in two phases; Firstly, in 1993 a pedestrianisation scheme was carried out, (i.e. the pedestrianisation of Komninon St., from Passalidi to Metamorfoseos St.). The second phase took place after 4 years (in 1997), with the implementation of a number of various traffic calming measures including:

- The extension of the pedestrianised street of Komninou.
- The construction of speed humps and the implementation of signal lights, flashing amber, in “sensitive” areas (i.e. near to schools, elderly centres, playgrounds, etc.)
- Street narrowings and construction of small pollards, in order to prevent illegal parking on the pavement.
- Pay-and-display parking scheme.

Map 1 shows the area most affected by the implemented measures, where the survey took place.

Map 1. The surveyed area of the Kalamaria Case Study
3.1.2. Municipality of Thessaloniki

The Municipality of Thessaloniki is the biggest Municipality in the TGMA with more than 800,000 residents, while a large amount of traffic passing through its centre every day (12). It is obvious, that the implemented traffic management measures in the city centre, have different philosophy than those implemented in Kalamaria. A balance between vehicles and VRU is essential. Major though corridors and arterials should not be prohibited to vehicles, while pedestrians must feel safe enough during their daily movements to centre and, where possible, to fully separate them from motorised traffic.

The area chosen for the survey is actually the CBD of the city with many shopping activities, carrying a significant number of pedestrian movements. Due to lack of adequate space for pedestrians (narrow sidewalks) before the scheme implementation, the existing conflicts between vehicles and pedestrians resulted to a high number of accidents. Also, the lack of parking spaces, forced the drivers to park their car on the pavement, reducing even more the free space, necessary for safe pedestrian movements and making the walking a difficult and dangerous task.

To overcome these problems, traffic management measures are designed by the local authorities, which were implemented in two phases; in 1997 a major pedestrianisation scheme took place, the pedestrianisation of Aristotelous St. The second phase has been taking place since 1999, with the implementation of a number of minor traffic calming measures such as:

- The construction of safety barriers along Tsimiski St.
- The construction of specific parking bays along the city centre streets.
- Street narrowings and implementation of pollards, in order to prevent illegal parking on the pavement.
- The construction of ramps, as well as the re-construction of pedestrian crossings in order to help people with special needs.

Map 2 shows the area most affected by the implemented measures, where the survey took place.

Map 1. The surveyed area of the Thessaloniki Case Study
3.2. Evaluation of the traffic management schemes

As it was mentioned above, the safety evaluation of the traffic management schemes in residential areas, where the number of accidents occurred is small, is a difficult task. Therefore, the evaluation of the traffic management schemes in the two examined case studies was based mainly on a questionnaire survey, which was carried out complementary to the accident statistical analysis.

3.2.1. The questionnaire survey

The questionnaire was designed, focusing mainly on the road user perception in terms of road safety, while special attention was given to VRU and motorcyclists. A number of 75 questionnaires were conducted in each area, covering various categories of people, i.e. residents, visitors, shoppers, etc. The selected interviewees used to live or travel in the area before the implementation of the measures, so that a “before” and “after” comparison could be possible. Answers were classified, taking into account the above categories of people as well the used mode of travelling in the study area (driver, pedestrian, motorcyclist, etc.) and the analysis of them resulted to interesting results (see appendix A).

3.2.2. The Kalamaria Case Study

The sample examined presents the following characteristics as far as the sex is concerned, 56% were men and 44% women, while the majority of the interviewees (more than 60%) were residents, which was expected as the area chosen for the survey is mainly a residential area. Most of the interviewees were pedestrians (53%), with drivers in the second place with 39% and motorcyclists in the third place with 8%.

As far as the public information for the proposed measures is concerned, the questionnaire revealed ignorance of the people for the implementation of the measures. More than 83% were not informed at all, while only 17% of the interviewees knew about the implementation of the scheme (Fig. 1). This issue is more severe taking into account the fact that the residents and the shop owners - the main acceptors of the measures - were informed only 13% and 29% respectively about the implementation.

As far as the effectiveness of schemes in terms of traffic is concerned, the majority of the interviewees (77%) have a positive opinion about their effectiveness (Fig. 2). It is characteristic that only 38% of the drivers believe that the measures are not effective, while this percentage drops to 13% as far as the pedestrians is concerned.

![Figure 1. Public information for the proposed measures](image1)

![Figure 2. Perceived effectiveness of measures in terms of traffic](image2)

Although only 2 people out of 10 were informed before the implementation, the majority of them (more than 80%) believes that the measures have a positive contribution to safety (Fig. 3). More specifically, the VRU - motorcyclists and pedestrians believe in their effectiveness, in percentages 83% and 76% respectively.
The examination of the relationship between perceived effectiveness and trip frequency (Fig. 4), showed that the more frequently people move in the area where traffic calming measures have been implemented, the more positive opinion concerning their effectiveness in terms of safety they have.

Concerning the difficulties of movements imposed from the implementation of the measures, the overall perception was positive, as a percentage of 76% of the interviewees believe that the measures did not influence significantly their trip. Drivers is the most affected category, as only 24% of them are fully satisfied by the implementation, while the equivalent percentage of the pedestrians is 55% (Fig. 5).

Finally, as far as the overall effectiveness of the traffic management scheme in Kalamaria is concerned, the majority of the interviewees keep a positive attitude, as 4 people out of 5 are generally satisfied from the measures (Fig. 6).

As far as the quantitative part of the evaluation is concerned, the values of traffic volumes along major streets in the affected area, as well as the number of accidents, were compared in two time periods, i.e. before and after the scheme implementation. As it is shown (Table 3), a small decrease in traffic volumes along the main streets is observed, showing that the management measures were positive as far as the car discouragement is concerned. As far as the number of accidents is concerned, a significant increase is observed at the outskirts of the area, which shows an accident migration from the small area where the scheme took place to a wider one.
Table 3. Accident and volume data before and after the scheme implementation (Kalamaria).

<table>
<thead>
<tr>
<th>VOLUMES (pcu/h)</th>
<th>ACCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Metamorfoseos St.</td>
<td>528</td>
</tr>
<tr>
<td>Chilis St.</td>
<td>665</td>
</tr>
<tr>
<td>Pontou St.</td>
<td>710</td>
</tr>
<tr>
<td>Passalidi St.</td>
<td>343</td>
</tr>
</tbody>
</table>

Sources (11), (13)

3.2.3. The Thessaloniki Case Study

The sample survey was again equally divided between the both sexes (48% men and 52% women), with the majority of the interviewees to be visitors (73%), which was expected, as the area examined is the CBD of the city with many shopping activities. Again, most of the interviewees were pedestrians (64%), while drivers are in the second place with 25% and the motorcyclists are the third place with 11%.

As in the case study of Kalamaria, the questionnaire revealed ignorance of the people concerning the implementation of the measures, as only 1 people out of 4 was informed for the scheme before its implementation (Fig. 7). Nevertheless, the majority of the interviewees (87%) are generally satisfied from the implementation of the measures (Fig. 8).

More specifically, the majority of the interviewees (76%) have a positive opinion for the effectiveness of the measures in terms of traffic regulation (Fig. 9). It is characteristic that only 13% of the pedestrians and 42% of the drivers believe that the measures deteriorate the traffic conditions.

The interviewees have even more positive opinion for the effectiveness of the measures in terms of road safety. It is characteristic that 9 people out of 10 (93%) believe that the measures have a positive contribution to safety (Fig. 10).
As far as the relationship between perceived effectiveness and trip frequency, the survey showed again that the more often people move in the area, the more positive opinion they have about the measures in terms of safety (Fig. 11). Finally, although the majority of the interviewees have a positive attitude against the measures, a negative criticism is observed, especially among people over 40 years old, concerning the way the implementation took place (Fig. 12).

As far as the quantitative part of the evaluation is concerned, the values of traffic volumes along major streets in the affected area, as well as the number of accidents, were compared in two time periods, i.e. before and after the scheme implementation. As it is shown in Table 4, there is a small decrease in traffic volumes along the main streets as in the case of Kalamaria. As far as the number of accidents is concerned, due to the short “after” period (some of the measures are still being implementing), accidents are not available for the examined area. Therefore, it is needed to collect accident data for the study area after a reasonable time period, so that the statistical analysis could have reliable results.
Table 4. Accident and volume data before and after the scheme implementation (city centre).

<table>
<thead>
<tr>
<th></th>
<th>VOLUMES (pcu/h)</th>
<th>ACCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Ag. Sofias St.</td>
<td>610</td>
<td>585</td>
</tr>
<tr>
<td>Aristotelous St.</td>
<td>580</td>
<td>-</td>
</tr>
<tr>
<td>Benizelou St.</td>
<td>670</td>
<td>550</td>
</tr>
<tr>
<td>Nikis St.</td>
<td>2300</td>
<td>2000</td>
</tr>
</tbody>
</table>

Source (12)

5. CONCLUSIONS

During the last decades various traffic management measures were implemented in many Greek urban areas with main objective the discouragement of car use and consequently the improvement of level of safety and of the environment.

In the framework of the present research the evaluation of the traffic management measures which were implemented in two characteristic urban areas in TGMA was attempted through a quantitative and a qualitative perspective. The basic conclusions, which were drawn from the qualitative evaluation based on a questionnaire survey, are:

- In both cases, i.e. in the residential area of the municipality of Kalamaria and in the CBD of Thessaloniki, there was no sufficient public information for the implementation of the scheme.

- There was acceptance of the measures from all road users, especially from the pedestrians, as the majority of measures are focused on them (traffic calming measures and pedestrianisation).

- The majority of people have a positive opinion for their effectiveness as far as the safety is concerned, while in the meantime the drivers consider that there were no particular difficulties in their movements imposed by their implementation. More specifically, the percentage of people who faced difficulties in their movements after the implementation of the scheme in the municipalities of Kalamaria and Thessaloniki was 24% and 8% respectively.

- An interesting conclusion derived from the analysis was that the perceived effectiveness of the measures increases as trip frequency increases, which shows that for a reliable evaluation of a scheme, a sufficient time period is required.

The quantitative evaluation - as far as traffic is concerned - is resulted to a small decrease of traffic volumes in the study areas which shows that the measures had a positive effect on car discouragement. As far as safety is concerned, the analysis showed that there is an accident migration (for the municipality of Kalamaria), from the area where the schemes took place to a wider one.
6. REFERENCES


APPENDIX A

ARISTOTLE UNIVERSITY OF THESSALONIKI
CIVIL ENGINEERING DEPARTMENT
TRANSPORT AND ORGANISATION SECTION

QUESTIONNAIRE SURVEY

Evaluation of traffic management measures in Greek urban areas

1. You would characterise yourself as:

   - Resident
   - Visitor
   - Employee
   - Shop owner

2. You usually move in the area using:

   - Car
   - On foot
   - Two-wheel vehicle

3. How many times do you usually move in the area during the week? .................

4. There have been implemented some traffic management measures in the area. Are you generally satisfied by the alterations?

   - Very satisfied
   - Enough satisfied
   - Not at all

5. Do you believe that you have been satisfactory informed before the implementation of the measures?

   - Very
   - Enough
   - Not at all

6. What is your opinion about the effectiveness of the measures in terms of traffic?

   - Very effective
   - Enough effective
   - Not at all

7. What is your opinion about the effectiveness of the measures in terms of road safety?

   - Very effective
   - Enough effective
   - Not at all
8. How much do you feel that the safety has been increased, during your daily movements, after the implementation of the measures?

Very [ ]

Enough [ ]

Not at all [ ]

9. Do you think that your daily movements have been deteriorated after the implementation of the measures?

Very [ ]

Enough [ ]

Not at all [ ]

10. Has your travel behaviour changed after the implementation of the measures?

Yes [ ]

No [ ]

If yes, how? ................

11. Have you increased your movements as pedestrian after the implementation of the measures?

Very [ ]

Enough [ ]

Not at all [ ]

12. Do you think that the measures have been implemented in the right way, so as to have the expected results?

Yes [ ]

No [ ]

If not, what do you think that should change? ................

13. Sex

Male [ ]

Female [ ]

14. Age

< 18 [ ]

18 - 30 [ ]

31 - 45 [ ]

46 - 60 [ ]

> 60 [ ]

13. Education

University [ ]

High school [ ]

Elementary [ ]