TRAFFIC SAFETY OF OLDER PARTICIPANTS OUT OF INFRASTRUCTURE SIGHT

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ABSTRACT

Many different studies show that the average age of the population in European Union countries in general as well as in Slovenia in particular, increases. Due to the statistical analysis the citizen's living period extending yearly. In Slovenia people over 60 years represent 21.6% of population. Consequence is larger number of older participants in traffic accidents.

Most of older people are daily participants in road traffic. They are car drivers, passengers, cyclists and pedestrians - threatens of older traffic participants could not be treated due to their large number; it should be focused on increasing their participation in traffic accidents. Older traffic participants are not "looking for" dangerous situations, their defence behaviour cause traffic situations in which other traffic participants react improper. Consider that, the infrastructure impact is very important. Older traffic participants should feel safety what we should have in mind to assure their involvement in traffic in way that consequently lower the possibility of traffic accidents.

1 INTRODUCTION

Many different studies show that the average age of the population in developed countries in general, and also in Slovenia in particular, increase. There are many reasons for this phenomena, the most important being development of medicine science, higher living standard in general and also improvement in the quality of micro-environment at work and at home. Statistical analysis shows that today in USA people over 60 represent 19 % of population. In European Union already 23 % of citizens are older than 60 years in Slovenia they represent 21.6 % of population. Therefore, in industrialized countries, drivers over 60 years of age represent a rapidly growing part of driving population. Increasing of average population age means increased part of older population. The current trend-projections for year 2015 show that the population older than 60 years will represent a fifth of the total population. According to the basic variant of Eurostat's population projections the number of citizens in Republic of Slovenia till year 2050 will decreased by approximately 5 %. Almost a third (31.1 %) of the population will be aged 65 years or more, while the proportion of younger than 15 years will be less than 13 %.

According to United Nations data, 75.4 % of economic developed countries population lives in urban areas, at the end of 2004 every second resident of Slovenia. It is a fact that most of those persons are still active participants of road traffic, especially in city traffic as pedestrian, cyclist or driver.

In order to be safe as a participant in road traffic, a person should posses certain psycho-physical qualities, which enables one to react quickly and correctly at sudden and unexpected changes of traffic situation around him/her. It is well-known that the quality sight and hearing as well as flexibility and reaction time deteriorate with advancing age.

Results of different studies concerning the behaviour of different population groups, with respect to age, and safety of elderly participants in road traffic were reported at Stewart et al.,

1993; Parker et al., 1995; Blockey and Havley, 1995; Stamatiadis and Deacon, 1995; Ryan et al., 1998, in Slovenia Kerle, 2002. These results show that the problem of older participant in road traffic on over-all safety is not negligible even today, while its importance will rise in future. Older people are more compromised in traffic, especially as pedestrians and cyclists. With age the number of fatalities increases, also more often they cause the traffic accident.

2 TRAFFIC SAFETY OF OLDER PARTICIPANTS

2.1 Characteristics and travel behaviours

Age changes that influence the safe integration of individual participant into traffic are reflected mainly in mental and physical ability - as uneven and uncoordinated decreasing of perception, adaptation and reaction to traffic situations. The decline in the abilities of individuals that are important for safe integration into the traffic, it is difficult to control or measure.

However, there are significant changes that affect the safety of elderly traffic participants, health-related, perception, ability of movement and cognition. Often the older participants reduced ability try to substitute with experiences, but in today's rapid development and changing of infrastructure it is often impossible.

Mainly changes connected to age and are important for safe integration in traffic:

- behaviour changes (habits, age adoption, weakening the physical and mental abilities, compensation of sensory and abilities),
- reducing of visual and hearing functions (sensitivity to colour and light, failing of eyesight, balance problems),
- illnesses,
- decrease of psycho-motoric abilities (longer reaction time, deterioration in coordination).

With time, older traffic participants are aware of own reduced abilities. According to that, their travel behaviour change. Results or researches shows decrease of driving kilometres per year for 50 % compare to “active” population.

The data for EU countries shows the older drivers n average per year drive between 5000 and 10000 km. Inquiry results made within drivers over 64 years: less than 5000 km per year drive 63.6 % of women and 27.0 % mans, between 5000 and 10000 km per year 30.3 % women and 54.0 % mans, more than 10000 km per year drive only 6.1 % of women and 19 % mans.

If it is possible, older drivers try to avoid time of traffic density. Due to unsafe feeling they choose settled routes for travelling, what mostly provide specific travel behavior – common, repeated daily migrations. It is important to understand and define the influence of road infrastructure on older participant’s traffic safety. For older driver complicated traffic situation that requires quick reaction present even travelling outside the standard route, being faced with high demand and, consequently to feel unsafe. In the moment, collection of many environmental information (infrastructure, traffic situation), appropriate decisions, coordinated own movements and carrying out a safe manoeuvre is necessary. Mostly, driving speed is reduced and movement “inconvenience”. Such behaviour the other drivers cause unexpected situation and increases the possibilities of traffic accidents.

2.2 How safe are older traffic participants in Slovenia?

Older traffic participants are the second most risk group from the traffic safety point of view. Due to statistical data, average number of fatalities per 100.000 inhabitants in the age group 0-14 is 1.95, 16.41 in age group 15-24 years, 10.28 in 25-64 years and between older,

over 65 years 11,25 fatalities per 100.000 inhabitants.

In Slovenia 10.3 traffic fatalities per 100.000 inhabitants is recorded in the age group over 65 years. Analyzing traffic accident data in period 2008-2009 for Slovenia, statistically it is possible to expose traffic accidents where older people are involved as different participants and accidents caused by older people.

In analyzed period in 5936 traffic accidents participants were older that 64 years, as driver 82. 3%, passenger 7.5 %, pedestrian 8.3 %, motorcyclist 1.9 %. Among those traffic accidents older people (over 64) incur responsibility for 3317 of them, which represent 55.9 % of all traffic accidents with older participant involvement. Significant is also level of injuries which mainly is higher comparing to other age groups.

Between all participant modes involved in traffic accidents, number of car drivers is the highest. The "traffic unsafe" reason of older traffic participants it is reasonable to analyze with identification of traffic accident location in correlation to infrastructure characteristics.

It is proved, according to older drivers travel behaviour that traffic accidents mostly happened in urban areas. Directly, locations of traffic unsafe traffic situations are connected with road intersections, above all, non-lighted. Out of sight road network infrastructure element changing's, in that type of intersection there are most novelties, which older traffic participants adopt slower and have difficulties concerning unlike motion on common used routes.

Capability of safety integration into traffic depends on actual traffic situation. Human factors influencing dangerousness in traffic are direct and indirect. Inattention to traffic happening, disturbance inside and outside the vehicle, not enough attention, incorrect assumption, unsuitable manoeuvres and driving techniques, driving to fast are most common identified indirect factors. Their impact to safety level of older traffic participants in intersections is significant. Often their integration into traffic is "routine", changes on route are not recognized on time considering decreased abilities the reaction is too slow or incorrect. The novelties adoption is slower, the feeling of doubt and fear is present. Doubt and fear is of importance for lower self-confidence level what could result in traffic accident.

On purpose to establish actual safety of older road traffic participants in Slovenia, analysis of their opinion was made. The main purpose was to find out how safe those traffic participants feel themselves in road traffic concerning different situations as well as level of traffic safety in different types of intersections. Dividing of participants was made according to different traffic modes of participation – pedestrians, cyclists and drivers. In questionnaire 350 coincidental chosen traffic participants were included, 321 of them aged over 60 years, 60 % man and 40 % women. Inquiry was made in three Slovenian cities, Maribor, Ljubljana and Celje. Separate analysis for drivers with more than 10000 km driven per year, less than 10000 km/year, drivers who are also pedestrians and cyclists and those involved in road traffic only as pedestrian or cyclist, all of them aged over 60 years, were elaborate.

From all inquiries, 72.6 % have driving licence, between them 95.3 % are active drivers and from this group approximately 38 % drive more than 10000 kilometres per year. 89 % of inquiries are involved in traffic as pedestrians, nearly 70 % as motorcyclists and approximately 30 % as cyclist, but different modes of traffic participation not eliminated each other.

More than 56 % of inquiries participate in traffic every day, 34 % few times per week.

Traffic safety experiences of inquiries were also analyzed. Nearly 30 % already have been involved in traffic accident, 78 % of them once, 15 % twice, and 7 % three times or more. In 50 % in traffic accidents inquiries were involved as drivers, 6.6 % as cyclists, 13.2 % pedestrians and in 30.2 % occasions as passengers. More than 63 % of all this accidents happened in intersections.

Older traffic participants are frequently less acquainted with novelties concerning traffic, for example roundabouts, traffic calming measures, changes in legislation, etc. Inquiries own opinion is that two thirds are well known, and one third badly or poorly know them.According

to different traffic modes of participation, we analyzed inquiries opinion about "feeling safe" in various types of road intersections (traffic lighted, one-lane roundabout, two-lane roundabout), as well as reason of their opinion. Starting with analysis, great deviations between different traffic modes participants were recognized.

Table 1: Traffic safety in different types of intersection – drivers with more than 10000 km/year

Intersection type	"very safe"	"safe"	"unsafe"
traffic lighted	46,74%	50,00%	3,26%
one-lane roundabout	50,00%	45,65%	4,35%
two-lane roundabout	28,26%	52,17%	19,57%

Table 2: Traffic safety in different types of intersection – drivers with less than 10000 km/year

Intersection type	"very safe"	"safe"	"unsafe"
traffic lighted	21,71%	68,42%	9,87%
one-lane roundabout	19,08%	63,16%	17,76%
two-lane roundabout	7,24%	51,32%	41,45%

Table 3: Traffic safety in different types of intersection – participants who are also pedestrians/cyclists

Intersection type	"very safe"	"safe"	"unsafe"
traffic lighted	29,86%	58,29%	11,85%
one-lane roundabout	19,43%	63,03%	17,54%
two-lane roundabout	10,90%	48,82%	40,28%

Table 4: Traffic safety in different types of intersection –pedestrians/cyclists

Intersection type	"very safe"	"safe"	"unsafe"
traffic lighted	30,84%	52,34%	16,82%
one-lane roundabout	12,15%	58,88%	28,97%
two-lane roundabout	5,61%	35,51%	58,88%

Because of older people characteristics, be reflected in traffic safety and their own feeling of safety in particular traffic situations, it is important to identify and understand reasons for definition of "safe" and "unsafe" infrastructure elements.

Most difficulties from the traffic safety point of view for older traffic participants are in the connection with road "classic" intersections. Significant in intention of higher traffic safety and understanding of traffic happening in intersections is classification of intersection types due to participant safety feeling. The safest, according to inquiry are one-lane roundabouts and trafficlighted intersections, less safe are two-lane roundabouts and turboroundabouts, as most unsafe between traffic participants over 64 years are non-lighted intersections.

Analyzing the reasons for feel unsafe in non-lighted intersections, it is find out:

- priority enforcing,
- poor visibility,
- inappropriate traffic signalization,
- ignoring of regulations and rules,
- traffic jams.

Most frequent reasons for feel safe in one-lane roundabouts are:

- continuous and easily control traffic,
- simple and safe integration into circulatory traffic flow,
- there is no priority enforcing in circulatory traffic,
- good visibility.

The traffic lighted intersections are safe for reasons:

- driving rules are well known,
- most easily integration into the traffic at intersection area,
- we are used to that intersection type.

The inquiries feel unsafe in two-lane roundabout because of conflict points while changing lanes in circulatory traffic flow (from outside to inside lane or opposite). In such situations older traffic participants feel unsafe account of "unclear situation" in which they are "weak", also exposed due to priority enforcing. In turbo roundabouts mainly reason for inconvenience, traffic signalization and driving conditions before and in the intersection is exposed.

Older participants feel safe in traffic, consecutive they are safer that remain in general traffic safety level, when traffic situations are easily controlled, transparent for them and traffic speed of all participants is lower. That makes them possibility to be in equal position as traffic participants of other age groups, mainly important during manoeuvres. The on time and comprehensible traffic signalization in required.

3 ROAD INFRASTRUCTURE MEASURES TO IMPROVE OLDER PARTICIPANT'S TRAFFIC SAFETY

The number of older traffic participants increases. To assure higher traffic safety level it is necessary taking into account their characteristics to perform measures, divided in two groups.

First group include measures of traffic inspection and control as well as introducing with changes and modifications in road traffic:

- traffic control on critical road network points,
- speed control,
- traffic control in traffic density conditions,
- performance of activities to increase tolerance between traffic participants of different age groups,
- stimulation of renew driver's knowledge and skills,
- upgrading the system of verifying older driver's efficiency and skills, and second group infrastructure measures:
- measures for traffic calming,
- improvement of infrastructure element's visibility, specially at night time,
- improvement of traffic signalization, recognition, understandable, visibility,
- intersection designing, which assure to all participants safe and understandable movement and participation in traffic.

Predictable traffic behaviour and better traffic safety recognition of traffic circumstances is required. At road infrastructure designing principle of road network functionality, traffic homogeneity, recognisability and predictability of behaviour should be considered. Functionality of the road network can be improved by defining and implementing clear and easily recognizable road categories, homogeneity of the traffic is increased by allowing only limited differences in sped and directions between road users, predictability of the behaviour of road users can be improved if route choice and the neccesarity of manoeuvres are simple and understandable for all road users.

Table 5: Traffic safety requirements according to application area for infrastructure measures

requirement	applicable to				
	network	routes	road sections	intersections	category transition
create large-size continuous residental areas	x				
minimize journey on relatively unsafe roads	x				
make journeys as short as possible	x				
let shortest and safest route coincide	x				
prevent search behaviour		x		x	
make road categories recognisable		x	x	x	x
limited number of standard traffic solutions		x	x	x	x
prevent conflicts with oncoming traffic			x	x	
prevent conflicts with crossing traffic			x	x	
separate traffic categories			x	x	
reduce speed at sites of potential conflict			x	x	
prevent obstacles along the carriageway			x	x	

Infrastructure measures for improving road network traffic safety should consider twelve requirements which are respectively related to network structure, selection of routes within the network, layout of the road section or intersection and category of transitions in locations where different road categories connect.

Requirements focus on prevention and migration of the effects of conflicts between vehicle and vehicle, vehicle and other road users, and vehicle and obstacles, while not all possible conflicts in these categories are covered. Especially single-vehicle situations are missing. These include single vehicle roll-over and single vehicle run-off road incidents, due to loss of control or wrong maneuvering, and inappropriate speed. Basic principles of infrastructure measures to improve older participant's traffic safety are: road network functionality, recognisability and predictability, traffic homogeneity, driving task simplification and error forgivingness.

Road network functionality: the structure and layout of the road network should be functional. Functional use of the road infrastructure should be encouraged and induced, and unintended use should be prevented – road network layout and use at a more global level inherently generate functional behaviour (as other behaviour is not possible).

Recognisability and predictability: road user should be informative about expected behaviour. Complex traffic situations should be avoided, and everywhere route choice and necessary maneuvers should be fully comprehensible for every road user. Recognisability of the traffic situation should induce predictable behaviour, and prevent insecure and ambiguous behaviour. Road users should accept and behave in accordance with the rules set by the traffic regulation.

Traffic homogeneity: homogeneous use of the road network aims at preventing encounters between road users, and between road users and obstacles, at high differences in speed, direction and mass.

Driving task simplification: avoiding of complex traffic situations, assurance of continuous driving process to reduce the needed attention for certain parts of the driving task and/or helping to take correct decisions in certain situations.

Error forgivingness: focus on correcting driving errors at an early stage and mitigating consequences of driving errors once they have developed too far and a conflict cannot be avoided anymore.

3.1 Infrastructure safety measures in intersections

Main factors affecting safety at intersections are: number of legs, angle of intersection, sight distance, alignment, auxiliary lanes, channelisation, friction, lighting, lane and shoulder widths, driveways, approach speed and traffic regulation. Traffic safety level of intersection depends on number of conflict points. General it is possible to improve traffic safety in intersections with measures:

- Traffic signalization – priority signs, traffic lights, grade intersections
- Speed reducing structures in intersections – "raised" intersection (reducing speed and raising drivers attention), use of different types of material, median islands, narrow arms before the intersection, extended sidewalks, roundabouts – applicability depend on traffic volume and road categorization
- Channelization – use of painted road markings, raised kerbs, traffic islands – simplifies the movements and reduce the potential "error space", reduces confusion, separates and localizes the conflict points
- Roundabouts – one-way circulating road contribute to improving traffic safety in several ways: reduce the number of conflict points, priority rule for traffic on roundabout is unambiguous, speed direction differences are minimal, most dangerous left turn manoeuvre in intersection is eliminated
- Separation of traffic modes – separation of motorized traffic and bicycles and separate bicycle ways important improve traffic safety in intersections (special in urban areas).

Figure 1: Samples of measurements for traffic safety improvement in intersections

3.2 Infrastructure safety measures on road sections

Road sections are from older participant's safety point of view specific. That traffic participants have particular psycho-fisical characteristics, their motion and driving are different as others age groups. From that reason older participants are frequently involved in traffic accidents (as driver, cyclist or pedestrian). General it is possible to improve traffic safety on road sections with measures:

- Separation of traffic modes – bicycle line from different materials and colour than surface for motorized traffic; the separation is more psychological than physical, especially when the bicycle lanes are very narrow. Bicycle track (separated from

the main road) provides a better solution (complete separation of traffic types with considerable differences in speed)

- Separation of opposing traffic flows on single-carriageway – double median white line, central reserve application, physical lane separation for opposite directions, as part of the risk originates from overtaking on main roads, 2+1 carriageway (creating a three- lane single-carriageway, where each direction has "periodical" the availability of 2 lanes for overtaking)
- Measures to prevent single vehicle run-off road – lane markings, rumble strips, ridges, grooves (they give a rumbling sound when driven over and so alert the driver to take corrective action), measures to prevent collision with obstacles
- Speed control measures – elevated speed reduction structures, speed humps, road and line narrowing structures and obstacles for speed reducing; certain measures may sometimes have adverse effects because of an improper design or location, despite good intentions
- Generic measures for road network - concerns the layout of the network as a whole in a certain area and is related to spatial planning; network structure (the implementation of changes in connectivity in some areas, traffic regulation – avoiding urban areas, common measures as roadd lighting, lane marking, regulatory road signs, warning road signs and information road signs.

4 CONCLUSION

According to reduced activity of participation in road traffic, older people start to feel discomfort in it. As consequence most of them compare to active drivers in new technical solutions of intersection constructions feel themselves less safe.

Older traffic participants will be due to risk factors always in the group which frequent cause traffic accidents or are involved in them. It is a challenge to, considering last studies and researching, examines closely the solutions and measures which implementation could reduce risk of older traffic participants. For them it is important that traffic infrastructure is functional appropriate and allowed all participants to foresee the expected behaviour of others. Specially, in road intersections, to make assure enough time drivers to make decision and respond, use of proper traffic signalization and infrastructure solutions should be implemented.

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