Older Drivers: Possibilities and Limits of Testing and Screening

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Abstract

Despite the physical and mental deficiencies of older drivers their accident involvement is not higher than average. Nevertheless, several countries have introduced age-based population screenings. Meanwhile various results from evaluation studies dealing with cost-benefit analyses of these screenings have been published. First the legislative background in western countries is summarized. Then an assessment of both the quality and results of the available evaluation studies is presented. Moreover the wide span of test procedures that can be found – from questionnaires to medical checks and visual tests and finally psychological testing and driver tests in real traffic – is critically discussed with respect to their potential for predicting future driving performance or even the accident risk of older drivers. On the whole it is concluded that the enormous societal and economic effort of the screenings in no way outweighs any adverse effects on overall road traffic safety and the undue limiting of older peoples' mobility. Future potentials to enhance traffic safety for elderly drivers lie in technical and constructional measures concerning the vehicle and traffic environment. The most promising approach, however, seems to be additional training for selected elderly drivers.

Keywords: age-based screenings; evaluation studies; future driving performance; accident risk.

Les conducteurs âgées: Possibilités et limitations de tests et évaluation

Malgré leur deficits corporel et mental les conducteurs âgées ne sont pas un groupe d'un risque accident particulièrement. Nèanmois, plusieurs pays ont introduissé (installé) evaluations qui faire reference á l'age. D'abord le regles legislative de pays occidental sont récapitulé. Après la qualite et les resultats des etudes d'evaluation sont presenté. En plus, il suit une discussion critiquante coté les procedures d'evaluation qui ont uitilisé – questionnaire, examen mèdical, examen de vue, examen psychologique, examen conduite sur la route – et coté leur puissance de pronostiquer le risque d'accident future. En tout on peut conclure qui les efforts sociales, economiques et enormes obligees avec les evaluations qui faire reference á l'age produisent effects negatives en ce qui concerne mobilité et securité de conducteurs âgées.

Mot-clè: evaluations qui faire reference á l'age; etudes d'evaluation, compétence de conduire; risque d'accident future,.

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1. Introduction

The effects of an aging society on the traffic system have been a field of intensive research for several years. Despite the physical and mental deficiencies of older drivers their accident involvement is not higher than average – and despite a fast growing senior population. Indeed in Germany the number of traffic participants over 65 years killed in accidents decreased significantly between 1980 and 2012 (Statistisches Bundesamt, 2013). Similar effects can be found in other countries (Sweden, USA, UK) (see Mitchell, 2013). Nevertheless, political decisions in a number of countries have led to the introduction of age-based population screenings. Meanwhile various results from evaluation studies dealing with the cost-benefit analyses of these screenings have been published. If, when and how older drivers´ driving competence is assessed, is subject to considerable variation between the countries. For a topical overview see Fastenmeier & Gstalter (2013).

Regulations and procedures can be grouped into four types as follows:

- Unlimited validity of the driving license (e.g. France, Germany)
- License has to be prolonged by a merely formal procedure (e.g. Sweden)
- License has to be renewed at a defined age, including a self-declaration of the applicant`s health (e.g. United Kingdom)
- Age-based assessments at a defined age (e.g. Finland, Spain).

The methods used to assess the fitness of the applicants vary considerably. Many countries use information dealing with medical aspects, sometimes merely in the form of self-declarations in medical checklists, sometimes through a certificate from a GP. If a medical check is part of the obligatory assessment, it is mostly conducted by a GP, and rarely contains detailed specifications. In some countries specialized physicians are involved in assessing the driver's health condition (e.g. vision, cognitive state or cardiologists). Some countries (e.g. Spain) also require a psychological examination (performance tests, explorative discourse). On-road tests are used in various countries to clarify unclear cases.

2. Evaluation studies

2.1 Results on screening methods and some inferences

Since the 1990s various studies have tried to evaluate the influence of age-based assessments of older drivers' fitness to drive on traffic safety indices. Most of these studies originate from North America (Canada, US) and Oceania (Australia, New Zealand), comparatively few deal with the situation in European countries. In the following section an assessment of both the quality and results of the available evaluation studies – all of them evaluating current regulations – is presented. Moreover, the wide span of test procedures that can be found – from questionnaires to medical checks and visual tests and finally psychological testing and driver tests in real traffic – is critically discussed with respect to their potential for predicting future driving performance or even the accident risk of older drivers.

The main criteria that were applied to assess the evaluation studies follow the usual scientific conventions and included among others:

- Between-groups comparisons of drivers or traffic participants: accuracy and elaborateness of considering differences between the groups and conditions.
- Adequate transfer of these differences to the methodological design.
- Before-after comparisons: use of control-groups.
- As usually the accident criterion is used as a dependent variable (DV): Have systematic biases in accident data been considered (e.g. frailty bias, low-mileage bias, context bias)?
- Are accident data weighed and put into perspective with exposure data with preference on parameters such as distance travelled over population based exposure.
- Questions of methodological design, type and number of subjects, a comprehensible and well-documented description of the study, an interpretation and discussion of the results in a realistic and critical way.

Table 1 indicates which evaluation studies (authors and country) met the criteria mentioned above; moreover, the main result of each study is briefly noted. Then the most important aspects in relation to the methods of screening used and evaluated in these studies are briefly summarized (see in detail the report of Fastenmeier & Gstalter, 2014).

Table 1: Relevant evaluation studies on age-based driver screenings

Hakamies-Blomquist et al. (1996):
Comparison of Sweden (no screening) vs. Finland (medical check 70+): No safety effect for car drivers, but negative safety effect (higher death rate for vulnerable road users).
Rock (1998):
Before-after study in Illinois, USA. No safety effects..
Grabowski et al. (2004):
Comparison of US-States with vs. without screening. Personal appearance of the candidate with positive effect; additional vision tests and on-road tests without safety effect.
Keall & Frith (2004).
Comparison of accident rates after on-road tests with vs. without repetition. Positive effect of on-road tests, but very small effect size.
Langford et al. (2004a):
Comparison of Sydney (screening with 80) and Melbourne (no screening): No safety effect.
Langford et al (2008):
Comparison of six Australian States. The only region without screening (Victoria) performed best. No general safety effect.
Mitchell (2008):
Comparison of 7 EU-countries. The mildest procedures were combined with the lowest accident rates.
Ross, Luszcz, Mitchell & Anstey (2011):
Comparison of mobility data of six Australian States after vision test and medical check: With screenings a priori revokement of the driving license; no differences in performance.
Siren & Meng (2012):
Study of additional cognitive tests to established medical checks in Denmark. Desired effects not reached, but negative safety effects concerning seniors.
Camp (2013):
Comparison of in-person license renewal with a new one consisting of various tests and procedures: no safety effect.

Medical checks.– There is not one single investigation which can demonstrate a significant decrease in accident statistics as a consequence of medical screenings. Obviously, serious medical impairments often lead to timely driving cessation, whereas the majority of active older drivers suffer from diseases which are not related to high accident risks (Ewert, 2008). For most older drivers, the knowledge about their deficiencies leads to a defensive driving style and a successful coping behaviour on all levels of the driving task („compensation“).

Vision tests.– Although a long history of research has repeatedly indicated that vision parameters and traffic accident involvement are unrelated, vision tests are the most common element of the screening methods, most often restricted to one parameter, namely static visual acuity. In tests of visual acuity a stationary subject has to recognize details of a stationary object defined by the test against a white background under optimal light conditions. This is the only task and it can be accomplished without time pressure. Perceptual requirements in traffic reality are totally different in nature: dual task conditions, time restraints, searching and detecting (and not only looking at) the relevant visual cues in a clutter, often under restricted lighting conditions and during movements of the driver and his visual targets. Whereas not a single European or Australian evaluation study could show a connection between vision testing and resulting accident involvement, some American papers documented more favourable results. Unfortunately, these investigations suffer from severe methodological shortcomings (see the criticism of Grabowski et al., 2004) and sometimes authors seem to have a fiduciary relationship to potential screening instruments (see e.g. the essay by O´Neill, 2012). Compared to daylight driving conditions, scotopic visual impairments are not as easily compensated for and limit older drivers more severely, but the vast majority of the reference population strictly reduces down its exposure when it is dawn, dusk or even in darkness.

Cognitive tests.– Although a lot of cognitive functions (perception, attention, memory, decision making) are involved in car driving, tests of these requirements are only rarely used in age-based assessments. What is used are rough cognitive screening methods which are mainly used in dementia diagnostics. It is therefore not surprising that none of the evaluation studies could demonstrate a safety effect with these measures. Some Australian studies even showed better safety indices for older drivers in Victoria, the only state without an aged-based check in comparison to other states using cognitive tests. A recent Danish investigation (Siren & Meng, 2012) proved negative consequences for elderly traffic participants after the addition of a cognitive test to the prior assessment procedure: Whereas the accident involvement of older vehicle drivers did not decrease, the elderly had considerably more crashes being pedestrians or bicycle riders. Many rough cognitive tests which are

not applied in current official screening procedures have recently been investigated (see Bowers et al., 2013), but no test or combination of tests and additional information was sufficiently and reliably able to classify candidates according to their performance in on-road tests. Compared to accident data observed driving behavior is a far more reliable criterion to validate tests; thus, prediction of individual accident involvement using test data seems to be nearly impossible.

In-person renewal.– Contrary to the regulations requiring only formal postal feedback to prolong the validity of the driving license, some US-states require the candidate's a personal appearance. At least for the oldest group of drivers (85+) Grabowski et al. (2004) could show a decrease in accident figures in states requiring an in-person renewal. Another study (Kulikov, 2011) found that the procedure led to a longevity of license possession. Maybe the procedure constitutes a good balance: It seems not to deter license holders who are still able to drive and gives the authorities a chance to get a better picture of the candidate and possibly order an extra screening method (e.g. an on-road test).

Restrictions.– Several countries allow driving with restrictions as an outcome of age-based population screenings. Restrictions most often relate to the length of the time intervals between assessments, set speed maxima on defined roads or give spatial regional restrictions. Results of evaluation studies regarding the effects of restrictions are contradictory. Possible safety effects should not be overestimated, because it has been shown that older drivers´ self-regulation activities lead to very similar limitations („compensation"), even without any legal regulations at hand. But clearly the possibility of allowing a restricted license eases the decision pressure on the authorities and is more accepted by the candidates than the loss of the license.

On-road tests.– Driving in real traffic is used in quite different ways as part of the screening procedures, but most often used as a decision criterion in unclear cases. The results of respective evaluation studies do not always point to the same direction. Australian and American investigations could not show any safety benefits provided by this method. In 2006, New Zealand abolished the on-road tests because they were considered ageist. Prior to that decision the on-road tests had been an obligation for those reaching the age of 80. Keall & Frith (2004) compared the accident rates of some 40.000 drivers and concluded that those who passed the road test at the first attempt had 33% fewer accidents in the two-year period following the road test than those who had a second try. This may appear as a significant effect, but the effect size is very small.

2.2 Conclusions on age-based screenings

On the whole, the conclusion of assessing the relevant evaluation studies on age-based population screenings is clear:

- It may be assumed that the enormous societal and economic effort of the screenings in no way outweighs any adverse effects on overall road traffic safety and the undue limiting of older peoples' mobility.
- An age-based population screening does not produce any positive safety effects; on the contrary, most of the concerns in this regard proved to be right. Due to these screenings some older people have lost their mobility and thus health, well-being and quality of life, although they would not have presented a high accident risk, nor would they – with high probability – have had an accident for the remaining duration of their lives. Others had their license revoked a priori in fear of the screening (and arguably without good reason), changing their mobility patterns by becoming a cyclist or pedestrian and thereby representing a higher accident risk than before.
- Thus, an age-based population screening may even have negative effects on overall road safety.
- There is no reliable indication as to which predictor should be taken for driver screening.
- From a scientific point of view, such results could have been expected because road accidents are statistically rare events and most at-risk drivers never have accidents. In addition, individual accident risk cannot be calculated. Numerous studies failed to find statistically and logically significant relationships between accident rates and the individual characteristics of drivers.

Only recently have several other authors collected relevant literature and drawn conclusions on the costs and benefits associated with the different assessment approaches (Vlakveld & Davidse, 2011; Siren & Meng, 2012; Alonso et al., 2013; Siren et al., 2013). All these reviews are in line with the results of our assessment and unanimously conclude that a general screening of the whole population of older drivers does not appear to be reasonable. This conclusion is drawn by combining safety as well as mobility and ethics-related aspects and also by a cost-benefit analysis.

3. The prediction of individual accident risk: Some theoretical considerations and a numerical example

In a conceptual analysis Hakamies-Blomqvist (2006) has shown why it is impossible to predict the future number of accidents of a car driver. At best one can succeed in identifying a senior driver as a member of a risk group, which in total has a higher accident risk. But we should keep in mind that even the risk of drivers with serious illnesses is only 2-3 times higher than average, meaning that also the vast majority of the risk group members will have no accidents in their future driving history. The exclusion of the whole group would thus lead to a large reduction in mobility for a minimum gain in accident numbers.

To illustrate the costs and benefits of a population wide age-based screening approach we present a calculation example with realistic data. First we use a Dutch investigation to estimate age-related accident numbers in relation to kilometres driven (see Fig. 1).

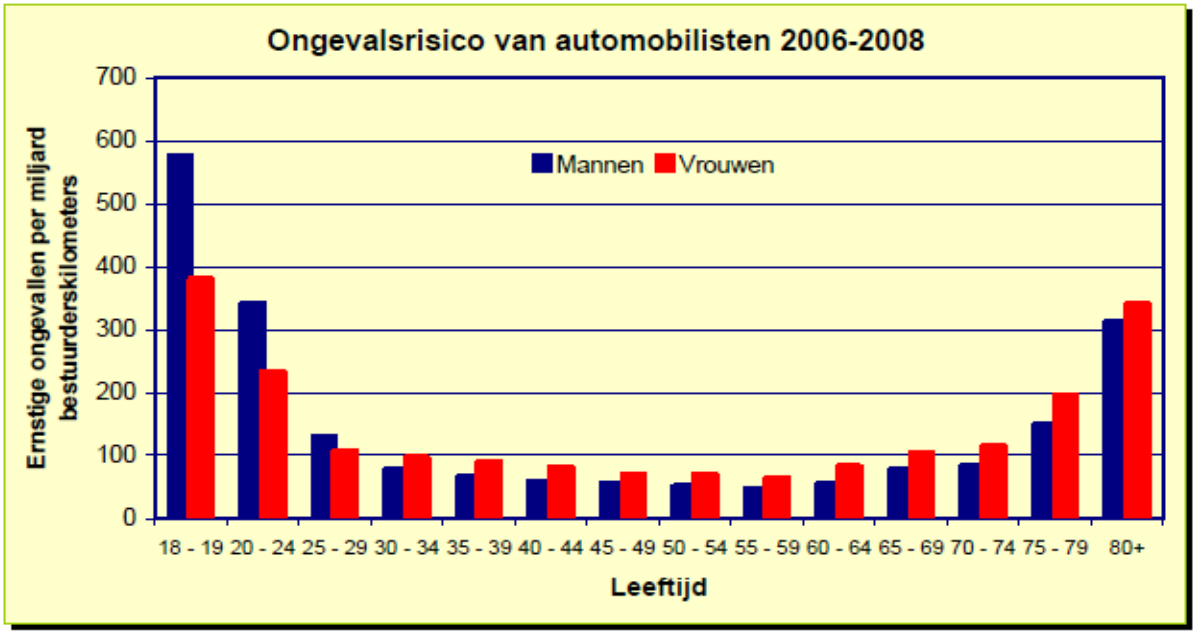

Fig. 1: Number of severe accidents (fatal or with hospitalization) per milliard km car driving from 2006 to 2008 in the Netherlands (from SWOV, 2010)

Selecting the group of 75 to 79-year old drivers we can estimate its average number of severe accidents to be about 200 per milliard km. This equals to one accident for every 5 million km or 100 senior drivers each of whom drove 50.000 km. Then the expected value of the total group´s number of serious accidents would equal unity, meaning that only one of the hundred older drivers would have an accident in a total exposure of 5 million km.

Fig. 2 illustrates what would happen to the 100 imagined drivers if they were taken to a screening with the purpose of using the test results to predict their individual future accident involvement. We assume a perfect screening procedure that could detect *everybody* who will have an accident in his future driving career. Such a test would have a sensitivity of 100%. This single positive finding is encircled in Fig. 2. With only one accident occurring in the future and the test having succeeded in finding the potential accident driver the procedure would have avoided that single accident from happening. What happens to the remaining 99 older drivers? The answer depends on the test`s specificity: Given a specificity of 80% (an unrealistically high value) the test will classify 80% of the candidates correctly, meaning that 79 drivers (80% out of 99) would be labeled as safe. On the other hand 20 senior drivers would be immobilized although not a single member of this subgroup would be involved in an accident within the next 50.000 km. Even with unrealistically high values of sensitivity and specificity the screening would immobilize 20 drivers to avoid one accident. Bayes' formula for calculating conditional probabilities yields the following result: The probability of a positively tested candidate to actually have an accident in the future 50.000 km is approximately 4.5%.

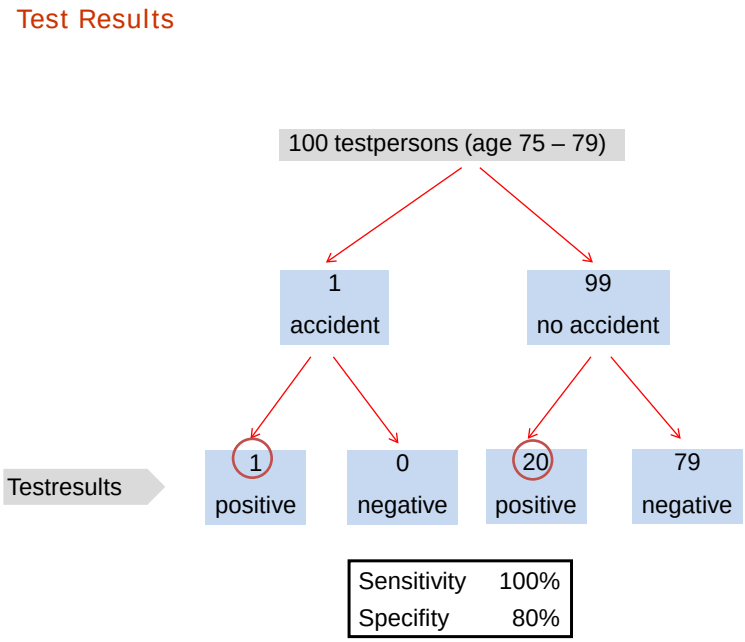

Fig. 2: Costs and benefits of screenings to predict accident occurrence

Let us finally throw some light on the more realistic values of the sensitivity and specificity of tests used for prediction purposes. Fig. 3 indicates values from studies in different countries. In these investigations several psychological, medical and biographical data have been combined to predict the performance of older drivers in on-road tests (which is, of course, much easier than to forecast accident involvement!). The best approximation to the true scores can probably be obtained from the Hoggarth et al. study because it is the only one with a cross-validation.

Prognostic value of psychological, medical and biographic data for results of on-road tests

Authors	Year	Sensitivity [%]	Specifity [%]
Burgard & Kiss	2008	82	75
Wood et al.	2008	91	70
Hoggarth et al.*	2013	63	57
Fastenmeier et al.	2013	75	43
Poschadel et al. **/***	2012	80	55
		85	50
Wood et al.	2013	80	73

*cross-validation, ** ophtalmologic, ** medical

Fig. 3: Quality of predictions of performance in on-road tests using data from medical, psychological and biographical sources.

The conclusion is obvious: Even a screening with unrealistic sensitivity and specificity values will produce too many wrong classifications, in particular the group of false positives will always be too large. In summary, no reliable procedure is available that could justify the selection of older drivers by the screening methods currently used for age-based population wide assessments of driver fitness.

4. On-road tests as a gold standard for the assessment of driving competence?

The restricted value of the accident criterion has led to the notion of implementing on-road tests or driver behaviour observations in real traffic as a (more reliable) criterion, and which could also be used as a validation criterion for all kinds of tests. Traffic safety experts unanimously regard on-road tests as the most valid approach to describe and assess individual driving competence and performance. This is the main reason why driving observation is used as an ultima ratio in driver diagnostics. Nevertheless, and as outlined above, the performance in on-road tests cannot be satisfactorily predicted by test data, laboratory data or biographical data. Although the performance of older drivers with good test performance will mostly be good in on-road tests, this statement does not hold true for older drivers with low test performance: these "false positives" often reach an acceptable result in on-road tests and are able to compensate for their displayed deficiencies in laboratory testing. Thus, arguably on-road tests could replace the conventional testing procedures. If driver behaviour observation gained such importance and were implemented in full scope, then some effort would have to be put in quality standards as there is a broad variability of methods which are not comparable – from basic driving license tests and driving tests featuring technical aspects to elaborate scientific techniques. Crucial questions concern e.g.: who is conducting the tests, how to standardize the procedure and the conditions for their implementation, what type of roads and situations are used, are they based on driving task analysis, how to ensure the reliability of the observational data, how to define cut-offs for passing the tests etc.?

5. Concluding remarks

Older car drivers do not constitute a specific high risk group.
The accident risk per mile driven is rising for drivers above 75 years of age. This is primarily due to three systematic biases in accident records.
"Frailty bias":
– The mortality risk of older car passengers is 2-5 times higher than that of younger car passengers
– The estimated number of reported cases is lower
„Low mileage bias":
– Drivers with low exposure reveal a higher accident risk – regardless of age. Older drivers are over-represented in the group of low mileage drivers
"Context bias":
– Low mileage drivers are more frequently exposed to complex situations.

With these effects taken into consideration the accident involvement of older drivers is not higher than average. The majority of elderly drivers is able to adequately compensate for their age-related sensory, cognitive and motoric deficits through driving experience and a defensive driving style.

Older drivers will continue to be safe drivers in future years.
The amount of automotive exposure of older drivers will continue to rise for some years because of the growing number of older people and the greater individual mobility of each elderly person. This forecast has been often been the motive to call for legal regulations and age-related assessments of driving competence regarding the elderly license holders. But experiences made in several countries (e.g. Germany, Sweden, UK, USA) point to the opposite direction: The relative numbers of accident involvements of older drivers have been decreasing considerably and even especially decreasing faster than the growth of the number of older drivers. For the situation in general, we suspect a cohort effect related to the average health and fitness of the present older generation compared to the past to be the main explanation for this favourable development.

An age-based population screening of driving competence is unnecessary and does not work.
The chronological age of a driver is a mean indicator of driving ability. An assessment solely based on age is not going to improve traffic safety, no matter which methods of screening are used. Experts who have analyzed the worldwide experiences from evaluation studies on the subject of age-based driving assessments of older drivers have come to this mutual conclusion.

Age-related assessments of driving competence have unpleasant side effects.
Several studies showed the negative safety effects of screenings. Especially female drivers often revoked their license prematurely instead of taking part in the screenings, thereby reducing their mobility or facing a much

larger accident risk as pedestrians or bicyclists. Even those drivers who passed the screenings reduced their mobility in comparison to older drivers who were not forced to take part in an assessment.

Individual accident involvement cannot be predicted.
The future number of accidents an individual driver will be involved in is an expected value of a random variable and cannot be reliably estimated. There are no sufficiently valid indicators, whether concerning personality, biography, medical or psychological performance tests, to predict future accident involvement. Trials to select apt drivers through these indicators will always produce many "false positives" because the selectivity of the tests is too low. This situation cannot be altered in principle because of the very nature of the dependent variable.

Behavioural observations in on-road driving tests provide useful information.
In contrast to other screening methods on-road tests in real traffic focus exactly on what is to be assessed, namely driving behaviour. This leads to high acceptance by the candidates and gives the method a good face validity. Processed in a professional matter the data should allow for precise individual feedback and define suitable training objectives.

The results from on-road tests cannot be reliably predicted by laboratory or test data.
For many years research has tried to correlate data from a diverse range of psychological and medical information gained from the results of driving tests. Despite the interpretation of some authors we seriously doubt the usefulness of this approach. Why should we prefer a low-sensitivity forecast over the real information from the driving test? The benefits of behavioral observations lie in themselves and not in their role as a validation criterion for tests.

Individual consulting and training for older drivers is desirable.
Individual consulting and training could help elderly drivers in improving their driving skills. Based on the results of an on-road test, a personalized training schedule could be specified. Theoretical conceptions for this purpose already exist and it could be demonstrated that long-term improvements in driving performance can be reached.

A balance between safety and mobility should be reached.
Mobility without risk is not possible. The discussion revolving around older drivers has narrowed too much to the point of car accident involvement and neglected the vital needs related to the broader concept of mobility as a prerequisite of health and life satisfaction.

There are other traffic safety problems for older traffic participants.
Research has focused almost exclusively on elderly car drivers and our present knowledge about this seems to be satisfactory. But also solutions are needed for other safety problems the older traffic participants have to face e.g. as pedestrians, bicyclists, moped riders, or accidents in public transport modes, inadequate passive safety facilities in vehicles etc.

The design of vehicles and traffic environments should be more adapted to older traffic participants.
Another approach to reduce risks and restrictions in mobility for older persons could come from an improved design of traffic modes and traffic sites and adequate urban and regional planning processes. Driver assistance systems with age-adapted HMI-design could simplify the driving task.

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