Education – Elderly training

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Please note: The studies included in this synopses were selected from those identified by a systematic literature search of specific databases (see supporting document). The main criterion for inclusion of studies in this synopsis and the DSS was that each study provides *a quantitative effect estimate*, preferably on the number or severity of crashes or otherwise on road user behaviour that is known to be related to the occurrence or severity of a crash. Therefore, key studies providing qualitative information might not be included in this synopsis.

1 Summary

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1.1 COLOUR CODE: GREY

The results from the available literature showed that in general safe driving behaviour of elderly is increased after training. However, specifically for accident rates as well as for the total number of effects reported in the studies, the majority of the results are not statistically significant. Therefore, the impact of training on the safety of elderly people is uncertain.

1.2 KEY WORDS

Training; Education; Elderly; Traffic Behaviour; Accidents

1.3 ABSTRACT

Training for elderly people aims to enhance the safety of activities undertaken by road users who are above 65 years old through education or additional training, which is not mandatory, as part of licencing or graduate licencing programmes. The effects of elderly training on road safety were investigated in seven studies, selected for this synopsis in three countries (i.e. USA, Canada and France). The relevant studies investigated the effect of training on accident rates of elderly as well as the enhancement or decline of safe traffic behaviour among car drivers and pedestrians. The dominant research designs used to derive the effects of training on elderly were experiments and quasi-experiments. The results demonstrated that training can result in safer traffic behaviour, however the majority of the results are statistically insignificant. This implies that no clear conclusion can be drawn about the effect of elderly training and that any positive outcome for the traffic behaviour of elderly cannot be easily transferable.

1.4 BACKGROUND

How is elderly training defined?

Education and voluntary training is a broad topic area that includes many different methodologies and teaching styles. Training for the elderly is defined here as any educational program/activity or training that aims to enhance the driving/pedestrian activities of drivers/pedestrians with an age above 65 years old to detect and avoid hazards. The primary concern is whether education or voluntary training (i.e. not mandatory as part of licensing or graduate licencing programmes) can promote safer driver behaviour of the elderly and consequently reduce the occurrence of accidents in which they are involved.

What type of education/training has been studied?

A number of different types of education/training have been used in the included studies, for example, driving simulator, practising crossing the road on a virtual road in a simulator, classroom-based training, on-road driving trials and video-reviewed feedback.

How is safe traffic behaviour of elderly assessed?

The effect of training on the traffic behaviour of the elderly is most often assessed by a practical assessment either in a driving simulator or during an on-road test. The assessment tasks include the ability to safely undertake manoeuvres such as starting/stopping or backing the car, to respect traffic signals and the right of way, to paying attention while driving, to safely overtake and keep a safe speed, to safely negotiate intersections and to safely cross the road. It is ethically difficult to assess risky behaviour such as the involvement in accidents by on-road tests, so changes to these are usually assessed via simulator or self-report methods such as questionnaires.

How many elderly people are killed in road traffic accidents?

In the EU in 2014, 25.8% (6,697) of the 25,958 fatalities in total (countries included in the CARE statistics) were aged >65 years old (European Commission, 2016).

What is the relationship between training for elderly and accidents?

The majority of studies looking at the relationship between training for elderly and road safety only investigated behaviour change and did not examine whether there is a link with accidents. Nevertheless, two studies (Ball et al., 2010; Nasvadi and Vavrik, 2007) investigated the effect of elderly training and accident rates. The former (Ball et al., 2010) found that training reduced accident rates for elderly. On the other hand, the latter (Nasvadi and Vavrik, 2007), in general demonstrated no significant difference in accident rates between drivers that undertook training and those that did not but indicated that male drivers aged 55-74 are more likely to be involved in accidents after training.

1.5 OVERVIEW OF RESULTS

In general, the results across the seven studies imply that training assists the enhancement of safe traffic behaviour among the elderly. When observing the two studies that were concerned with the correlation between training and elderly accident rates, it is shown that results are split (i.e one study demonstrates a reduction of accidents and the other indicates an increase of accidents for a specific age group) and thus, cannot indicate a clear effect on road safety. However, both in behavioural and accident rate studies, the majority of the results are not statistically significant, which hinders a solid conclusion that training has a positive effect on the road safety of elderly.

2 Scientific Overview

2.1 INTRODUCTION

Seven studies were identified as the most appropriate to be included in this synopsis regarding the training of elderly drivers and its effect on road safety. Three of those studies were experimental, another three studies were quasi-experimental and one was an observational study. The experimental studies utilized simulator devices, video- and classroom-based training or on-road driving tests, whereas quasi-experiments combined classroom-based training with on-road driving only. The majority of the studies (6/7) concerned the task of car-driving, while one study focused on pedestrians. Regarding the geographical dispersion of the studies, five of them were conducted in the USA, one in Canada and one France. Moreover, five of the studies were concerned with enhancing the traffic behaviour of elderly drivers or pedestrians and two of them investigated the effect of training on crashes.

2.2 METHODOLOGY

As there was no meta-analysis included in the seven studies included in this synopsis, the effect of training on elderly is assessed individually. Regarding the quasi-experiments, the samples of Ball et al. (2010), Bédard et al. (2008) and Marottoli et al.(2007) were randomized while the latter two studies included "before-after" and crossover measurements regarding driving behaviour. The experimental studies of Dommes and Cavallo (2012), Romoser and Fisher (2009) and Romoser (2013) were all based on a "before-after" design and concerned driving simulator experiments with or without classroom-based training.

Regarding the methods which were used to analyse the results, most studies employed ANalysis Of VAriance (ANOVA)-based techniques such as ANalysis of COVAriance (ANCOVA; Bédard et al., 2008), Multivariate ANOVA (Dommes and Cavallo, 2012), F-tests and Mann-Whitney U-tests (Romoser and Fisher, 2009) and repeated-measures ANOVA (Romoser, 2013). On the contrary, Ball et al., (2010), Marottoli et al., (2007) and Nasvadi and Vavrik, (2007) utilized regression models, namely Poisson, Linear Mixed Models and Binary Logistic respectively.

An overview of the methodology followed by each of the coded studies is given in Table 1.
For the overall methodology, please see Martensen et al. (2018).

Table 1: Overview of study methodologies

Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
Ball et al., 2010. USA	Quasi-experimental study examining the effect of cognitive training on crash risk	908 older adults who were living independently with no evidence of substantial functional or cognitive decline. 73 % were female with age range 65-91 (mean 73.1).	Poisson regression model using generalised estimating equations to calculate relative risk
Bedard et al., 2008. Canada	Quasi-experimental study using classroom-based training and on-road driving practice	Participants from 2 sites in Canada: Thunder Bay (age range 65-86) and Winnipeg	Analysis of covariance (ANCOVA) with change in test score as outcome, intervention

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Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
	aiming to evaluate changes in driving behaviour before and after the training sessions.	(age range 65-81). They all had a valid driving licence and still driving and have a Mini-Mental State Examination score of less or equal to 24.	vs control as the factor and baseline driving score as the covariate
Dommes and Cavallo, 2012. France	An experimental study using a simulator device and aiming on improving the street-crossing ability of elderly pedestrians.	40 participants. The training group comprised of 11 women and 9 men, age range 65-83. The control group was made up of 12 women and 8 men, age range 61-82. Each participant took part in the four stages of the study.	A multivariate analysis of variance (MANOVA) was conducted with group (intervention, control) as a between group factor, and with testing point (pre-test, immediate post-test, and 6-month post-test) and speed of the approaching car as within-group factors.
Marottoli et al., 2007. USA	A quasi-experimental study using classroom-based and on-road driving training in order to assess the safety of driving behaviour through a knowledge test as well as the on-road driving performance.	126 community-living drivers 70 years old or older who were recruited from clinic and community sources. The mean age was 80 years, 15 % were women, and approximately two thirds drove daily averaging 110 miles per week.	A linear mixed regression model was used to analyse the effect of treatment (intervention relative to control) and treatment comparisons were adjusted for the study design-recruitment site and road test examiners at baseline and follow up-and baseline road test score. The statistic used was the t-test.
Nasvadi and Vavrik, 2007. Canada	Observational matched-pairs cohort study conducted in three stages: Phase 1 addressed the issue of self-selection bias among elderly who attend driver education programs; Phase 2 addressed the impacts of the training course on crash involvement of elderly; and Phase 3 used focus group sessions to examine the components of the course that affect the driving behaviours of participants	884 older drivers who attended the 55 Alive/Mature Driving program (565 female, average age 75,5 years and 319 males, average age 76,6)	Non-parametric analysis was used to determine differences between groups; binary logistic regression was used for dichotomous outcome variables because it does not assume a linear relationship between the dependent and independent variables, and because it does not require the dependent variable to be normally distributed.
Romoser and Fisher, 2009. USA	Experimental study describing two experiments: **Experiment 1**-Younger and older participants drove a series of virtual intersections scenarios, were shown video replays, and were provided feedback. **Experiment 2**-older drivers were assigned to one of three cohorts: active simulator training, passive classroom	**Experiment 1:** 18 drivers older than the age of 70 (range =72 to 87; sample mean = 77.7, sample standard deviation = 4.62) and 18 younger drivers between the ages of 25 and 55 (range = 25 to 55; sample mean = 35.0; sample standard deviation = 9.00) with 10 or more years of driving experience. **Experiment 2:** The 54	F-tests and Mann-Whitney U-tests were used to examine the differences in driving behaviour (i.e. taking secondary looks) between the training and the control group and determine whether training alters older drivers' perception of their abilities.

Author(s), year, country	Study Methodology	Sample	Analysis method/ Effect measure
	training, or no training. Pre- and post-training simulator and field drives assessed training effectiveness.	participants for Experiment 2 were all active, healthy adults between the ages of 70 and 89 (range = 70 to 88; sample mean = 77.54; sample standard deviation = 4.55) and were divided into three age groups: 70 to 74, 75 to 79, and 80 to 89 years old. The 18 participants within each age group were assigned to one of three treatment groups (active learning, passive learning, and control), balanced for gender.	
Romoser, Matthew R. E., 2013. USA	Experiment (the results of a 2-year follow-up with drivers who had previously participated the older driver training study reported in Romoser and Fisher (2009).	Individuals from the active and control groups who participated in the training study (Experiment 2) reported in Romoser and Fisher (2009) were recruited.	Repeated measures ANOVA was used to investigate the differences in driving behavior (i.e. taking secondary glances) between the first experiment (Romoser and Fisher, 2009) and the 2-year follow-up

2.3 ANALYSIS AND RESULTS

It is difficult to draw comparisons between all of the studies, as the focus, methodology and design of each individual study is different. However, a comparison between similar outcome variables is attempted in the following paragraphs.

Two studies (Ball et al., 2010; Nasvadi and Vavrik, 2007) investigated the effect of training on the crash involvement of elderly drivers, but no clear conclusion can be drawn as the two papers conclude in opposing effects on road safety. Ball et al., (2010) found that cognitive speed-of-processing and reasoning training resulted in a lower at-fault crash rate in older drivers that took part in training than those who did not. On the contrary, in the work of Nasvadi and Vavrik (2007), who also investigated the effect of training on the number of crashes caused by elderly drivers, it was demonstrated that trained male drivers aged 75 years or older were involved in more crashes than those who did not receive training.

The rest of the studies (Bédard et al., 2008; Dommes and Cavallo, 2012; Marottoli et al., 2007; Romoser, 2013; Romoser and Fisher, 2009) were concerned with the potential improvement of safe traffic behaviour of elderly road users after participation in training. In Bédard et al., (2008) participants' knowledge improved from 61% of correct answers before the in-class education component to 81% after ($p<.001$). The on-road evaluation results of the same study also suggested improvements in aspects of safe driving (e.g., moving safely in the roadway or when starting/stopping/or backing the vehicle). However, for other evaluation metrics such as not violating traffic signals, keeping the right of way, driving cautiously and overtaking/speeding, the results were not statistically significant. Similarly, in Romoser and Fisher, (2009) and Romoser, 2013), training, and especially video-feedback, was found to enhance the driving abilities of elderly drivers in terms of safer negotiation/entrance of intersections. Another positive effect of training , this time on elderly pedestrians was prominent in Dommes and Cavallo, (2012) where it was found that elderly who undertook training crossed the road in a significantly safer way.

2.4 VOTE COUNT ANALYSIS

As the number of studies is limited and the individual reported effects vary among the selected studies it was decided that the best way to evaluate the seven papers would be through a vote count analysis. Table 2 shows the results of the vote count analysis for the selected studies. Care was taken to ensure that data was not counted twice from the same study.

Table 2: Vote count result of comparing "Hazard perception" studies in terms of accident rate and safe traffic behaviour.

Outcome Definition	Included in no. of studies	Result (no. of studies)			Result (% of studies)			Result (no. of effects)			Result (% of effects)		
		↑	-	↓	↑	-	↓	↑	-	↓	↑	-	↓
Accident rate [a]	2	-	1	1	-	50%	50%	1	10	4	7%	67%	27%
		↓	-	↑				↓	-	↑	↓	-	↑
Safe driving performance [b]	5	-	2	3	-	40%	60%	-	8	13	-	38%	62%
Total	7	-	3	4	-	43%	57%	1	18	17	3%	50%	47%

a: Accident rate includes papers providing results on relative accident risk and odds ratio of accident involvement
b: Safe traffic behaviour includes papers providing results on safe manoeuvring (e.g. turning, starting, stopping), safe road crossing for pedestrians, scores in driving and knowledge tests and safe negotiation of intersections
overlap in the number of studies including these outcomes.

↑ = *Significant positive effect on road safety of elderly people, following training (i.e. reduced accident rates and speed, or increased safe traffic behaviour).*
↓ = *Significant negative effect on road safety of elderly people, following training (i.e. increased accident rates or reduced safe traffic behaviour).*

Examining Table 2, it can be observed that the available literature slightly points towards a positive effect of training on road safety of elderly people but the results are inconclusive in total. More specifically, studies on accident rate are split, while it is shown that 60% of the studies enhance safe traffic behaviour by elderly people. This is further demonstrated when investigating the reported effects. More specifically, 67% of the reported effects on accident rate are inconclusive or statistically insignificant, whereas 62% of reported effects lead to an enhancement of safe traffic behaviour. In total, half of the reported effects are unclear or statistically insignificant, whereas 47% demonstrate an enhancement of road safety.

2.5 CONCLUSION

The effect of training elderly drivers or pedestrians on general road safety is unclear. Training was found to encourage a safer attitude towards the safety of tasks such as driving and manoeuvring (for car drivers) as well as road crossing (for pedestrians) with sufficient evidence from statistical analyses. On the contrary, training was not distinctly associated with a reduction in accidents as results were mixed and, in most cases, statistically insignificant.

Overall, the fact that drivers and pedestrians behave more safely on the road after training is an expected outcome because educational tasks, and especially video-reviewed feedback, aim to prepare road users for potential mistakes or possible dangers that might occur. Nevertheless, it is significant to acknowledge the ambiguity of the effect that such educational activities have on accident rates of elderly. On one hand, it is generally positive that training enhances safe driving behaviour, but on the other, it would be much more meaningful if this enhancement was resembled in low accident figures. Moreover, the fact that 50% of the reported effects are statistically insignificant limits the transferability potential of the results found.

3 Supporting Documents

3.1 DESCRIPTION OF STUDIES

The following paragraphs give an overview of each paper included here with a summary of the relevant findings.

Ball et al., (2010) aimed at testing the effects of cognitive training on subsequent motor vehicle collision (MVC) involvement of older drivers. Their sample consisted of 908 older adults who were living independently with no evidence of substantial functional or cognitive decline. 73% were female with age range 65-91 (mean 73.1). Four test sites (Alabama, Indiana, Maryland and Pennsylvania) were used. Participants were randomised by computer to one of four conditions: no-contact control, memory, reasoning or speed of processing training. Memory training involved teaching mnemonic strategies for remembering verbal material e.g. work lists. Reasoning training involved teaching strategies for finding the pattern in a letter or word series and identifying the next item. Speed of processing training entailed practice of visual attention skills and the ability to identify and locate visual information quickly in increasing demanding visual displays. Exercises focused on understanding patterns in everyday life e.g. travel schedules, abstract reasoning and everyday problem solving. Up to 10 training sessions were conducted with groups of 2-4 participants lasting approximately 70-minutes. These were conducted twice a week over a period of 5-6 weeks. Data about MVCs was obtained by the relevant government department and the MVC report was used to determine whether the older driver or opponent could be considered to have caused the collision. Two outcome measures were used. The first was at fault motor vehicle collisions per year of driving exposure (person years). Person years were calculated as the time between the date of assigning to a condition and the date of driving cessation, death or 31 December 2004, whichever came first. The second was at fault motor vehicle collisions per person miles driven. Person miles of travel was calculated by multiplying each participants' person years by their self-reported annual mileage during the follow up period. A Poisson regression model using generalised estimating equations was used to calculate unadjusted and adjusted rate ratios (RR). Adjustments were for age at baseline, sex, race, education, location, visual acuity, health, depression, and mental status. There were no significant associations between MVCs and memory training. Those receiving speed of processing training had significantly fewer at-fault MVCs per year of driving exposure and per person mile driven (adjusted RRs = 0.52,95% CI =.31–0.87 and 0.57, 95% CI = 0.34–0.96 respectively). Participants who took part in reasoning training had a significantly lower rate of at-fault MVCs per year of driving exposure (RR = 0.44, 95% CI = 0.24–0.82) and person- miles driven (RR = 0.50, 95% CI = 0.27–0.92) but only after adjustment.

The study of Bédard et al., (2008) examined if the combination of an in-class education program with on-road education would lead to improvements in older drivers' knowledge of safe driving practices and on-road driving evaluations. Only the on-road driving evaluation results were reported. Participants were recruited for the on-road training from 2 sites in Canada: Thunder Bay and Winnipeg. They had to be 65 or older, have a valid driving licence and still driving and have a Mini-Mental State Examination score of less or equal to 24. Participants from Thunder Bay had an age range of 65-86 and those from Winnipeg had age range 65-81. Participants completed a knowledge test and a baseline on road driving evaluation. They were then randomly assigned to either the control or intervention group. The intervention group completed another on-road driving evaluation 4-8 weeks following training and the control group waited a similar length of time and then also repeated the on-road driving evaluation. The driver training involved taking part in the 55-Alive/Mature driver training program (USA, adapted for Canada) which is a group refresher course (classroom based) that aims to improve older drivers driving skills. The training group also took part in two 30-40 minute on road practice sessions with an instructor either in their own vehicle (Thunder Bay) or a dual control vehicle (Winnipeg). The on-road driving evaluation was a 35-minute drive with an instructor along a standardised route. The scoring was standardised based on the Province of Manitoba evaluation procedure and drivers were given 5 or 10 demerit points for each unsafe action, based on the severity of the action. The driving evaluation was split into 5 categories: Starting/stopping/backing; Signal violation/right of way/inattention; Moving in roadway; Passing/speed; and Turning. Changes in the driving evaluation scores, were assessed using an analysis of covariance (ANCOVA) with the change score as the outcome, intervention versus control as the factor, and baseline driving score as the covariate. This resulted in adjusted mean change scores from these analyses. A greater reduction in demerit points was observed in the intervention group compared to controls for 'moving in the roadway' ($p<.05$ for both sites). E.g. straddles traffic lane, fails to check changing lane, wanders, fails to drive in proper lane. For the Thunder Bay site, a greater reduction was also observed for 'starting/stopping/backing ($p=.049$)'. All other results were not statistically significant.

Dommes and Cavallo, (2012) assessed the effectiveness of combined behavioural and educational intervention on older pedestrian's crossing decisions. 40 participants were equally split between the intervention and control group according to age and gender. The training group comprised of 11 women and 9 men, age range 65-83. The control group was made up of 12 women and 8 men, age range 61-82. Each participant took part in the four stages of the study. First, a 1-hour pre-test in a simulated road crossing environment, then the Intervention group took part in two 1.5-hour street crossing training sessions in the simulator and the control took part in two 1.5-hour internet use training sessions. Finally, participants took part in a 1-hour post-test 1 week after training, which was repeated 6 months later. In the simulated street crossing task used in tests the participants were asked to stand on pavement, look left at the simulated scene and decide whether it was safe to cross between 2 cars - if they judged it to be safe then they walked across the 'road' (4m) and if not, they stayed where they were. A variety of measures were taken including the Safety margin which was calculated as the time between when a participant reached the opposite pavement and when the front end of the car reached the crossing line and 'Tight fits' which were the number of crossing with a Safety Margin between 0 and 1.5s divided by total number of crossings made by the participant. For the training sessions, the - participant walked across the simulated road when thought it was safe. Feedback was given about the safety margin (>1.5s considered safe) and if this was not safe a discussion took place about what made the behaviour risky. The participant then repeated the exercise. Car speeds and time gaps were varied. Feedback was also given on median time gap measured for that session. A multivariate analyses of variance (MANOVA) was conducted with group (intervention, control) as a between group factor, and with testing point (pre-test, immediate post-test, and 6-month post-test) and speed of the approaching car as within-group factors. This indicated that there was a significant improvement in older pedestrians crossing decisions in those that had partaken in training when compared to the control ($F(14,25) = 2.7$, $p<.05$, ή^2_p = .60, ω^2 = .93).

The investigation of the effect that classroom based and on-road driver training has on the increase of the driving performance of older drivers was the aim of Marottoli et al., (2007). 118 participants completed the trial. They were 70 years or older, drove at least once a week, had no deteriorating medical condition and were in a good state of mental health. All participants had to have an on-road baseline driving score of between 40 and 65. All participants took part in base line assessments – a knowledge test and an on-road test – which were repeated 8 weeks following training. The on-road driving assessment included off road manoeuvres, low, medium and high traffic density areas and highway segments. All participants drove the same route and driving was evaluated by an experienced driving assessor. Participants were randomly assigned to the intervention or control group. The Intervention group received 8 hours of classroom and 2 hours of on-road instruction and the control group were presented material about home/environment safety and vehicle safety. This aimed to counter inadequate scanning to sides/rear; not using seat belts, mirrors, or directional signals; not maintaining safe following distances; problems backing up; and poor left turns, lane changes, and speed regulation. Two outcome measures were used, driving performance and knowledge test scores. A linear mixed regression model was used to analyse the effect of treatment (intervention relative to control) and treatment comparisons were adjusted for study design—recruitment site and road test examiners at baseline and follow-up—and baseline road test score. The difference in least squares mean change in test score at 8 weeks relative to baseline between treatment and control groups was calculated. The statistic used was the t-test. The least squares mean change in road test score at 8 weeks relative to baseline was 2.87 points higher in the intervention than in the control group (p= .001) and the knowledge test score was 3.45 points higher (P < .001). It was not clear how this impacts road safety in terms of reduction in crash risk but the authors estimate that this could equal a 9.5% reduction. However, no further statistical detail was provided.

The study of Nasvadi and Vavrik, (2007) examined whether the number of crashes of older drivers can be reduced by driver training. Older drivers (male and female, age range 55-94) who had attended the 55 Alive/Mature Driving classroom based refresher course were compared to control drivers matched for age, gender, postal code region and for number of crashes over a 2-year period prior to training course date. The 55-Alive/Mature driver course provided information on rules of the road hazard recognition and age-related changes that effect driving. It also covered information on reducing exposure to complex situations and planning for driving cessation. Drivers in both the intervention and control groups were labelled as 'crash' or 'non-crashed' drivers. 'Crash drivers' were those who had been involved in crash following training /date of training (controls) where the older driver was considered at least 25% liable. Crash data originated from the Insurance Corporation of British Columbia licensing, claims and traffic violation records including minor and police attended crashes. The time period examined, varied between participants as data was available until 31st December 2003 and training was conducted between January 2000 and July 2003. Binary logistic regression was used to determine if there was a difference between the two groups and odds ratios were calculated. Results were presented and included for the whole sample for all ages and split into the age ranges 55-74 and 75-94. Results were also divided by gender for the same age categories. No statistically significant benefit was identified but training appeared to increase the at fault crash risk for males in the older age category (i.e. ages 75-94; Odds ratio 3.8; β = 1.344, p=0.005). The study also examined the pre-training crash risk of participants attending the 55 Alive/Mature Driving course compared with controls matched for age, gender and postal code region and those attending the course had significantly more police attended crashes (χ_2=23.634, p<0.001) and total number of crashes (χ_2=9,310, p=0.010) than controls.

Romoser and Fisher, (2009) aimed to compare the effects of active vs training on older drivers' performance at intersections. There were three equal groups of participants (age 70-88): Active training, passive training and control. The participants from the training and control groups took part in a pre-test where drivers' Secondary look behaviour at intersection was assessed in a simulator and in a 30 minute on road unaccompanied drive. A secondary look was defined as a head turn made by the driver either at onset of a turn or within two seconds of entering intersections, away from the path of vehicle and towards areas where other vehicles could conflict. The active training group were given feedback via video review of their performance and then practiced performing secondary looks in driving simulator. The passive training group received lecture style training with PowerPoint slides, figures and animation with a demonstration of how a secondary look should be executed. The control group had no training. A post –test using the same methodology of the pre-test took place 6-8 weeks following the training. The active group significantly increased their secondary glance behaviour when compared with their pre-test score. There was also a significant difference between the pre- to post-test percentage change result of the active training group and the passive training group and the active and control group. There were no significant differences between the passive training and control group.

Finally, Romoser (2013) investigated the long term effects of active training on older drivers scanning in intersections. This paper was a follow-up to the paper of Romoser and Fisher (2009). In the original study both participants from the experimental and control groups took part in a pre-test where drivers' secondary look behaviour at intersections was assessed in a simulator and in a 30-minute on road unaccompanied drive. A secondary glance was defined as a head turn made by the driver either at onset of turn or within two seconds of entering intersection, away from the path of vehicle and towards areas where other vehicles could conflict. The experimental group engaged in active training whereby they were given feedback via video review of their performance and practice of secondary glances in driving simulator. A post –test using the same methodology of the pre-test took place 6-8 weeks following the training and showed that the experimental group significantly increased their secondary glance behaviour when compared with their pre-test score. The follow-up study of Romoser (2013), re-tested both experimental and control participants two years later. Participants took part in an unaccompanied on-road drive with their own vehicle. They wore a camera fitted with a light weight headband to record head movements and 3 cameras were fitted on the roof of the vehicle (straight ahead, left, right). Drivers drove the same 30-minute post-training drive route as they did in the initial study 2 years previously. Drivers who had undergone training still showed a significant ($F(1, 10) = 11.11$, $p=0.05$) increase in secondary glance behaviour when compared with the original pre-test score. The difference between the control group original pre-test and the 2-year post test results were not significant. There was a decrease in secondary glances between the 6-8 week and 2-year post-test but this change was not significant.

Table 3 illustrates an overview of the main outcomes of the coded studies.

Table 3: Summary of measures and results

Author(s), Year, Country	**Independent / Exposure variable**	**Dependant / outcome type**	**Effects on Road Safety**		**Main outcome - Description**
Ball et al., 2010. USA	Memory training: teaching mnemonic strategies	At fault crashes per year of driving exposure	—	Relative risk = 0.82; 95% CI 0.53-1.27	There was not a significant difference in the number of at fault crashes per year of driving exposure, between elderly that received memory training and those that did not.
		At fault crashes per person miles driven	—	Relative risk = 0.93; 95% CI 0.6-1.45	There was not a significant difference in the number of at fault crashes per person miles driven, between elderly that received memory training and those that did not.
	Reasoning training: strategies for finding the pattern in a letter or word series	At fault crashes per year of driving exposure	↗	Relative risk = 0.44; 95% CI 0.24-0.82	The elderly drivers who undertook reasoning training were involved in significantly fewer crashes per year of driving exposure than the drivers who did not receive the specific training.
		At fault crashes per person miles driven	↗	Relative risk = 0.50; 95% CI 0.27-0.92	The elderly drivers who undertook reasoning training were involved in significantly fewer crashes per person miles driven than the drivers who did not receive the specific training.

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	Speed of processing training: visual attention skills, identifying and locating visual information	At fault crashes per year of driving exposure	↗	Relative risk = 0.52; 95% CI 0.31-0.87	The elderly drivers who undertook the "speed of processing" training were involved in significantly fewer crashes per person miles driven than the drivers who did not receive the specific training.
		At fault crashes per person miles driven	↗	Relative risk = 0.57; 95% CI 0.34-0.96	The elderly drivers who undertook the "speed of processing" training were involved in significantly fewer crashes per person miles driven than the drivers who did not receive the specific training.
Bedard et al., 2008. Canada	Classroom based on-road training	Relative difference between the intervention and the control group regarding the evaluation scores on starting/stopping/ backing manoeuvres Ages 65-86; Thunder Bay area	↗	F=4.16, p=0.049	The elderly drivers who undertook training, achieved significantly higher evaluation scores regarding starting/stopping/backing manoeuvres in the Thunder Bay area.
		Relative difference between the intervention and the control group regarding the evaluation scores on starting/stopping/ backing manoeuvres Ages 65-81; Winnipeg area	—	F=0.55, p=0.472	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding starting/stopping/backing in the Winnipeg area.
		Relative difference between the intervention and the control group regarding the evaluation scores on signal violation/right of way/ inattention Ages 65-86; Thunder Bay area signal	—	F=1.08, p=0.31	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding signal violation/right of way/ inattention in the Thunder Bay area.

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		Relative difference between the intervention and the control group regarding the evaluation scores on signal violation/right of way/ inattention Ages 65-81; Winnipeg area signal	—	F=0.00, p=0.981	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding signal violation/right of way/ inattention in the Winnipeg area.
		Relative difference between the intervention and the control group regarding the evaluation scores on "moving in the roadway" driving tasks Ages 65-86; Thunder bay area	↗	F=4.15, p=0.049	The elderly drivers who undertook training, achieved significantly higher evaluation scores regarding «moving in the roadway» manoeuvres in the Thunder Bay area.
		Relative difference between the intervention and the control group regarding the evaluation scores on "moving in the roadway" driving tasks Ages 65-81; Winnipeg area	↗	F=5.23, p=0.037	The elderly drivers who undertook training, achieved significantly higher evaluation scores regarding «moving in the roadway» manoeuvres in the Winnipeg area.
		Relative difference between the intervention and the control group regarding the evaluation scores on passing and speed driving tasks Ages 65-86; Thunder bay area	—	F=1.85, p=0.183	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding passing and speed driving tasks in the Thunder Bay area.
		Relative difference between the intervention and the control group regarding the	—	F=0.01, p=0.936	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding passing and speed driving tasks in the Winnipeg area.

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		evaluation scores on passing and speed driving tasks Ages 65-81; Winnipeg area			
		Relative difference between the intervention and the control group regarding the evaluation scores on turning driving tasks Ages 65-86; Thunder bay area	—	F=0.22, p=0.643	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding turning driving tasks in the Thunder Bay area.
		Relative difference between the intervention and the control group regarding the evaluation scores on turning driving tasks Ages 65-81; Winnipeg area	—	F=0.33, p=0.572	There was not a statistically significant difference in the evaluation scores of the training and intervention groups regarding passing and speed driving tasks in the Winnipeg area.
Dommes and Cavallo, 2012. France	Street-crossing simulation training	Multivariate effect on crossing time, safety margin, tight fits and missed opportunities between control and intervention groups	↗	η^2=0.60 F(28,11)=14.25 P<0.05	Significant improvement in older pedestrians crossing decisions in those that had partaken in training when compared to the control.
		Relative difference of safety margins between control and intervention groups	↗	η^2=0.31 F(2,76)=16.8 P<0.01	Older pedestrians who received training allowed significantly larger safety margins when crossing when compared to the control group.
		Relative difference of tight fits allowed between control and intervention groups	↗	η^2=0.20 F(2,76)=9.2 P<0.01	Older pedestrians who received training allowed larger safety margins when crossing when compared to the control group.
Marottoli et al., 2007. USA	Classroom and on-road training	Relative difference in mean on-road driving test score between	↗	Least-Squares mean difference =2.87 t-statistic=3.38	Older drivers who received training performed significantly better in the driving test than the drivers who did not partake training

		treatment and control groups with regards to the baseline		p=0.01	
		Relative difference in mean test score in the knowledge test at 8 weeks between treatment and control groups with regards to the baseline	↗	Least-Squares mean difference =3.45 t-statistic=5.88 p<0.01	Older drivers who received training performed significantly better in the knowledge test than the drivers who did not partake training
Nasvadi and Vavrik, 2007. Canada	Classroom-based training program	Odds Ratio of involvement in a crash between training and control groups Ages: 55-94	—	OR= 1.15 β=0.141 p=0.427	Older drivers who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-74	—	OR= 0.81 β=-0.213 p=0.425	Older drivers who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 75-94	—	OR= 1.53 β=0.425 p=0.078	Older drivers who participated in the training program are marginally not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-94; Female drivers	—	OR= 1.03 β=0.025 p=0.91	Older female drivers who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-74; Female drivers	—	OR= 1.06 β=0.062 p=0.86	Older female drivers (between 55 – 74 years old) who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between	—	OR= 1 β=0.326 p=1	Older female drivers (between 75 – 94 years old) who participated in the training program are not

		training and control groups Ages: 75-94; Female drivers			significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-94; Male drivers	—	OR= 1 β=0.326 p=1	Older male drivers who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-74; Male drivers	—	OR= 0.55 β=-0.596 p=0.157	Older male drivers (between 55 – 74 years old) who participated in the training program are not significantly more likely to be involved in crashes
		Odds Ratio of involvement in a crash between training and control groups Ages: 55-74; Male drivers	↘	OR= 3.8 β=1.344 p=0.05	Older male drivers (between 75 – 94 years old) who participated in the training program are significantly more likely to be involved in crashes
Romoser and Fisher, 2009. USA	Active training (video feedback)	Difference in secondary looks during the simulator session between active and passive training groups	↗	F(1,34)=5.87 p<0.05	Compared with passive training, active training is a more effective strategy for increasing older drivers ´likelihood of looking for threats during a turn.
		Difference in secondary looks during the simulator session between the active training group and the control group	↗	F(1,34)=18.89 p<0.001	Older drivers who undertook active training, were (slightly) more likely to take a secondary look while turning in opposition with drivers who did not participate in the training session.
	Passive training (lecture)	Difference in secondary looks during the on-road driving session between active and passive training groups	↗	F(1,22)=13.11 p<0.005	Compared with passive training, active training is a more effective strategy for increasing older drivers ´likelihood of looking for threats during a turn.
		Difference in secondary looks during the on-road driving	↗	F(1,22)=11.83 p<0.005	Older drivers who undertook active training, were more likely to take a secondary look while turning in opposition with drivers

		session between the active training group and the control group			who did not participate in the training session.
Romoser, Matthew R. E., 2013. USA	Training via video-feedback	Percent change difference between the number of intersections, where a driver took secondary looks before training and 2 years after the training session	↗	26.4 % increase $F(1,10)=11.11$ $p=0.05$	Customized feedback and active learning in a simulator is an effective strategy for improving the safe driving habits of older drivers over the long term. It provides drivers a means by which to reincorporate previously extinguished behaviours into their driving habits.
		Percent change difference between the number of intersections, where a driver took secondary looks 6-8 weeks after the training test and 2 years after the training session	—	6.9 % decrease	The performance of older drivers who participated in training did not differ significantly after a short-time and a long-time follow-up.

↗ = Significant positive effect on road safety, following training (i.e. reduced accident rates and speed, and increased hazard perception ability).
↘ = Significant negative effect on road safety, following training (i.e. increased accident rates and speed, and reduced hazard perception ability).
— = Differences in road safety effects may have been found, but are not statistically significant or not known (i.e. statistical analysis not carried out).

3.2 LITERATURE SEARCH

A systematic literature search was undertaken to identify papers that examined the effectiveness of education and/or training in improving road safety. The initial search was general and was then refined to focus on education/training that focused on teaching the elderly. This section describes the search terms, screening and eligibility selection processes that were used to identify relevant papers.

The following criteria were applied to a key word search in the database Scopus. See Table for full results.:

- Search field: TITLE-ABS-KEY
- published: year > 2000
- Document Type: "Review" and "Article"
- Source Type "Journal"
- Language: "English"

Table 4: Scopus search terms and results

Database: Scopus **Date:** 7 Dec 2016

search no.	search terms / operators / combined queries	Hits
#1	"Education" OR "Training"	891777
#2	"road safety" OR "traffic safety" OR "driv*" OR "road" OR "transport" OR "traffic" OR	1381363

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	"Pedestrian" OR "Rider"	
#3	"collision*" OR "crash*" OR "accident*" OR "incident*" OR "casualt*" OR "fatalit*" OR "injur*"	1023558
#4	#1 and #2 and #3	5274

Due to the large number of search results, the search was limited to papers originating in the following countries: Europe, Israel, North America, Australia, New Zealand and Japan and excluded those in the subject areas: health professions, nursing, biochemistry, genetics and molecular biology and chemical engineering. This reduced the number of papers to be screened to **3327.**

Screening

A screening process then took place where titles and if necessary abstracts were quickly assessed to eliminate papers that were not relevant (Table). During this process, the relevant Education and Voluntary Training subtopic(s) that the paper related to was identified.

Table 5: Title and abstract screening for relevance

Total number of studies to screen title/ abstract – 1st screening	**3327**
-De-duplication	15
-Exclusion: not relevant (not focusing on Education/training in relation to road safety)	3159
Remaining studies to obtain full texts	**168**

Eligibility

The final stage was to identify the papers for which a full text could be obtained based on paper availability and which of these were eligible to be included in the SafetyCube Decision Support System (DSS) for the topic Training for Elderly. (Table 2).

Table 2:Eligible papers

Total number of studies to screen full-text for subtopics 'children' and 'Pedestrian'	**16**
Full-text could be obtained	12
Additional relevant studies identified from reference lists/other sources	3
Exclude: included in meta-analysis	0
Exclude: not relevant	4
Exclude: not suitable for inclusion in DSS	4
Total number of eligible papers	7

Prioritisation

Once the full papers had been evaluated as eligible, they were assessed as to their suitability to be included in this synopsis based on the following prioritisation criteria:

- Prioritizing Step A: Meta-analysis;
- Prioritizing Step B: Studies examining crashes – objective/subjective

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- Prioritizing Step C: Studies assessing behaviour change via a practical test;
- Prioritizing Step D: Studies assessing behaviour change via self-reported behaviour ;

For each prioritisation step, papers from Europe were coded before papers from USA, Japan, Australia, with the most recent papers being coded first.

Exclusion decisions

The full list of 19 eligible papers and the reasons why they were coded or not are shown in Table 3.

Table 3: Inclusion decisions

No.	Publication	Coded Y/N	Reason
1.	Romoser, M. R. E. (2013). The long-term effects of active training strategies on improving older drivers' scanning in intersections: A two-year follow-up to Romoser and Fisher (2009). *Human Factors*, *55*(2). http://doi.org/10.1177/0018720812457566	Y	Prioritizing step C
2.	Dommes, A., & Cavallo, V. (2012). Can simulator-based training improve street-crossing safety for elderly pedestrians? *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(2), 206–218. article. http://doi.org/10.1016/j.trf.2011.12.004	Y	Prioritizing step C
3.	Ball, K., Edwards, J. D., Ross, L. A., & McGwin Jr., G. (2010). Cognitive training decreases motor vehicle collision involvement of older drivers. *Journal of the American Geriatrics Society*, *58*(11), 2107–2113. article. http://doi.org/10.1111/j.1532-5415.2010.03138.x	Y	Prioritizing step B
4.	Romoser, M. R. E., & Fisher, D. L. (2009). The effect of active versus passive training strategies on improving older drivers' scanning in intersections. *Human Factors*, *51*(5). http://doi.org/10.1177/0018720809352654	Y	Prioritizing step C
5.	Bédard, M., Porter, M. M., Marshall, S., Isherwood, I., Riendeau, J., Weaver, B., … Miller-Polgar, J. (2008). The combination of two training approaches to improve older adults' driving safety. *Traffic Injury Prevention*, *9*(1), 70–76. article. http://doi.org/10.1080/15389580701670705	Y	Prioritizing step C
6.	Marottoli, R. A., Ness, P. H., Araujo, K. L., Iannone, L. P., Acampora, D., Charpentier, P., & Peduzzi, P. (2007). A randomized trial of an education program to enhance older driver performance. *J Gerontol A Biol Sci Med Sci*, *62*, 1113–1119. Journal Article. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17921424	Y	Prioritizing step C
7.	Nasvadi, G.E., Vavrik, J., 2007. Crash risk of older drivers after attending a mature driver education program. Accid. Anal. Prev. 39, 1073–1079.	Y	Prioritizing step B
8.	Owsley, C. . e, McGwin Jr., G. . b c, Phillips, J. M. ., McNeal, S. F. ., & Stalvey, B. T. . (2004). Impact of an educational program on the safety of high-risk, visually impaired, older drivers. *American Journal of Preventive*	Y	Prioritizing step C

	Medicine, *26*(3), 222–229. article. http://doi.org/10.1016/j.amepre.2003.12.005		
9.	Keay, L., Coxon, K., Brown, J., Clarke, E., Boufous, S., Bundy, A., ... Ivers, R. (2013). A randomized trial to evaluate the effectiveness of an individual, education-based safe transport program for drivers aged 75 years and older. *BMC Public Health*, *13*(1). article. http://doi.org/10.1186/1471-2458-13-106	N	No results – describes future study
10.	Korner-Bitensky, N., Kua, A., von Zweck, C., & Van Benthem, K. (2009). Older driver retraining: An updated systematic review of evidence of effectiveness. *Journal of Safety Research*, *40*(2). http://doi.org/10.1016/j.jsr.2009.02.002	N	Review – no codable results
11.	Lee, H. C. (2006). Virtual driving tests for older adult drivers? *British Journal of Occupational Therapy*, *69*(3), 138–141. article. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-33645295741&partnerID=40&md5=838a11cc5f5ede36997dc148cc967110	N	Review – no codable results
12.	Jones, V., Gielen, A., Bailey, M., Rebok, G., Agness, C., Soderstrom, C., & Parrish, J. (2012). The effect of a low and high resource intervention on older drivers' knowledge, behaviors and risky driving. *Accident Analysis and Prevention*, *49*, 486–492. article. http://doi.org/10.1016/j.aap.2012.03.021	N	Not relevant
13.	Gaines, J. M., Burke, K. L., Marx, K. A., Wagner, M., & Parrish, J. M. (2011). Enhancing older driver safety: A driving survey and evaluation of the CarFit program. *Journal of Safety Research*, *42*(5), 351–358. article. http://doi.org/10.1016/j.jsr.2011.07.007	N	Not relevant
14.	Dommes, A., Cavallo, V., Dubuisson, J.-B., Tournier, I., Vienne, F. 2014. Crossing a two-way street: Comparison of young and old pedestrians. Journal of Safety Research, 50, pp. 27-34	N	Not relevant
15.	Marottoli, R.A., Allore, H., Araujo, K.L.B., Iannone, L.P., Acampora, D., Gottschalk, M., Charpentier, P., Kasl, S., Peduzzi, P. 2007. A randomized trial of a physical conditioning program to enhance the driving performance of older persons. Journal of General Internal Medicine, 22 (5), pp. 590-597.	N	Not relevant

3.3 REFERENCES

Coded studies

Ball, K., Edwards, J.D., Ross, L.A., McGwin, G., 2010. Cognitive training decreases motor vehicle collision involvement of older drivers. J. Am. Geriatr. Soc. 58, 2107–2113.

Bédard, M., Porter, M.M., Marshall, S., Isherwood, I., Riendeau, J., Weaver, B., Tuokko, H., Molnar, F., Miller-Polgar, J., 2008. The combination of two training approaches to improve older adults' driving safety. Traffic Inj. Prev. 9, 70–76.

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Nasvadi, G.E., Vavrik, J., 2007. Crash risk of older drivers after attending a mature driver education program. Accid. Anal. Prev. 39, 1073–1079.

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Romoser, M.R.E., Fisher, D.L., 2009. The effect of active versus passive training strategies on improving older drivers' scanning in intersections. Hum. Factors 51, 652–668.

Additional references

European Commission, 2016. Annual Accident Report.

Martensen, H. et al. (2018). Methodological framework for the evaluation of road safety measures. Deliverable Number 3.3 of the H2020 project SafetyCube.