Transportation Research Part F: Psychology and Behaviour 87 (2022) 379–390

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf

Does age matter? Examining age-dependent differences in at-fault collisions after attending a refresher course for older drivers

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ARTICLE INFO

Keywords:
Older drivers
Educational courses
Evaluation
Collision risk

ABSTRACT

The “Driver 65+” course is a voluntary refresher course offered to all drivers aged 65 years or older in Norway. The current study estimated differences in at-fault motor vehicle collisions (MVCs) between older drivers who had attended in the course and older drivers who had not attended the course.

Methods: Two samples of drivers were selected from the database of an insurance company and were sent a questionnaire in the mail. The first sample consisted of 2039 car owners aged 70 years or older who had reported a collision to the insurance company during the last 24 months. The second sample consisted of 1569 drivers aged 70 or older who had not reported any collisions during the last 24 months.

Results: The results indicated an age-dependent effect; drivers attending the course before 75 years of age had a significantly lower risk of being the at-fault driver in a multi-MVC than older drivers who did not attend the course.

Conclusion: The results indicate that the refresher course had a beneficial effect on collision risk for drivers who attended the course before reaching 75 years of age. One possible explanation of this age-dependent effect is that a certain level of visual, cognitive, and motor functioning is needed to implement the strategies learned in the course. However, the design of the study makes it difficult to draw definite conclusions about the causal relationship between course attendance and later collision involvement.

1. Introduction

Due to the substantial increase in the number of older citizens with a driver licence in Western countries, measures aimed at promoting safe mobility among older drivers have been a focus for at least the last two decades. Driver educational courses are common safety measures aimed at this group of road users (see, e.g., Sangrar, 2019). Such courses may also prevent older drivers from prematurely retiring from driving and thus help them to maintain their freedom of movement and independence from others (Dickerson et al., 2007). On the other hand, an increased amount of driving may result in more motor vehicle collisions (MVCs) if such courses do not improve driving skills or driving style or if they result in overconfidence in one’s own driving skills (see, e.g., Nasvadi & Vavrik, 2007). Furthermore, a certain level of visual and cognitive functioning is believed to be necessary to successfully translate new knowledge learned into safe driving. Because visual and cognitive functioning important for driving deteriorates with age (see, e.g.,

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https://doi.org/10.1016/j.trf.2022.04.016
Received 16 November 2021; Received in revised form 20 April 2022; Accepted 26 April 2022
Available online 7 May 2022
1369-8478/

Deacon, 1988; Dickerson, 2017), the effect of educational courses on safe mobility may be different for the "youngest old" and the "oldest old" course participants. The present study aims to examine the effect of an educational course for older drivers on MVCs, including possible age-dependent effects of the course.

1.1. Previous research on the effect of educational courses for older drivers

Most evaluation studies have studied the effect of older driver retraining/educational courses using driver knowledge or on-road driving performance as the primary outcome measure (for a review, see Kua, Korner-Bitensky, Desrosiers, Man-Son-Hing, & Marshall, 2007, Korner-Bitensky, Kua, von Zweck, & Van Benthem, 2009, Sangrar, 2019, for a *meta*-analysis, see Fausto, Maldonado, & Ross, 2021). The effect of such courses on MVCs is, however, uncertain as only a few evaluation studies have used MVCs as an outcome measure. Based upon a sample of 40 000 US drivers, Janke (1994) found ambiguous effects of an improvement program directed towards older drivers on the number of MVC, and no conclusion regarding the effect of the program could be made. Ulleberg (2006) compared participants of refresher course for older drivers with a random sample of older drivers before and one year after completing the course. Course participants, especially females, were found to exhibit a reduction in collision risk compared to nonparticipants. This reduction in risk was, however, not statistically significant. The course was not found to affect mobility, the traffic situations the drivers were exposed to, or driving confidence. Based on a longitudinal randomized controlled trial, Owsley, McGwin, Phillips, McNeal, and Stalvey (2004) also found no evidence for an effect on the number of MVCs of an educational intervention directed towards visually impaired older drivers. A tendency of an increase in collision risk was found for the course participants when annual milage was adjusted for, although this tendency was not statistically significant. It should be mentioned that the number of collisions analysed by Owsley et al. was low, only 88 in total. Evaluation studies based upon larger numbers of MVC originating from national or regional databases have also given inconclusive results. Using time-series analysis of at-fault MVCs, Ichikawa, Nakahara, and Taniguchi (2015) found no effect of a short mandatory program for Japanese drivers aged 70 or more. The program consisted of a one-hour lecture, a driver aptitude test, an on-road driving assessment and a discussion session. Vanlaar, Hing, Robertson, Mayhew, and Carr (2016) estimated the effect of a mandatory 90-min educational session for Canadian drivers aged 80 or older. Using drivers aged 70–79 years as a comparison group, Vanlaar et al. concluded that the mandatory program had reduced the odds of being involved in MVC's.

To the authors' knowledge, only one study has analysed possible age-dependent effects of older driver educational courses on MVCs. Nasvadi and Vavrik (2007) concluded the effect of a group-based education course for older drivers depended on participants age and gender. Compared to a matched group of nonparticipants, male participants aged 75 years or older were involved in more collisions after course attendance. In contrast, male participants aged 74 years or younger showed a decrease in the number of MVCs, although this decrease was not statistically significant. The course was not found to influence collision risk for female participants, regardless of their age. Nasvadi and Vavrik (2007) suggested that the increased collision rate among the oldest course participants might be a result of the mismatch between the level of motoric and cognitive functioning, and the driver's capability to cope with demanding traffic situations. Focus group interviews suggested that older men who attended the course expressed a high level of driving confidence and used fewer relevant driving strategies (e.g., avoiding demanding driving situations) to cope with a decline in functioning compared to younger male course participants. Notably, Nasvadi & Varvik's study was based upon a relatively low number of MVCs, and exposure/mileage was not adjusted for. Further support for gender- and age-specific effects of driver educational courses was found in an evaluation study by Hawley, Smith, and Goodwin (2018). In this study, female participants 75 years of age or older rated their driving confidence as lower after the course compared to male participants in the same age group. To sum up, the effect of older driver educational courses on the risk of MVCs is uncertain, and previous studies suggest paying further attention to possible age- and gender-specific effects of such courses.

1.2. Aims of the present study

The "Driver 65+" is a voluntary two-day refresher course offered to all older drivers in Norway. The present study aims to examine possible age- and gender-dependent effects of this refresher course on the risk of at-fault MVCs. To be comparable to the study of Nasvadi and Vavrik (2007), course participants were categorised into those attending the course before 75 years of age and those attending the course at the age of 75 years or older. Possible effects of the course on driver confidence and driving avoidance will also be examined. To summarize, the aims of the present study were:

1. To estimate the effect of the "Driver 65+" course on at-fault MVCs
2. To examine whether the effect of the "Driver 65+" course on at-fault MVCs is dependent upon driver age and gender.
3. To test possible age- and gender-dependent effects of the "Driver 65+" course on driving confidence and the use of driving avoidance strategies.

2. Materials and methods

2.1. Description of the refresher course

Since 1990, a voluntary two-day refresher course for older drivers named "Driver 65+" has been arranged by the Norwegian Public Roads Administration in collaboration with authorized driving schools. The course is offered in all parts of the country and has in

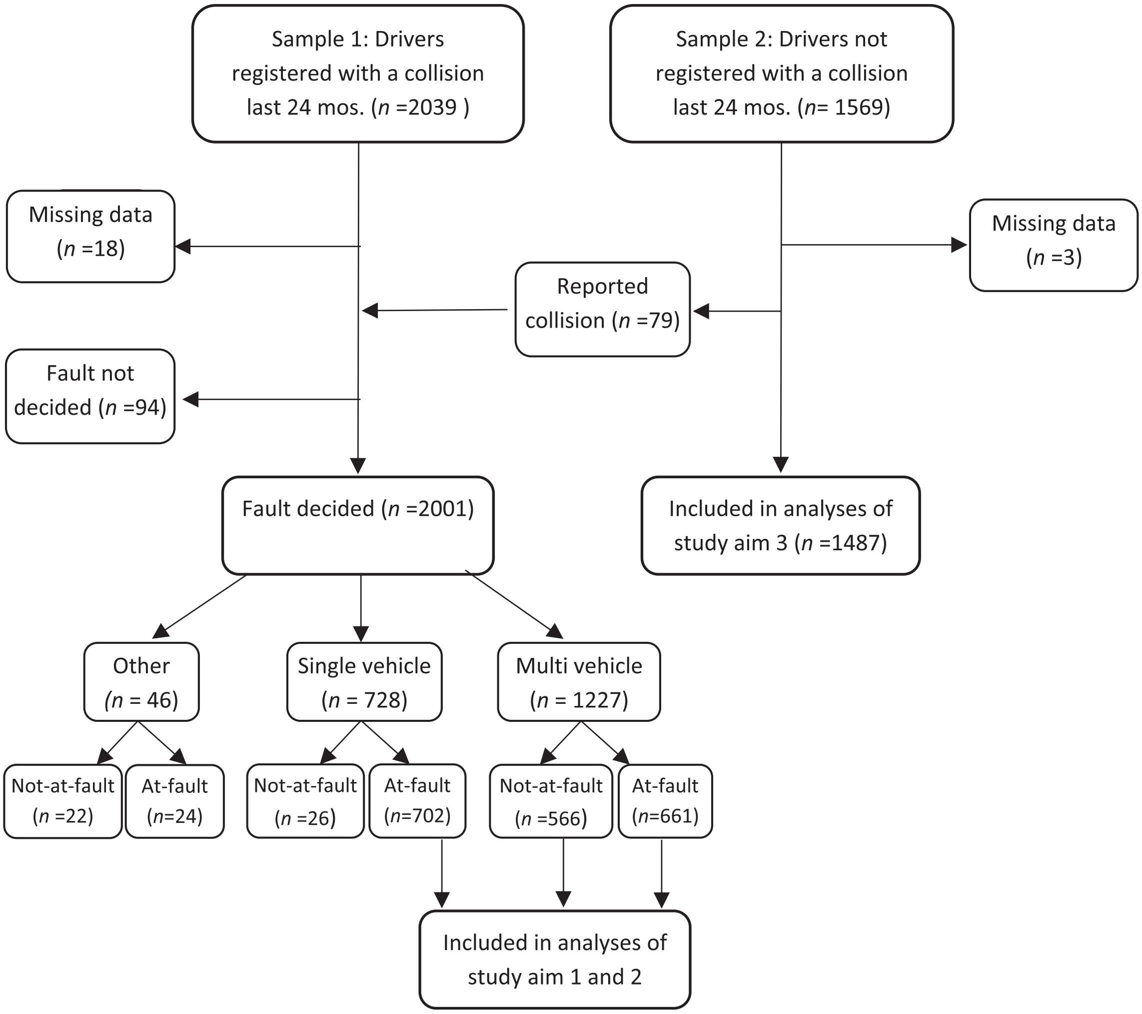

Fig. 1. Flow-chart of the participant in the current study.

practice had the same content the last 20 years. The aim of the course is to improve the safety and mobility of older drivers by focusing on various traffic situations or traffic environments that are particularly problematic for this age group, such as driving in roundabouts, in intersections, on motorways, in tunnels, and at night. Thus, the course can be described as an educational intervention. All drivers with a valid driver licence receive a letter from the Norwegian Public Roads Administration inviting them to participate in the course when they reach 70 years of age. In practice, the age of the course participants varies considerably, from 65 to 90 years of age (Ulleberg, 2006). In the invitation letter, the drivers are informed that participation is voluntary, free of charge, that there is no exam on the course, and that they do not risk losing their driver's licence if they participate in the course.

2.2. Procedure and sample

Two samples of drivers were drawn from the registry of one of the largest insurance companies in Norway. The first sample consisted of 5800 car owners aged 70 years or older who had reported a collision to the insurance company during the last 24 months. The second sample consisted of 4000 drivers aged 70 years or older who had not reported a motor vehicle collision to the insurance company during the last 24 months.

The car owners received a questionnaire in the mail. From the first sample, 2 039 questionnaires were returned, in addition to 37 being sent to an invalid address, resulting in a response rate of 35.4%. Eighteen respondents were excluded due to a high proportion of missing values/invalid responses. From the second sample, 1569 questionnaires were returned, yielding a response rate of 39%. Three respondents were excluded due to a high proportion of missing values/invalid responses. Although selected from the "non-collision" sample, 79 drivers reported an MVC to the insurance company in the period between the time when the sample was selected and the time they received the questionnaire. These 79 drivers were transferred to the collision-involved sample (see Fig. 1 for an overview). Both samples received a cover letter from the University of Oslo and Institute of Transport Economics informing the participants about

Table 1
Characteristics of the two samples.

	Collison-involved (n = 2001)	Not involved in collisions (n = 1487)
Age, mean (*SD*)	78.7 (4.9)	77.6 (4.9)
Gender (pct males)	77.0%	81.3%
Driver 65+ course[a]	23.6% (n = 472)	20.7% (n = 308)
Attended course at age 74 or younger[a]	13.9% (n = 278)	12.5% (n = 185)
Years ago course, mean (*SD*)	5.8 (3.3)	5.3 (3.6)
Attended course at age 75 or older[a]	9.1% (n = 182)	7.6% (n = 113)
Years ago course, mean (*SD*)	4.6 (3.0)	4.1 (3.2)

[a] For drivers involved in collisions, attending course before being involved in an MVC.

Table 2
Overview of the types of motor vehicle collisions categorized by responsibility assignment.

	Not-at-fault	At-fault	Total (*pct of all collisions*)	Mean speed limit (*SD*)
Multi-vehicle collisions				
Head-on collision	46 (56.1%)	36 (43.9%)	82 (4.1%)	49.6 (20.1)
Collision while overtaking	11 (50.0%)	11 (50.0%)	22 (1.1%)	52.4 (21.9)
Collision in intersection	102 (43.4%)	133 (56.6%)	235 (11.7%)	43.4 (18.0)
Collision in roundabout	24 (44.4%)	30 (55.6%)	54 (2.7%)	37.7 (15.7)
Collision while changing lane	5 (15.6%)	27 (84.4%)	32 (1.6%)	50.6 (22.4)
Rear-end collision	147 (61.0%)	94 (39.0%)	241 (12.0%)	45.4 (20.9)
Hit while stopped at the roadside	28 (84.8%)	5 (15.2%)	33 (1.6%)	39.7 (19.2)
Collision while reversing	196 (37.6%)	325 (62.4%)	521 (26.0%)	24.7 (10.8)
Collision with pedestrian/cyclist	7 (100.0%)	0 (0.0%)	7 (0.3%)	34.3 (23.0)
Sum multi-vehicle collisions	***566*** (46.1%)*	***661*** (53.9%)*	*1227 (61.3%)*	*37.0 (19.6)*
Single-vehicle collisions				
Driving off the road	3 (2.3%)	126 (97.7%)	129 (6.4%)	54.8 (22.3)
Hitting parked vehicle	3 (1.8%)	167 (98.2%)	170 (8.5%)	23.3 (10.5)
Hitting fixed object	9 (2.2%)	398 (97.8%)	407 (20.3%)	27.7 (17.0)
Collision with animal	11 (50.0%)	11 (50.0%)	22 (1.1%)	65.9 (21.4)
Sum single vehicle collisions	*26 (3.6%)*	***702*** (96.4%)*	*728 (36.4%)*	*35.9 (20.8)*
Other (not specified)	*22 (47.8%)*	*24 (52.2%)*	*46 (2.3%)*	*34.1 (19.6)*
Total	614	1387	2001	35.7 (20.4)

*Included in further analyses.

the aim of the study, that participation was voluntary, and that the questionnaires should be answered anonymously. Ethical approval of the study was not required according to Norwegian regulations, as participation did not have any consequences for the participants and they retuned the questionnaire voluntarily and anonymously, i.e., no information in the questionnaire could be traced to the participants.

2.3. Questionnaire

The respondents were asked whether they had been involved in an MVC during the prior 24-month period. If so, the questionnaire was to be completed by the person who had been driving the car during the collision. Questions about the collision included the type of collision, time of day, speed limit, driving conditions (e.g., icy, rain) and whether the driver, as judged by the insurance company, was at fault or not at fault for the collision. An overview of the different types of motor vehicle collisions reported by not-at-fault/at-fault drivers is presented in Table 2 and in Fig. 1. Collisions with shared responsibility or in which responsibility had not been decided were excluded (n = 94), resulting in a final sample size of 2001 drivers involved in collisions.

All respondents were asked whether they had attended the “Driver 65+ course” and if so at what age they had attended the course. Drivers involved in collisions had to report whether they had attended the course before or after the collision. All drivers were asked to estimate their driving distance (in kilometres) for the last year using categorical responses (1) under 4 000 km, (2) 4 000–6 000 km, (3) 6 000–8 000 km, (4) 8 000–10 000 km, (5) 10 000–12 000 km, (6) 12 000–14 000 km, (7) 14 000–16 000 km, (8) 16 000 km or more. They also reported how often they drove a car, on a scale ranging from (0) have stopped driving (1) fewer than 1–3 days per month, (2) 1–3 days per month, (3) 1–2 days per week, (4) 3–4 days per week and (5) 5–7 days per week. Only 43 drivers reported having stopped driving. In addition, the following self-report measures were included:

2.3.1. Driver behaviour questionnaire

A short version (16 items) of the Manchester Driver Behaviour Questionnaire (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) was included. The DBQ has been widely used as a measure of aberrant driver behaviour (see, e.g., Scialfa et al., 2010) and is predictive of collision involvement (for a *meta*-analysis, see De Winter & Dodou, 2010), also for older drivers (Spano, Caffò, & Lopez, 2019). The 16 items were separated into four DBQ subscales, each consisting of four items: Violations, ($\alpha = 0.677$), e.g., “Disregard the speed limit to follow traffic", Inattention (α = 0.487), e.g., "Misread signs and find yourself lost", Inexperience (α = 0.557), e.g., "Intend to reverse and find that the car is moving forward because it's in the wrong gear" and Mistakes (α = 0.521), e.g., "Misjudge the gap to oncoming vehicle when you are turning left and force the oncoming vehicle to slam on the brakes". Each item within the violations subscale was scored from 0 (never) to 6 (very often). On the items within the three other subscales, the respondents were asked how many times they had committed the error/mistake during the last month, ranging from 1 (0 times) to 5 (10 times or more), as recommended by Bjørnskau & Sagberg (2005). The mean scores on each subscale were calculated, and the higher the score was, the more aberrant driving behaviour was reported.

2.3.2. Driving confidence

A Norwegian-authorized translation (Rike, Johansen, Ulleberg, Lundquist, & Schanke, 2015) of the Adelaide Driving Self Efficacy Scale (ADSES) (George, Clark, & Crotty, 2007) was included. The ADSES has been found to be a reliable and valid measure of driving self-efficacy due to the scale's ability to predict performance in on-road driving tests, i.e., high self-efficacy is related to better driving performance (George et al., 2007; Stapleton, Connolly, & O'Neill, 2012). The ADSES is a 12-item self-reported scale that asks participants to rate their confidence levels about driving situations, such as driving in roundabouts, at night, in high-speed areas, and to a new destination. An additional item, "driving on slippery/icy roads", was included in the present study due to the relevance of this driving situation in Norway. Each item was scored on a scale from 1 (no confidence) to 7 (full confidence). In the present study, the reliability of the ADSES estimated by Cronbach's alpha was 0.947.

2.3.3. Driving avoidance

The participants were asked to report how often they avoided 11 different driving situations, rated on a scale from 1 (never avoid) to 5 (always avoid). These 11 situations corresponded to those presented in the ADSES, exempt from two indicators excluded due to low relevance as indicators of self-restriction: "responding to road signs/traffic signals" and "driving in your local area". Although this driving avoidance scale was self-developed, these 11 situations and Blaloc et al.'s (2006) Driver Avoidance Scale overlap considerably. The estimated reliability of the scale compromising the 11 driving situations was found to be satisfactory in the present study (α = 0.898).

2.4. Analysis

The method of quasi-induced exposure (Carr, 1969; Haight, 1971; Stamatiadis & Deacon, 1997) was used to estimate relative collision risk based on MVC data. This method relies on two main underlying assumptions: (1) one can distinguish between at-fault and not-at-fault drivers in motor vehicle collisions, and (2) not-at-fault drivers are believed to be randomly selected from the population of drivers on the road at the time of collision occurrence. Not-at-fault drivers are believed to be involved in a multi-MVC due to randomness, simply because they are in the wrong place at the wrong time. Therefore, not-at-fault drivers are believed to be representative of the population of road users in the traffic situation in which the collision occurred and can thus be used as a proxy measure of exposure. The latter is particularly relevant to older drivers because they commonly use compensatory driving strategies and hence avoid driving in potential high-risk situations, such as driving during rush hour traffic, at night, and in bad weather (National Highway Traffic Safety Administration, 2009, Molnar et al., 2013). Thus, the relative collision risk for a specific group of drivers (e.g., older drivers who have taken a refresher course) can be estimated by comparing the at-fault/not-fault MVC ratio for these drivers with the same ratio for other drivers (e.g., older drivers without the refresher course). Although the method of quasi-induced exposure is primarily developed for multi-MVCs, the method can also be applied for single MVCs, using drivers not-at-fault in multi-MVCs as a reference group (Hing, Stamatiadis, & Aultman-Hall, 2003; Stamatiadis & Deacon, 1997).

Binary logistic regression analysis was used to examine the effect of the "Driver 65+" course on at-fault MVCs vs. not-at-fault MVCs. Predictors in the logistic regression model included drivers' age in years, gender, whether they had attended the "Driver 65+" course, and whether they had attended the course when they were 75 years of age or older. Although there was a significant positive point-biserial correlation between participants' present age and whether they had attended the course at the age of 75 or not ($r = 0.264$, $p < .001$), the size of the correlation was rather small and would thus not cause any problems with multicollinearity in the analyses. All predictors were mean centered, i.e., the mean value on a predictor was subtracted from each individual's value on the same predictor. Mean centring was done to make the interaction terms more interpretable.

Multiple regression analysis was applied to test possible age- and gender-dependent effects of the "Driver 65+" course on driver confidence and avoidance of traffic situations. The latter analysis was primarily based on the sample of older drivers who were not involved in MVCs because being involved in a collision is likely to affect both driving confidence and the avoidance of difficult driving situations. Missing values on the DBQ scale, ADSES and driving confidence scale were replaced with the mean of valid scores on items within the same scale.

Preliminary analyses were conducted as a safeguard before the main analyses. First, the effect of the refresher course on at-fault MVCs may depend on the time lag between course attendance and collision involvement. A binary logistic regression analysis using time lag as a predictor of at-fault MVC was therefore estimated. This analysis was restricted to drivers who had attended the course, because this time lag was only relevant for this group. Time lag was not found to be related to at-fault multi MVC ($OR = 1.005$, $p = .900$), and thus not believed to be a possible confounder when estimating the effect of the course upon at-fault MVC.

Second, the assumption that not-at-fault drivers in multi MVCs were a random sample of the driver population was tested. ANCOVAs (using age, mileage, and gender as covariates) were used to examine possible differences in the driving skills (Mistakes, Inattention and Inexperience) and driving style (Violation, driving distance, frequency of driving) of not-at-fault older drivers in multi-

Table 3
Logistic regression analyses estimating the effect of the Driver 65+ course on at-fault multi- and single-vehicle collisions.

	Model 1		Model 2		Model 3	
	OR	95% *CI*	OR	95% CI	OR	95% CI
Multi-vehicle collisions (n = 1180)[a]						
Driver 65+ course (0 = no, 1 = yes)	0.81	(0.62. 1.07)	0.68*	(0.48, 0.95)	0.68*	(0.48, 0.96)
65+ course after 75 years (0 = no, 1 = yes)			1.62	(0.94, 2.80)	1.65	(0.95, 2.87)
Age (in years)			1.05***	(1.02, 1.07)	1.05***	(1.02, 1.07)
Gender (0 = male, 1 = female)					0.89	(0.67, 1.18)
Gender * Driver 65+ course					1.10	(0.51, 2.39)
Gender * 65+ course after 75					0.86	(0.24, 3.10)
Single-vehicle collisions (n = 1218)[b]						
Driver 65+ course (0 = no, 1 = yes)	1.07	(0.82. 1.39)	0.86	(0.63, 1.17)	0.83	(0.60, 1.15)
65+ course after 75 years (0 = no, 1 = yes)			1.86*	(1.11, 3.12)	1.91*	(1.13, 3.24)
Age (in years)			1.01	(0.98, 1.03)	1.01	(0.98, 1.03)
Gender (0 = male, 1 = female)					1.21	(0.92, 1.58)
Gender * Driver 65+ course					1.21	(0.61, 2.43)
Gender * 65+ course after 75					0.70	(0.21, 2.30)

All predictors are mean centred. Each block of predictors were entered in a single step.
*p <.05, **p <.01, *** p <.001.
[a] 0 = not-at-fault in multivehicle collision, 1 = at-fault in multivehicle collision.
[b] 0 = not-at-fault in multivehicle collisions, 1 = at-fault, single vehicle collisions.

MVCs compared to the sample of older drivers who were not involved in collisions. These analyses supported the assumption of not-at-fault drivers being a random sample of the driver population (see Appendix).

3. Results

Table 1 presents an overview of the two samples of older drivers, i.e., those who had reported a collision during the last 24 months and those who had not reported a collision. The mean age was a bit higher in the sample of collision-involved drivers (78.6 years) compared to those not involved in collisions (77.6 years). In total, 78.8% of the drivers were male, being highest in the sample who had not reported a collision. The proportion of drivers who attended the Driver 65+ course was highest in the sample the collision-involved drivers, 23.6%. In general, it was more common for drivers to participate in the Driver 65+ course before turning 75 years of age. The time-lag between course attendance and the study period was a bit shorter for those attending the course at the age of 75 or more compared those attending at an earlier age.

3.1. *Classification of collisions type and responsibility of collision*

An overview of types of collisions, categorized by responsibility, is presented in Table 2. Most of the collisions were classified as multi MVC's. Among these, collisions while reversing were the most frequent type, followed by collisions at intersections and rear-end collisions. The two latter types of collisions occurred in areas with a considerably higher speed limit compared to the former, approximately 50 km/h vs. 25 km/h. In single-vehicle collisions, most drivers (96.4%, n = 702) were, as expected, found to be at fault. Hitting fixed objects and parked vehicles in areas with a low speed limit was the dominant type of single-MVCs. Drivers found to be at-fault (n = 661) or not-at-fault (n = 566) in multi-MVCs, and drivers found to be at-fault in single-MVCs (n = 702) were included in further analyses aiming to estimate the effect of the Driver 65+ course on the risk of at-fault collisions.

3.2. *Estimation of the effect of the driver 65+ course on at-fault MVCs*

Table 3 shows the results of a multiple logistic regression analysis estimating the effect of Driver 65+ separately for multi- and single-MVCs. In Model 1, Table 3, the effects of the course on at-fault collisions were estimated without accounting for possible age- and gender-dependent effects. The results from Model 1 showed no significant effect of the Driver 65+ course on at-fault multi- or single–MVCs.

In Model 2, possible age-dependent effects of the course were estimated by dividing course participants into those who attended the course before reaching 75 years of age and those who attended the course at the age of 75 years or older. The driver's present age was also controlled for in Model 2, as those who attended the course at age 75 or older were on average 6.8 years older than participants who attended the course at a younger age (p <.001). For each year of increase in age, there was a small, but significant increase in the odds of being at fault in a multi-MVC. The results from Model 2 showed that drivers who had attended the course before 75 years of age had a significantly lower likelihood of being at fault in multi-MVCs compared to drivers who had not taken the course (OR = 0.68). The

Table 4
Multiple regression analyses estimating differences between Driver 65+ participants and nonparticipants in driving avoidance and driver confidence.

	Driving Avoidance		ADSES		Annual driving distance (km)	
	b	*(se)*	*b*	*(se)*	*b*	*(se)*
Intercept	1.82	(0.02)***	5.56	(0.03)***	8421.3	(100.8)***
Age (in years)	0.04	(0.01)***	−0.04	(0.01)***	−334.5	(21.0)***
Gender (0 = male, 1 = female)	0.35	(0.05)***	−0.42	(0.07)***	−2868.7	(253.7)***
Driver 65+ course (0 = no, 1 = yes)	0.08	(0.05)	−0.22	(0.09)*	722.4	(298.6)*
Gender * Driver 65+ course	−0.01	(0.12)	−0.02	(0.20)	−206.2	(682.2)
65+ course after 75 years (0 = no, 1 = yes)	−0.22	(0.08)**	0.26	(0.14)†	132.5	(468.9)
Gender * competed course after 75	−0.07	(0.20)	0.23	(0.32)	817.1	(1119.1)
R^2	0.11***		0.05***		0.21***	

Analyses are based upon 1390 non-involved drivers. All predictors are mean centred and were entered in a single step in the model. ADSES: Adelaide Driving Self Efficacy Scale.
† $p < .10$, *$p < .05$, **$p < .01$, *** $p < .001$.

same tendency was found for single-MVCs; however, the trend was not statistically significant. On the other hand, attending the course at 75 years of age or older had an effect in the opposite direction, i.e., a significant increase in the likelihood of being the at-fault part in a single-MVC ($OR = 1.86$).

In Model 3, the main and moderating effects of gender were included. In short, no main or moderating effect of gender on at-fault MVCs were found. Thus, no support for gender-specific effects of the course was found.

3.3. Age- and gender-specific effects of the course on driving avoidance and confidence

Possible age- and gender-specific effects of the refresher course on driving avoidance and driver confidence (ADSES) were tested using multiple regression analysis. As being involved in an MVC is likely to affect both driving confidence and the avoidance of difficult driving situations, the analyses based upon the sample of older drivers not involved in MVCs are presented. Corresponding analyses based upon the MVC-involved sample are included in the Appendix.

Table 4 shows that drivers who had attended the Driver 65+ course at 75 years of age or older reported less avoidance of difficult driving situations compared to non-participants, adjusted for drivers' age and gender. It should be noted that this difference was rather small: 0.22 points on a scale from 1 to 5. There was also a tendency for older drivers who attended the course at 75 years of age or older to have higher driving confidence (ADSES), although this difference was not statistically significant using the conventional significance level of 5% ($p = .054$). In contrast, drivers who had attended the course before reaching 75 years of age expressed lower driving confidence than non-attendees and reported a higher annual driving distance than non-participants. Although older female drivers on average reported more avoidance and less driver confidence than older male drivers, no gender-dependent effects of the refresher course were found.

Corresponding analyses based upon the MVC-involved sample (Table A2, Appendix) showed that drivers who had attended the refresher course before 75 years of age expressed significantly lower driving confidence and more avoidance of difficult driving situations compared to non-attendees. Although drivers attending the course at age 75 or older did not differ significantly from drivers who did not attend the course, the differences occurred in the same direction as those for older drivers who were not involved in MVCs.

4. Discussion

Without considering at what age the drivers attended the course, no significant effect of the Driver 65+ refresher course on at-fault MVC was found. This result is in line with most other evaluation studies of educational interventions aimed at old adult drivers (see Owsley et al., 2004; Janke, 1994; Ichikawa et al., 2015). However, considering at what age the drivers attended the course gave a different conclusion. That is, attending the refresher course before 75 years of age reduced the odds of being at fault in multi MVCs. Attending the course at older age that 75 gave no beneficial effect on safety. In contrast, an increase in the odds of single MVC's was found for the oldest course participants.

This age-dependent effect corresponds with the findings of Nasvadi and Vavrik (2007). A possible explanation of the age-dependent effect is that a certain level of visual, cognitive, and motoric functioning is needed to translate new knowledge into safe driving behaviour. Such functioning is found to decline at high age (see e.g., Deacon, 1988). In other words, it might be difficult for the "oldest old" course participant to reap the benefits of the refresher course, because the course content is not matched with the individuals' level functioning. It should, however, be emphasized that there are large individual differences in such functioning, meaning that an old adult driver does not necessarily exhibit reduced functioning. Nevertheless, interventions aimed at improving such functioning may be a more efficient safety measure than education for many old adult drivers. For instance, a randomized control trail (RCT) study by Ball, Edwards, Ross, and McGwin (2010) has shown promising results. Old adult drivers who participated in 10 training sessions targeting speed of processing for visual attention tasks had roughly 50% lower rate of at-fault MVCs than a control group. Physical retraining/exercise of older drives may also be an alternative safety measure for older drivers. A recent *meta*-analysis based on RCT studies concluded that such interventions improve the driving performance of older adults (Fausto et al., 2021). The effect of physical training on collision risk is, however, uncertain.

The results suggested an increase in the risk of single MVCs for those attending the course at the age of 75 years or older. This finding should be interpreted with some caution. The single-vehicle collisions in the present study were typically associated with parking the vehicle (e.g., hitting fixed objects/parked vehicles), most likely resulting in less serious consequences compared to multi-MVCs. It should also be noted that the use of the method of quasi-induced exposure (QIE) to estimate the risk of single-MVC has been debated. This is primarily because drivers who are not at fault in multi-MVCs are not necessarily a random sample of drivers in situations in which single-vehicle MVCs occur (Stamatiadis & Deacon, 1997). Still, other studies (Janke, 1994; Owsley et al., 2004) have also found a tendency for an increase in older adult drivers' collision risk after attending educational courses. This increase was, however, not statistically significant in either of these two studies.

No evidence for a gender-dependent effect of the refresher course on at fault MVCs was found. This result is in contrast with a previous evaluation of the Driver 65+ course (Ulleberg, 2006), and to the evaluation study by Nasvadi and Vavrik (2007). Both previous studies were based upon relatively few collision-involved drivers, possibly explaining the difference from the present study. Nevertheless, the results from the present study suggest that the gender of the course participants seems to be of minor importance.

Possible effects of the refresher course upon driver confidence and driver avoidance were estimated from the sample of older drivers who were not involved in collisions. The reason was that collision involvement is expected to influence driver confidence and driving avoidance. Although estimated from a different sample, the results showed a similar pattern to the effects found on collisions risk. That is, drivers attending the course at the age of 75 years or older expressed somewhat higher driver confidence and less driving avoidance compared to nonparticipants. The opposite was found for the "young old" course participants, i.e., lower driving self-efficacy compared to nonparticipants of the same age. Both Owsley (2004) and Nasvadi and Vavrik (2007) have suggested that overconfidence in own driving abilities can be an unwanted effect of educational courses. In combination with reduced functioning, overconfidence in driving abilities could be an explanation of lack of beneficial effect of the course for the "oldest old" drivers. Vice versa, low driving confidence and more avoidance of complex traffic situations among the "youngest old" course participants could be an explanation of the reduced risk of at-fault collisions for this group of drivers. While being statistically significant, the differences found in driver confidence and driving avoidance were regarded as rather small effect. Thus, it is unlikely that changes in driver confidence and driving avoidance was the main reason for the age-dependent effect of the course upon at-fault collisions. In contrast to Hawley et al. (2018) no gender-specific effects of the course in driver confidence or driving avoidance was found.

5. Limitations of the present study

The main strength of the present study is the use of a large dataset of MVC, resulting in high statistical power to detect possible age-dependent effects of the refresher course on collision involvement. A major limitation of the present study is that participants were not randomized to receive the refresher course or not. In addition, no information about participants' collision history prior to the course was collected. To claim a cause-and-effect relationship between course attendance and later risk of collision involvement is therefore problematic. An alternative explanation of the beneficial effect of attending the course at a "young old" age could be self-selection bias, e.g., the most safety conscious drivers with the lowest initial collision rate are more likely attend the course at a "young old" age. The seemingly detrimental effect of attending the refresher course at the age of 75 years or older could also be a result of self-selection. Experiencing collisions or near-collisions as a result age-related functional decline could motivate course attendance to keep their driver licence. In this context, it should be noted that the study by Nasvadi and Vavrik (2007) compared course participants with a matched control group of older drivers based on their prior collision involvement. Notwithstanding the difference in research design from the present study, both studies found the same indication of an age-dependent effect after course attendance.

The present study did not include any measures of cognitive or visual functioning found to be important for collision involvement (see e.g., Ball, Roenker, & McGwin, 2006, Owsley, Ball, & McGwin, 1998). The inclusion of such variables would made it possible to adjust for possible self-selection bias in these variables. In addition, the impact of driver's functional level on the effect of refresher course could have been tested directly instead of using age as a proxy variable for functioning. A suggestion for future research is to include measures of visual and cognitive functioning when evaluating the effect of refresher courses.

The present study relied on self-report measures. Such measures can be subjected to recall bias, especially among the oldest old drivers. For instance, misreporting of annual travel distance by car (see e.g., Porter, Smith, & Cull, 2015, Friedrich, Duerksen, & Elias, 2019), of responsibility assignment, of type of collisions, and of course participation could have occurred. Alternative ways of measuring such variables by such as using registered data, or to avoid using categorical responses for measuring km driven, would have given more reliable measurement compared to self-reports. However, there is no reason to expect systematic differences in recall bias between course participants and non-participants.

The choice of the method of quasi-induced exposure (QIE) in relation to multi-MVCs has both advantages and disadvantages. The main advantage is the assumed ability to capture exposure to different traffic situations, which is believed to be of particular importance due to a large variation in when and where old adults drive. Using non-at-fault drivers in MVCs as measure of the travel exposure is debated (see, e.g., Méndez & Izquierdo, 2010). For instance, the greater collision-avoidance skills a driver has, the lower the likelihood of being the not-at-fault party in a multi-MVC. If so, less capable drivers would be more likely to be the not-at-fault in multi-MVC and thus play a part in causing collisions. In the present study, we found no indication of poorer driving skills among older drivers who were not at fault compared to older drivers who were not involved in collisions, supporting the validity of QIE (see analyses in the Appendix).

6. Conclusion

The results indicate that the refresher course has a beneficial effect on safe mobility, provided that the driver attends the course before reaching 75 years of age. The most likely explanation of this result is that the ability to learn new skills declines rapidly at high age, and the “oldest old” drivers are more likely to fail in implementing strategies learned in the course due to functional decline associated with aging. Consequently, interventions aimed at improving functional abilities such as motoric or cognitive training may better suited for the oldest adult drivers, possibly in combination with education.

The research design of the current study makes it difficult to draw definite conclusions about causal relationship between course participation and collision involvement. Future evaluation studies of educational course are therefore encouraged use large scale randomized control trials for this purpose. Moreover, future studies should take participants’ age of into consideration when estimating the effect of interventions aimed at old adult drivers, and to include measures of drivers’ visual and cognitive abilities.

CRediT authorship contribution statement

Pål Ulleberg: Conceptualization, Methodology, Formal analysis, Writing – original draft, Project administration, Funding acquisition. **Torkel Bjørnskau:** Conceptualization, Methodology, Funding acquisition, Writing – review & editing. **Knut Inge Fostervold:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research has received support from The Research Council of Norway, project No. 187780 “The Impact of Everyday Mobility for Elderly People’s Welfare and Mobility – Mobile-age”. The authors would like to thank the three anonymous reviewers for their constructive suggestions for revisions.

Appendix A

A central assumption underpinning the method of quasi-induced exposure is that drivers not at fault in multi-MVC are believed to be a random sample of the driving population. To test this assumption, driving skills and driving style of older drivers not at fault in multi-MVC were compared to older drivers who were not involved in MVCs. Table A1 presents an overview of the four groups of older drivers classified on the basis of their involvement in MVCs. The results presented in Table A1 show no significant differences between not-at-fault drivers and drivers not involved in collisions on the four DBQ scales. However, not-at-fault drivers reported a higher annual driving distance and frequency than drivers who were not involved in MVCs. These findings suggest that not-at-fault drivers were involved in multi-MVCs due to more exposure to traffic situations and not as a result of a riskier driving style. Thus, the use of the methods of quasi-induced exposure to estimate the effect of the “Driver 65+” course on at-fault MVCs was found to be suitable.

At-fault drivers in multi-MVAs reported significantly more mistakes and inexperience errors than the other groups. Although statistically significant, differences between the three groups of drivers could be described as relatively small. Furthermore, the DBQ scales clearly had a floor effect, meaning that most drivers did not report making mistakes or errors. Consequently, the scores on the DBQ scales deviated considerably from a normal distribution. Analyses based upon logarithmic transformed scores were performed to remedy the non-normal distribution of scores. These latter analyses reach the same conclusions as those reached based on the original scores. Hence, only analyses based upon the original scores are reported.

Additional group comparisons adjusting for age, gender, and mileage was also performed. These results from these analyses gave only trivial differences for the results reported in Table A1, and are therefore not reported Table A2.

Table A1
Comparison of older drivers by involvement in and responsibility for collisions.

	Collision involved			Non-involved		Pairwise comparison[e]					
	1. At-fault multi-MVC (n = 661)	2. At-fault single-MVC (n = 702)	3. Not-at-fault multi-MVC (n = 566)	4. (n = 1487)	χ^2	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4
Gender (pct males)	79.7%	73.6%	76.9%	81.3%	17.4***	6.1%*	−2.8%	1.6%	3.3%	7.7%**	4.4
Driver 65+ course[a]	20.9%	26.4%	24.3%	20.7%	10.7*	−5.5%	3.4%	0.2%	−2.1%	−5.7%*	−3.6
Attended course before 75[a]	11.1%	14.5%	17.5%	12.5%	12.2**	3.4%	6.4%*	1.4%	3.0%	−2.0%	−5.0*
Attended course at 75 +[a]	9.4%	10.8%	6.6%	7.5%	9.7*	1.4%	−2.8%	1.9%	−4.2%	−3.3%	0.9
					F						
Age, mean (*SD*)	79.3 (5.0)	78.5 (4.9)	78.0 (4.7)	77.6 (4.9)	19.4***	0.80*	1.26***	1.67***	0.49	0.90***	0.41
Age, range	71–94	66–102	71–96	67–93							
Annual driving distance (in 1000 km)	8.9 (4.1)	9.0 (4.0)	9.5 (4.0)	8.9 (4.1)	3.80*	−0.07	−0.63*	0.10	−0.55	−0.02	0.65**
How often drive[b]	4.3 (0.9)	4.2 (1.0)	4.4 (0.8)	4.1 (0.9)	16.9***	−0.12	−0.10	0.19***	−0.22***	−0.07	0.29***
DBQ											
Violations[c]	2.1 (0.8)	2.1 (0.8)	2.0 (0.8)	2.1 (0.8)	0.42	0.01	0.05	0.01	0.04	0.00	−0.04
Mistakes[d]	1.2 (0.3)	1.1 (0.2)	1.1 (0.2)	1.1 (0.2)	6.08***	0.04*	0.05**	0.05***	0.01	0.01	0.00
Inattention[d]	1.2 (0.3)	1.2 (0.3)	1.2 (0.3)	1.2 (0.3)	3.18*	−0.01	0.01	0.03	−0.02	0.03*	0.01
Inexperience[d]	1.3 (0.3)	1.3 (0.3)	1.2 (0.3)	1.2 (0.3)	7.35***	0.01	0.05**	0.05**	0.05*	0.04**	−0.01

*p <.05, **p <.01, ***p <.001.
[a] For drivers involved in collisions, pct attending course before being involved in an MVC.
[b] Range 1 (stopped driving) to 6 (5–7 days per week).
[c] Range 1–6.
[d] Range 1–5.
[e] Bonferroni correction.

Table A2
Multiple regression analyses estimating differences between Driver 65+ participants and non-participants in driving avoidance, driver confidence and annual driving distance. Collision-involved older drivers (n = 2001).

	Driving Avoidance		ADSES		Annual driving distance (km)	
	b (se)		*b (se)*		*b (se)*	
Intercept	1.75	(0.02)***	5.64	(0.02)***	9144.6	(84.6)***
Age (in years)	0.04	(0.01)***	−0.04	(0.01)***	−309.9	(18.3)***
Gender (0 = male, 1 = female)	0.39	(0.04)***	−0.35	(0.05)***	−3220.9	(201.1)***
Driver 65+ course (0 = no, 1 = yes)	0.16	(0.04)***	−0.20	(0.07)**	121.6	(248.8)
Gender * Driver 65+ course	0.06	(0.09)	0.12	(0.14)	−582.8	(540.5)
65+ course after 75 years (0 = no, 1 = yes)	−0.12	(0.07)	0.14	(0.10)	180.5	(381.1)
Gender * competed course after 75	0.04	(0.15)	−0.21	(0.23)	588.3	(866.4)
R^2	0.15***		0.06***		0.23***	

All predictors are grand mean centered. ADSES: Adelaide Driving Self Efficacy Scale.
† *p* <.10, * *p* <.05, ** *p* <.01, *** *p* <.001.

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