Enhancement of

Driving Performance

Among Older Drivers

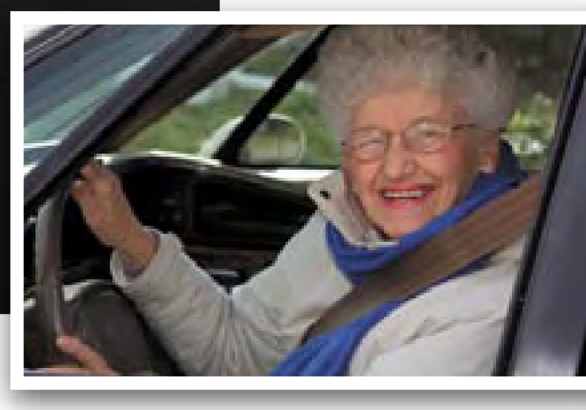

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Acknowledgements

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ABSTRACT

Purpose: To determine whether an education program consisting of classroom and on-road training could enhance driving performance.

Design: A randomized, controlled trial with blinded endpoint assessment was conducted.

Participants: 126 community-living drivers 70 years of age and older were recruited from clinic and community sources. Participants randomized to intervention underwent two four-hour classroom and two one-hour on-road sessions focused on common problem areas for older drivers. Controls received one-on-one sessions directed at vehicle, home, and environment safety.

Data collection: A written test was given and driving performance was assessed at the baseline and eight weeks later. An experienced evaluator in a dual-brake-equipped vehicle assessed on-road driving performance in urban, residential, and highway traffic. Driving performance was rated on a 36-item scale with potential scores ranging from 0 to 72 (higher scores were better). The written test included 20 knowledge and 8 road-sign questions and was scored from 0 to 28.

Results: The least-squares mean change in the road-test scores relative to the baseline was 2.87 points higher in the intervention than in the control group (p=0.001). The least-squares mean change in the written-test scores relative to the baseline was 3.45 points higher in the intervention than in the control group ($p<0.001$).

Conclusions: An education program consisting of classroom and on-road training targeted to common errors older drivers make enhanced their performance on written and on-road tests. Such interventions may allow older drivers to continue driving safely for longer and maintain their out-of-home mobility.

OVERVIEW

The objective of this study was to determine whether an education intervention, consisting of classroom and on-road training focused on commonly encountered problem areas for older drivers, could enhance driving performance among 126 active drivers 70 years of age and older. Eligible individuals who consented to participate were randomized to receive a focused, multi-component education intervention or a control program. Individuals in the intervention group participated in a program that combined classroom education (covering rules of the road and typical problems older drivers experience) and on-road training (directed at common errors older drivers make, as well as driver-specific errors identified at the baseline). The content of this training was based on the AAA Driver Improvement Program, a literature review, and earlier studies. Individuals in the control group received a series of modules directed at vehicle, home, and environment safety. In both groups, participants' driving performance was assessed and they took a written test at the baseline and at the end of the intervention.

LITERATURE REVIEW

Motor-vehicle crashes are among the leading causes of injurious and fatal accidents among individuals ages 65 and older.[1] The number of older drivers in the United States is expected to increase dramatically in the next 25 years.[2, 3] In 1999, individuals ages 65 years and older comprised approximately 16 percent of the driving population in the United States and accounted for 14 percent of fatal crashes in the country. It is estimated that by 2030, 25 percent of the driving population will be 65 years old or older and it will account for 25 percent of fatal crashes.[4] This increase in the number of older drivers may be even greater than anticipated because, in addition to the aging of the population as a whole, increasing numbers of older women will drive as their current cohorts age.[2, 3, 5]

While the absolute number of crashes among older drivers is low, when adjusted for the average mileage driven, crash rates increase with advancing age, as does the likelihood of injury, hospitalization, or death resulting from a crash.[6, 7] Several studies have demonstrated a 2- to 4-fold increase in rates of injury, hospitalization, and death among individuals 65 years old and older compared to younger individuals in crashes of similar magnitude.[8–11] It is postulated that a combination of increased fragility and crash overrepresentation (per mile driven) contribute to an increased risk of injury.[12] While the youngest and oldest drivers are at greatest risk for at-fault fatal crashes, older drivers are more likely to be responsible for their own death rather than others.[13]

It is not age per se, however, that accounts for the increased risk of crashes. Rather it is likely that functional impairments due to, or compounded by, medical conditions or medications give certain older drivers this higher chance of being in a crash. Efforts to determine the driver-related factors contributing to the increased crash risk among older drivers typically have focused on medical conditions or functional impairments. Although many of the studies of medical conditions have limitations, associations with crashes or driving performance have been found for a number of conditions, including cardiac arrhythmias, stroke, Parkinson's disease, sleep apnea, and dementia.[14–19] Previous studies on the relationship of functional impairments to driving ability and crash history have concentrated on visual and cognitive abilities, although the strength of the association of individual domains varies.[20] Elements of visual function linked to driving ability or crashes include distance acuity, peripheral fields, and contrast sensitivity.[21–25] Cognitive domains associated with driving performance or crashes include visual attention, visuospatial ability, and executive function.[25–28] A number of studies also have demonstrated the effect of physical abilities on driving safety. [29–33]

Crashes involving older drivers are more likely to occur at intersections, particularly while turning (especially when making left turns).[11, 34] Low-mileage motorists (those who drive fewer than 1,800 miles annually) tend to be at a greater risk for crashes because they are more likely to drive in urban settings (with more traffic and intersections) and perhaps because of greater functional limitations.[35–37] Older persons who drive more miles or are able to use highways, however, tend to have crash risks comparable to the rest of the population.[35, 38]

Much of the literature on crash risk and driving performance focuses on specific diseases or impairments and whether they affect driving safety and mobility. Only recently has attention turned to potential interventions to enhance driving performance, although again the focus has been on remediation of the associated functional impairments. A more-direct approach to enhancing driving performance would be to concentrate on errors older drivers commonly make or on the specific errors an individual driver makes on a road test. Eventually that information could be combined with interventions directed at functional impairments to maximally enhance driving performance.

The rationale for such interventions is clear: there is increasing evidence to support the importance of driving to a person's independence and quality of life. Like younger people, older persons depend primarily on cars for transportation, either as drivers or passengers.[39, 40] This mobility is important because participation in social and productive activities has been associated with survival and better functional status.[41–45] And driving cessation has been associated with decreased participation in out-of-home activities, increased depressive symptoms, and possibly even nursing-home placement.[46–50]

Several educational programs have been developed for older drivers or their physicians to raise the awareness of potential medical conditions or functional limitations that may affect driving safety.[51–53] These programs, however, do not directly train or enhance driving capability.

A number of classroom-based education programs geared to older drivers exist. Millions of older Americans have used them, and they have a great deal of face validity based on their content. Few studies of their effectiveness in enhancing safety, however, have been published. McKnight and colleagues found no statistically significant difference in crashes between groups of older drivers who had and had not participated in such a program, although the response rate to questions about crash occurrence was low.[54] A larger-scale study by Janke using state records of crashes and violations found a slight increase in crashes, but a decrease in violations among individuals who attended the education program.[55] A recent study by Nasvadi suggested an increased crash risk for men ages 75 and older who attended a classroom education program, but no effect on crash risk for men ages 55 to 74 or women in either age group.[56] Bedard and colleagues compared the on-road driving performance of 65 drivers with a mean age of 71 before and after a standard classroom education program.[57] They found no statistically significant difference in scores between those who did and did not take the course. A recent study by the same group used a similar design but added on-road instruction to the classroom education. Although the results have not been published, preliminary findings suggested greater improvement in road-test scores in the intervention group compared to controls.[58]

Unfortunately for older drivers who must limit or stop driving, alternative modes of transportation are limited in many areas and when present may be inconvenient or difficult to access.[59, 60] The ability to continue driving safely would allow for continued mobility. Interventions directed at functional impairments associated with driving-performance difficulties are potentially limited by applicability (not everyone has the same impairment) and effectiveness (in an aging population, the odds of dramatically improving in any functional area are low). Direct educational enhancement of driving performance, however, potentially has broad applicability as almost all drivers could benefit from it now or in the future. In addition, once the effectiveness of a program was established, it could be combined with interventions directed at functional impairments to tailor an intervention to an individual's needs and to maximally enhance performance.

In light of the evidence of the importance of driving to older persons' mobility and quality of life, this study was initiated. Its primary aim was to determine, among 126 drivers age 70 years and older, whether an intervention that included classroom and on-road training could enhance driving performance. It was hypothesized that it would. To test this hypothesis, participants underwent assessments of on-road driving performance at the baseline and at the end of the intervention period. The driving-performance assessment covered a range of routine and challenging situations and was performed by an experienced driving evaluator. Analyses focused on changes over time in the intervention group compared to controls. The primary outcome was change in road-test scores, while the secondary outcome was change in written-test scores.

METHODS

A. Overview of Study Design

Active drivers age 70 and older were recruited from clinic and community sources. Participants underwent a baseline assessment in which their health, function, and sociodemographic factors were ascertained. Those who met the study's eligibility criteria underwent an on-road assessment of their driving performance. Participants who scored neither too high nor too low on the road test and who agreed to participate in the intervention study were randomized to receive either two one-hour one-on-one sessions directed at vehicle, home, and environment safety (the control) or a classroom and on-road driver-training program (the intervention). Intervention participants received eight hours of classroom and two hours of on-road instruction over eight weeks. After that period, intervention and control participants underwent reassessment of their on-road driving performance and took a written test of road knowledge and road signs, by assessors blinded to treatment assignment.

B. Study Inclusion Criteria

The inclusion criteria for the study (Table 1) were that a person be at least 70 years old, drive at least once a week, have a valid Connecticut driver's license, speak English, have a phone, not have a medical condition that might deteriorate during the course of the study (for example, dementia and other neurodegenerative disorders or metastatic cancer) or acute medical illness at the time of screening, has not received driver training in the past year, has binocular distance visual acuity of 20/70 or better, scores 24 or better on a mini-mental state examination (MMSE), and scores between 40 and 65 (on a 72-point scale) on the on-road assessment.

Table 1. Study-Inclusion Criteria

Age 70 years or older
English speaking
Has a telephone
Has a current driver’s license
Drives a minimum of one time per week
MMSE score = 24 or higher
Distance vision = 20/70 or better
No driver training in the past year
No neurodegenerative disorder or metastatic cancer
Scores between 40 and 65 on road evaluation

C. Participants

The 106 participants (84 percent of the study) recruited from the waiting area of the general medical clinics of the Veterans Affairs Connecticut Healthcare System (VACHS) site underwent their baseline assessment at VACHS and started their on-road assessment there as well. The 20 participants (16 percent of the study) recruited from a variety of community sources (prior study participants (13),[61] senior-housing complexes (5), and senior centers(2)) had their baseline assessment and started their on-road assessment at the Yale University site. The same route through New Haven and West Haven was used with entry points at VACHS and the university site. Recruitment began in November 2004 and ended in June 2006.

D. Baseline Assessment

Participants underwent the baseline assessment of their health, functional status, and sociodemographic factors developed in earlier studies.[29, 30, 61] Two research associates were trained in its administration and underwent initial assessment of inter-rater reliability and periodic quality control checks during the study. Inter-rater reliability among the two research associates and the project manager, established on measures of function, was excellent with kappa values for categorical variables ranging from 0.76 to 1.0 and intra-class correlation coefficients for continuous variables ranging from 0.89 to 1.0.

Health factors ascertained included chronic conditions, medication use, and alcohol use. Elements of function assessed included vision, cognition, and physical ability.[30] Sociodemographic factors included age, gender, education, and driving practices. The latter included driving frequency (how many days an individual drove in a given week), mileage (how many miles in an average week), driving circumstances (types of roads, times of day, weather, and traffic conditions), and self-reported adverse driving events (such as crashes, moving violations, and being stopped by police). A written test was administered based in part on road-knowledge questions from the AAA Driver Improvement Program and on road-sign questions used in earlier studies (Appendix I). The test included 20 multiple-choice knowledge questions and 8 road-sign questions, which were summed for a possible total score of 0 to 28 correct.

E. Assessment of Driving Performance

Studies of driving safety have used a number of outcomes to gauge risk. From a clinical and public-health standpoint, the outcomes of greatest interest are preventing the consequences of crashes (injuries, hospitalization, and death) and maintaining safe driving, given that driving cessation is associated with a decrease in activity level and an increase in depressive symptoms. Crashes, however, in particular fatal or injurious ones, are uncommon events. In addition, a number of details unrelated to the driver may influence the occurrence of a crash, including vehicle and environmental factors, as well as other drivers or pedestrians. Also, drivers with impaired driving performance may be fortunate enough to avoid crashes through luck, circumstances, limiting exposure, or the skill of other drivers. As a result of these factors, and because it can be measured directly, driving performance is often utilized as an outcome.

Driving performance can be measured in several ways, including computer programs; interactive or non-interactive simulators; off-road, closed-course driving tests; and on-road driving tests. Each method has potential advantages and disadvantages. On-road driving performance was chosen as the primary outcome in this study because it provides the most-realistic approximation of driving skills in actual driving situations, it is a more-familiar task to older drivers than simulators or computerized measures, and it is the standard that state motor-vehicle departments use to determine whether a license is granted, maintained, or revoked.

The road test used is based on the Connecticut Department of Motor Vehicles road test and has been used in earlier studies.[61, 62] The test assessed a range of driving abilities in different settings. These situations included an off-road portion (parking-lot maneuvers); low-, medium-, and high-traffic-density areas; and highway segments (Appendix II). There were two entry points; the one used depended on the recruitment site. Parameters assessed included speed, lane changes, merging, observance of signs and signals, interaction with traffic, and operation of vehicle controls. An alternative course that circumvented the highway segment was used for individuals who usually did not drive on that type of road. Evaluations were performed in a dual-brake vehicle over the same route, at approximately the same time of day, under reasonable weather conditions.

The road route covered 10 miles (including a 1.7-mile highway segment) that took approximately 45 minutes to complete (depending on traffic). The route included urban and residential areas with low-, medium-, and high-traffic densities. Speed limits ranged from 10 to 35 miles per hour on access roads and city streets and 55 miles per hour on the highway segment. There were 63 intersections on the route (32 crossing, 31 t-type), with 45 traffic lights, 2 flashing lights, and 11 stop signs. There were 15 right and 15 left turns and 12 merges, as well as several opportunities to take a right on red at a traffic light.

A scoring system graded each of 36 components on a 0- to 2-point scale, ranging from poor (0) to fair (1) to good (2) driving performance with standardized criteria for rating each item (Appendix III). These individual scores were added to create a total possible score ranging from 0 (worst) to 72 (best).[61, 62] Inter-rater reliability between the two raters of the on-road assessment was established in a sample of 10 older volunteer drivers. Weighted kappa values for the 36 elements ranged from 0.34 to 1.0 (all but two were greater than 0.58) and the overall intraclass correlation coefficient for the total driving score was 0.96. The planned study inclusion criterion, based on road-test scores ranging from 40 to 62, was derived from the distribution of scores from an earlier study.[61] This range was chosen to eliminate drivers likely to be deemed unsafe (scores less than 40) as well as the best drivers, who were unlikely to benefit from the intervention. The scores of initial participants were monitored. As the population and the distribution of scores were different from the earlier study, the upper limit was raised to 65 early in this research, which still allowed for detection of the target change of 4 points with the intervention (5 individuals with scores 63 to 65 had been excluded before the change).

F. Intervention

Participants randomized to the intervention group received eight hours of classroom and two hours of on-road instruction.

1. Classroom instruction: The content of the classroom instruction was based in part on the AAA Driver Improvement Program (Safe Driving for Mature Operators), the literature, and common driving errors encountered in an earlier study.[61] The most-common areas of driver error in that study are outlined in Table 2. Both the classroom

and on-road training sessions addressed these elements and strategies to counteract them or compensate for them (Table 3). The classroom training consisted of group sessions focused around the chapters of the AAA Driver Improvement Program.[63] At the end of the each chapter a knowledge test was administered. Classroom topics included driving risk, developing good visual habits, communicating, adjusting speed, margin of safety, driving emergencies, vehicle features, driving and alcohol, medications, and aggressive drivers.

The classroom sessions followed the outline and videos of the AAA Driver Improvement Program,* with supplemental information on a number of topics for added emphasis. The additional topics included a review of all road signs, neck rotation for head checks, checking blind spots, the use of side mirrors, steering-wheel hand placement, the steps for changing lanes and merging in traffic, right-on-red rules, limiting distractions and focusing on driving, search strategies for intersections, scanning to the rear, backing-up strategies, the consistent use of turn signals, and strategies for left turns across traffic or how to avoid such turns.

* The AAA Driver Improvement Program (DIP) used was current at the time of the study, but it has been updated since then. Among the revisions is the inclusion of more information about age-based changes drivers experience, adaptations to these changes, traffic situations that are problematic for older drivers, self restriction, changing driving habits to reduce risk and prolong safe driving, the effects of medication, drowsy driving, and dealing with large trucks and aggressive drivers. Thend retention. The program this study utilized differed from the AAA DIP as it included additional topics, as outlined in this text (in particular, the AAA DIP does not include an on-road component). Hence this study is not an evaluation of the AAA DIP.

Table 2. Most-Common Errors in Earlier Driving Study[61]

Scans side to side	86%*
Scans to rear/head check	84%
Uses seat belt	42%
Centers car in lane	49%
Safe following distance	57%
Uses directional signals	72%
Backing up	69%
Lane changes	86%
Speed regulation	62%

* percent scoring fair or poor on a given item

Table 3. Elements Taught in Classroom and On-Road Sessions

Proper seat adjustment
Hand positioning on the steering wheel
Mirror adjustment
Seat belt and head restraint
Use of lights and horn
Four-second stopping distance
Stop bars at intersections
Seeing the two back tires
Searching intersections
Changing lanes
Merging in traffic
Checking the blind spot
Checking the mirrors
Checking the rear zone of car
Backing up
Looking 30 seconds ahead
Use of directional signals
Parking
K-turns
Cruise control
Positioning car in the lane
Positioning car for turns
Right-on-red rules

2. On-road Instruction: The content of the on-road instruction was based in part on the literature regarding common areas of driving difficulty for older persons, as well as the common errors encountered in earlier studies.[61, 62] It covered the same topics as the classroom sessions, but also included techniques for enhancing safety.

Each session was one-hour long and the instructor provided one-on-one training. The first session covered any errors the driver may have made in the baseline assessment. The second session reviewed these points as well as addressed the common errors of older drivers in general. Topics and settings covered in the on-road training are described in Table 4. This training was done on a different route than the assessment, but one that had similar features and traffic patterns.

A single AAA-certified instructor taught all of the classroom sessions. An individual experienced in on-road instruction, distinct from the classroom instructor and the on-road driving assessor, performed the on-road training. The driving instructor had a copy of the participant's baseline on-road assessment.

Table 4. On-Road Instruction Topics and Settings

Vehicle orientation	Adjusting seat position, mirrors, seat belt, head restraint, lights, and controls; hand position; and distance from wheel
Parking lot	Parking, backing up, using mirrors, and looking over shoulder
Very-low- and low-volume streets	K-turns; intersection strategies, such as stopping position (stop bars and seeing the tires of the vehicle in front); search strategies; using directional signals; yielding to pedestrians; and left turns across on-coming traffic
Moderate- and high-volume streets	Looking 30 seconds ahead; looking out for people, vehicles, and vehicles changing direction or slowing down; stop lights (vehicle position, looking in the rearview mirror, right-on-red rules, and checking the intersection for traffic when the light turns green); turning strategies (lane selection, gap acceptance, and speed); straight segments (speed regulation, safe following distance, and monitoring parked cars); lane-change strategies and blind spots; mirrors and head checks; and directional signals
Highways	Entering, exiting, merging, lane changes, mirrors and head checks, blind spot, speed regulation, traffic flow, cruise control, and safe following distance

G. Control Group

The choice of a protocol for the control group was dictated by the desire to maximize participant recruitment and retention in the study; have minimal effect on the primary outcome, driving performance; and minimize costs. To maximize retention, based on the results of earlier studies it was felt that the relevance to the participant of both the intervention and control protocols needed to be clear.[61] To achieve this understanding, and to be consistent with the theme and objectives of the study, the control protocol involved driving, safety, and mobility.

Safety-oriented education modules were created in an earlier study that were felt to have little effect on driving performance, such as tips for vehicle maintenance and information about safety devices.[61] In addition, modules based on home safety and fall prevention were developed previously based on existing materials. A trained research assistant presented these two modules to participants, accompanied by materials written at an eighth-grade level and illustrated with simple line drawings.

The home and environment safety module was conducted in the participant's home and included a home-safety evaluation that covered topics such as fall and trip hazards, lighting, handrails, throw rugs, and chair design as applied to different locations in the dwelling. The vehicle-safety module covered topics such as tire pressure, lights, mirrors, vehicle maintenance, emergency equipment, crime prevention, and pedestrian issues. Information on appropriate footwear and minimizing the risk of back pain also was provided.

H. Outcomes

Both intervention and control groups had the baseline and on-road assessments re-administered after eight weeks. The assessors were blinded to the treatment group (a blinded end-point assessment). After their last intervention or control session and again just before their final assessment, participants were reminded not to mention anything about their group assignment or anything about their experiences in the intervening eight weeks. The assessors also were instructed not to ask about group assignments and to quickly redirect participants if any elements of the discussion suggested group identification. The primary outcome was change in driving performance at eight weeks compared to the baseline. Change in written test scores at eight weeks compared to baseline was the secondary outcome.

I. Informed Consent

The Yale School of Medicine Human Investigation Committee and the VACHS Human Subjects Subcommittee approved this study. Written informed consent was obtained for all participants.

J. Statistical Methods

Randomization

The randomization was stratified by recruitment site using a permutated block scheme with a randomly varied block size and equal allocation to the two treatment groups. Because treatment was administered in groups, participants were randomized in groups of up to seven to the two treatment arms. Treatment allocation was concealed from all parties until interventions were assigned after eligibility was established.

Sample Size

Based on the results of the author's previous driving study that used a multicomponent physical intervention, a clinically meaningful difference in the primary outcome was defined as a change of four points.[61] The sample size to detect this difference between the intervention and control groups was 126 participants for a type I error of 5 percent (two-sided), 80 percent power, road-test score standard deviation of 7.5 points (prior study data), and 10 percent adjustment for losses.

Statistical Analysis

All analyses were conducted according to the original treatment assignment. The primary outcome was the change in road-test score from baseline to the eight-week follow-up measurement. Because eight participants had missed follow-up driving evaluations, two analyses were conducted: one that excluded the participants with missing data (complete-case analysis) and one that was a sensitivity analysis which used multiple imputation to replace the missing road-test scores assuming missing at random (intent-to-treat analysis). Based on Little's test for missing completely at random, the data reasonably satisfied this criterion (p=0.25).[64, 65] The variables used for the imputations were those included in the linear mixed model (described in the following paragraph) and others correlated with variables having missing data (that is, age, marital status, driving frequency, whether the subject is living at home, impaired trunk rotation, the average seated hip flexion at baseline, and the number of critical errors at baseline). For the imputation analyses, 20 complete datasets were generated and then combined using standard methods.[64]

A linear mixed regression model was used to analyze the effect of treatment (intervention relative to control) on the primary outcome for both the complete case and intent-to-treat analyses. In the model, treatment comparisons were adjusted for the study design— recruitment site (VACHS versus community) and road-test examiners at baseline and follow-up—and baseline road-test score.[66] Because enrollment in the study occurred over several years, to control for possible temporal effects a continuous variable for enrollment date also was included in the multivariable model. And as treatment sessions were given in groups of participants, the linear mixed model included a random intercept and accounted for the clustering of individuals within instructional groups. Treatment effects were summarized as least-square means, and the t-statistic assessed statistical significance. Model goodness-of-fit was assessed using information criteria, residual analysis, and regression diagnostic tools.

The effect of treatment on the secondary outcome—a written test for road knowledge and road signs—was analyzed similarly to the primary outcome using a linear mixed regression model adjusted for the study design, the baseline written-test score, and the date of enrollment in the study. Because 10 participants assigned to intervention and 22 assigned to control had missing knowledge tests, multiple imputation was used to replace missing values. Little's test provided some evidence that the data missing were not completely random ($p<0.001$); most participants, however, had missing knowledge tests early in the study because of an administrative oversight that was later corrected. Thus, the missing data mechanism could reasonably be considered ignorable (that is, involving dependence upon the observed data but not the unobserved data because a variable for enrollment date was included in the linear mixed model and the multiple-imputation process). The variables used for the imputation were those included in the linear mixed model and other variables correlated with the variables having missing data (that is, the baseline road-test score, difference in baseline and follow-up road-test scores, number of critical errors at follow-up, and score for the number of correct responses to the knowledge component of the written test at follow-up). Similar to the analysis of the primary outcome, a complete case and an intent-to-treat analysis (with imputed values) were conducted.

SAS 9.1.3 was used for all analyses and a p-value of 0.05 (two-sided) was used for all tests of significance.[67]

RESULTS

Participant Characteristics

A total of 645 drivers ages 70 and older were screened from November 2004 to June 2006 (Figure 1). Of these people, 155 (24 percent) did not advance beyond the screening stage. The primary reasons for them not proceeding were that they did not meet the medical, visual, or cognitive criteria for participation (42 or 27 percent); lived outside the catchment area, planned travel, or recently attended a driver-education course (25 or 16 percent); or refused to participate (77 or 50 percent). Among the most-common reasons for refusal were scheduling conflicts (with appointments or work), unwillingness to drive someone else's car or to drive in New Haven, or because their family recommended against participation.

Of the 490 participants who underwent a road test, 316 (64 percent) were ruled out, primarily because they scored above the entry-criteria limit of 65 (305 or 97 percent). Of the remaining 174 individuals, 48 (28 percent) were not enrolled (20 or 42 percent because they were moving out of the catchment area, had planned travel, or had taken a driver-education course; while 21 or 44 percent refused, primarily because of the time commitment). A small number of people at both junctures opted out of participating because they were caregivers for an ailing spouse. The remaining 126 people were enrolled and randomized. All participants completed the eight-week follow-up evaluation except for eight people who had stopped driving during the intervention period (three of whom were in the intervention group), and three who withdrew from the study after initially agreeing to participate (two of whom were in the intervention group).

Figure 1. Screening and Eligibility Flow Diagram

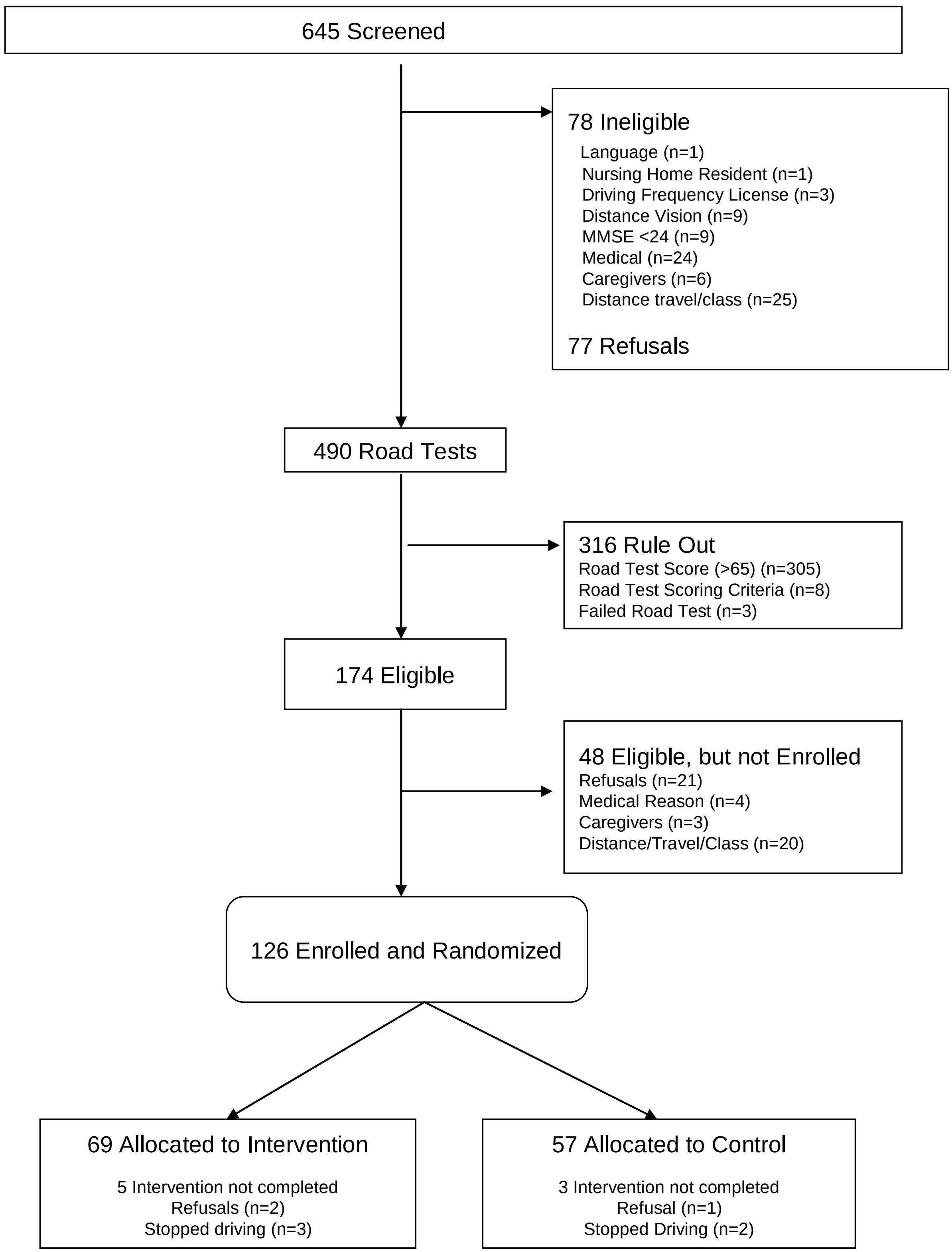

Table 5 displays the baseline characteristics of the 126 participants. They had a mean age of 80 years, 85 percent were men, 84 percent were recruited from clinic sites, and approximately two-thirds of them drove daily with a mean of 110 miles per week. The only factor significantly different between the groups was the proportion that drove daily, although the vast majority of both groups drove frequently, with 98 percent of intervention and 89 percent of control participants driving daily or every other day.

Table 5. Baseline Characteristics of Participants in the Intervention and Control Groups

Characteristics	**Intervention (n=69)**	**Control (n=57)**	**p-value**
Age, mean (SD) in years	80.8 (4.7)	79.7 (4.6)	0.21
Education, mean (SD) in years	13.5 (2.4)	13.2 (2.5)	0.43
Gender (male), N (%)	58 (84)	49 (86)	0.77
Race (non-white), N (%)	5 (7)	6 (11)	0.52
Recruitment site (clinic), N (%)	58 (84)	48 (84)	0.98
Number of miles driven per week, mean (SD)	121.1 (110.4)	97.1 (90.5)	0.19
# of chronic conditions, mean (SD)	3.3 (1.6)	3.2 (2.0)	0.85
MMSE score, mean (SD)	27.5 (1.7)	27.5 (1.7)	0.87
Distance vision (20/x), mean (SD)	35.5 (10.7)	35.7 (11.4)	0.93
Driving frequency, N (%)			
Daily	52 (75)	28 (49)	0.003
Every other day	16 (23)	23 (40)	
1 to 2 times per week	1 (2)	6 (11)	
Self-rated health, fair/poor/bad, N (%)	20 (29)	15 (26)	0.74
Fall in the past year, N (%)	19 (28)	18 (32)	0.62
Road-test score, mean (SD)	60.6 (4.84)	61.2 (4.43)	0.51
Written-test score, mean (SD)	15.8 (3.1)	16.4 (2.5)	0.22

*Continuous characteristics tested with a t-test and categorical with a chi-square or Fisher's Exact t's

Driving Performance

Table 6 displays the scores on individual elements of the road test at the baseline. Table 7 shows the raw scores at the baseline and follow-up for the on-road and knowledge tests for intervention and control participants. Table 8 presents the difference between the treatment groups in baseline and eight-week road-test scores based on the linear mixed model. The least-squares mean change in road-test score relative to the baseline was 2.87 points higher in the intervention than in the control group (p=0.001), adjusted for baseline score, recruitment site, examiner, and enrollment date. Imputation of missing values for participants not completing the follow-up evaluation yielded similar findings. The full model results are in Appendix IV.

Table 6. Baseline Road-Test Components and Frequency of Occurrence (N=126)			
Performance Measure	**Poor (0)** **N(%)**	**Fair (1)** **N(%)**	**Good (2)** **N(%)**
Scan to sides	27(21)	53(42)	46(37)
Scan to rear/head check	34(27)	60(48)	32(25)
Uses mirrors	3(2)	11(9)	112(89)
Uses seat belt	20(16)	0(0)	106(84)
Responds to traffic signals	29(23)	2(2)	95(75)
Responds to vehicles/pedestrians	3(2)	5(4)	118(94)
Grants right of way	1(1)	4(3)	121(96)
Centers car in lane	15(12)	36(29)	75(60)
Safe following distance	5(4)	29(23)	92(73)
Uses directional signals	16 (13)	23(18)	87(69)
Positions car for turns	0(0)	20(16)	106(84)
Proper lane selection	5(4)	31(25)	90(71)
Gas-to-brake reaction time	3(2)	9(7)	114(91)
Appropriate steering recovery	3(2)	8(6)	115(91)
Acceleration	10(8)	14(11)	102(81)
Braking	1(1)	14(11)	111(88)
Shifting	2(2)	6(5)	118(94)
Right turns	23(18)	71(56)	32(25)
Left turns	45(36)	56(44)	25(20)
Backing up	1(1)	7(6)	118(94)
K-turns	10(8)	23(18)	93(74)
Angle parking	4(3)	14(11)	108(86)
Low-density traffic areas	4(3)	0(0)	122(97)
Simple traffic situations	1(1)	0(0)	125(99)
Medium traffic situations	4(3)	0(0)	122(97)
Limited access highway	8(7)	0(0)	112(93)
Enter	4(3)	15(13)	101(84)
Exit	13(11)	0(0)	107(89)
Merge	6(5)	8(7)	106(88)
Lane change	5(4)	25(20)	96(76)
Speed regulation	1(1)	15(12)	110(87)
Follows directions	14(11)	32(25)	80(64)
Judgment	11(9)	34(27)	81(64)
Decision making	11(9)	26(21)	89(71)
Memory	13(10)	32(25)	81(64)
Attitude/emotions	0(0)	1(1)	125(99)

Table 7. Baseline and Follow-up Road-Test and Written-Test Scores by Treatment Group

	Intervention mean (SD)	Control mean (SD)
Baseline road-test score	60.6 (4.8)	61.2 (4.4)
Follow-up road-test score	66.2 (4.2)	63.9 (6.2)
Baseline written-test score	15.8 (3.1)	16.4 (2.5)
Follow-up written-test score	20.4 (3.1)	17.5 (2.9)

Table 8. Comparison of Road-Test Scores at Baseline and Eight Weeks for Intervention and Control Groups

Adjusted Complete Case Mixed Model[a]

	Intervention	Control	Difference
N	64	54	
LS mean	5.95	3.08	2.87
Standard error			0.86
T-statistic			3.34
P-value			0.001

Adjusted Intent to Treat Mixed Model with Multiply Imputed Missing Data[b]

N	69	57	
LS mean	5.82	2.93	2.89
T-statistic			3.38
P-value			<0.001

LS mean = least-squares mean change

a. Linear mixed model including covariates for baseline road-test score, site, baseline road-test examiner, follow-up road-test examiner, and enrollment date; the model contains a random intercept for individuals clustered within instructional classes.

b. Multiple imputation was used to replace the missing driving scores for eight participants without follow-up driving evaluations. The same linear mixed model described in the previous note was used for the data with the multiply imputed values.

In an exploratory analysis to assess which of the 36 elements of the road test showed the most improvement and which exhibited the least worsening with intervention, participants were classified for each element as improved if their post-intervention score increased relative to the baseline, as worsened if their post-intervention score was lower than baseline, or as unchanged if the score was the same at both points. Table 9 displays the distribution of participants who were improved, unchanged, or worsened for each of the 36 items by treatment group. The items showing the most improvement and least worsening with intervention were scanning to the rear, lane selection, right turns, and judgment. These results need to be interpreted with caution, however, because of the multiplicity of analyses resulting in inflation of type I error.

Table 9. Change in Road-Test Score Components at Final Assessment Relative to Baseline by Treatment Group

Component	Intervention (N= 64)			Control (N = 54)			
	%Imp	Unch	Worse	%Imp	Unch	Worse	P-value*
Scan-side	34	44	22	39	35	26	0.67
Scan-rear	55	38	8	35	44	20	0.05
Mirrors	11	89	0	9	89	2	0.75
Seat belt	16	80	5	7	91	2	0.28
Respond traffic	19	67	14	17	70	13	0.96
Respond vehicles	8	91	2	4	91	6	0.38
Right of way	3	97	0	6	94	0	0.66
Centers car	27	58	16	28	54	19	0.90
Safe distance	22	73	5	20	69	11	0.48
Signals	28	63	9	26	70	4	0.44
Positions for turns	13	86	2	20	80	0	0.32
Lane selection	25	70	5	20	57	22	0.02
Reaction time	8	91	2	11	87	2	0.77
Steering	8	88	5	6	89	6	0.91
Acceleration	16	83	2	20	72	7	0.23
Braking	9	89	2	7	87	6	0.55
Shifting	5	95	0	9	85	6	0.08
Right turns	52	41	8	28	56	17	0.02
Left turns	47	36	17	30	39	31	0.09
Backing up	9	89	2	4	96	0	0.29
K-turns	19	77	5	31	65	4	0.24
Angle parking	14	83	3	15	80	6	0.86
Low traffic	6	94	0	0	100	0	0.12
Simple traffic	2	98	0	0	100	0	1.00
Medium traffic	6	92	2	0	96	4	0.14
Limited-access highway	10	90	0	4	94	2	0.21
Enter highway	16	75	10	9	87	4	0.26
Exit highway	6	71	22	11	81	7	0.07
Merge highway	16	81	3	7	91	2	0.44
Lane change	19	72	9	15	72	13	0.76
Speed regulation	14	80	6	9	80	11	0.49
Follows directions	31	63	6	28	63	9	0.84
Judgment	36	58	6	24	56	20	0.05
Decisions	33	59	8	19	61	20	0.06
Memory	33	58	9	26	57	17	0.40
Emotion	0	100	0	2	96	2	0.21

* Fisher's Exact test P-value
Improved = Improved from 0 or 1 at baseline to 1 or 2 at final assessment
Unchanged = No change in scores between baseline and final assessment

Worsened = Declined from 2 or 1 at baseline to 1 or 0 at final assessment

Written Test

Table 10 shows the difference between the treatment groups in the baseline and eight-week written-test scores based on the linear mixed model. The least-squares mean change in written-test score relative to the baseline was 3.45 points higher in the intervention group than in the control one ($p<0.001$), adjusted for baseline score, recruitment site, and enrollment date. Imputation of missing values for participants who did not complete the follow-up written-test yielded similar findings.

Table 10. Comparison of Written-Test Scores at Baseline and Eight Weeks for Intervention and Control Groups

	Adjusted Complete Case Mixed Model[a]		
	Intervention	Control	Difference
N	57	35	
LS mean	4.60	1.16	3.45
Standard error			0.57
T-statistic			6.02
P-value			<0.001
	Adjusted Intent to Treat Mixed Model with Multiply-Imputed Missing Data[b]		
N	69	57	
LS mean	4.52	1.09	3.43
T-statistic			5.88
P-value			<0.001

LS Mean = least squares mean change

a. Linear mixed model including covariates for baseline written-test score, site, and enrollment date; the model contains a random intercept for individuals clustered within the instructional class.

b. Multiple imputation was used to replace the missing written-test scores for 34 participants without follow-up written-test scores. The same linear mixed model described in the previous note was used for the data with the multiply-imputed values.

Intervention Participant Perceptions

Overall, participants in the intervention group liked the program (mean score 91.9 on a scale of 0 to 100, with a standard deviation of 12.6) and found it beneficial (mean 89.1, standard deviation 12.4). Among the qualities participants most-often cited that they liked about the course were the instructors, the small class size and personalized instruction, the interactive nature of the training, the constructive feedback provided, and the refreshments. Among the aspects they disliked most were the length of the sessions, the car used for training, and finding a parking space. Seventy-five percent reported that the program reinforced old knowledge, while 87 percent felt they had learned new information. The most-commonly mentioned elements of old knowledge that the program reinforced were safe following and stopping distances, intersection strategies, general knowledge, alertness and attention to surroundings, and search strategies. The most-commonly referenced elements of new knowledge learned were safe following and stopping distances, intersection strategies, search strategies and the blind spot, attention, and hand position on the steering wheel.

Ninety percent of intervention participants felt their driving had improved as a result of the program. Their suggestions for potential improvements to the program reflected the aforementioned dislikes, focusing on complaints about the car and difficulty finding parking spaces when attending the sessions. Some people requested more sessions, while others felt that the sessions should have been shorter. Changes and improvements in how they drove as a result of the program were consistent with the old knowledge reinforced and new knowledge learned: greater awareness of a variety of road situations and rules, greater caution, more-direct application of strategies regarding searching, following and stopping distances, and negotiating intersections.

Adherence

All 118 participants who completed the follow-up assessment finished all eight hours of classroom training and the two one-hour driving lessons.

DISCUSSION

The intervention consisting of classroom and on-road instruction was more effective than the control in improving driving performance and written-test scores. The improvement in the road-test driving score at eight weeks was 2.87 points higher on a 72-point scale, comparing intervention with control. The improvement in written-test score at eight weeks was 3.45 points higher on a 28-point scale, comparing intervention with control. Intervention participants enjoyed the sessions and found the content applicable to their driving practices.

Among the strengths of this study was its design: a randomized, controlled trial of classroom and on-road instruction with intervention arm assignment concealed until eligibility was established and a blinded endpoint assessment. All participants were volunteers from clinic sites and the community at large rather than being referred because of concern for driving difficulties. The study's findings have broad potential applicability. The intervention was designed to address common errors of older drivers; thus a range of drivers could benefit from it.

There are several limitations of the study, however. Although the difference of 2.87 points between intervention and control groups achieved statistical significance, the clinical implications of a difference of this magnitude are unclear. In a previous study, a 1-point increase in the driving score equated to a 3.3 percent decrease in crash occurrence over 2 years of follow-up (unpublished data). Thus, an improvement of 2.87 points would equate to a 9.5 percent decrease in crash risk. The clinical interpretation of the 3.45-point difference in written-test scores is not known. Comparing change in written-test scores to change in road-test scores provides indirect evidence. The Spearman correlation coefficient was 0.34 ($p<0.001$) suggesting that improvement in written-test scores was associated with improvement in road-test scores. In addition, because of the small sample size it is difficult to distinguish individual driver factors that may have contributed to the between-group difference. Also, as there was considerable overlap (by design) between the content of the classroom and on-road sessions, it is difficult to determine the extent to which each one contributed to the improvement detected.

Overall, both groups were well matched. Although there was a statistically significant difference in driving frequency, both groups drove frequently and their respective average annual mileage was well above the 1,800 mile per year threshold reported to be associated with increased risk.[35] Also, mean baseline road test scores were comparable in those who drove daily or less then daily (60.9 versus 60.7, respectively). The most common problem areas at baseline (right and left turns, scanning to the sides and rear) are consistent with the problem areas identified in the literature.[11,34] Although the analyses were only exploratory, it was encouraging that among the areas of greatest improvement in intervention versus controls were right and left turns and scanning to the rear.

As noted previously, while the intervention yielded a statistically significant improvement in road- and written-test scores relative to control, the study was not powered or designed to look at clinical outcomes of interest such as crashes, injuries, fatalities, or changes in driving patterns. Also there may be some negative consequences to such an intervention, such as enhanced confidence leading to increased exposure and more-adverse driving events. While an intervention such as this one that trains driving ability has face validity as a way to enhance driving performance, the results of earlier education-intervention studies have been mixed. The study that most closely resembled this one in design, with a combination of classroom and on-road instruction, also noted a positive effect.[58] The study described herein used a non-referral volunteer sample drawn from general-medicine-clinic waiting areas and the community at large. It may be possible to enhance the effect by focusing on a higher-risk group (with worse baseline performance) or extending the length or intensity of training.

Thus there are many outstanding issues and unanswered questions that could be the subjects of future studies:

- prospective follow-up on a sample of sufficient size and diversity to determine the effects of such an intervention on crashes, moving violations, and driving patterns
- a causal model of potential mechanisms of action to determine which elements of the intervention were most effective and on which elements of performance, so that subsequent interventions could be streamlined or enhanced
- determining ancillary effects on confidence, awareness, and exposure
- serial measurements over time to determine how long effects last

- separate arms and a sufficient sample size to determine the effects of classroom versus on-road training versus both combined
- exploring potential synergistic effects with other interventions, such as those directed at drivers with physical limitations, which have been found to enhance driving performance[61]

Despite these limitations, this study's findings are encouraging. While much has been made of the potential safety risk of older drivers and the factors that may contribute to it, little attention has been paid to enhancing their driving performance. Using a broadly applicable intervention, the current study demonstrated a statistically significant improvement in driving performance among intervention participants relative to controls. These findings offer encouragement to a spectrum of drivers that an easy-to-implement intervention can enhance their driving performance and potentially prolong their safe-driving years, thereby maintaining their activity level and mobility. In addition, the availability of effective interventions may encourage drivers and clinicians to engage in discussions about this important safety issues.

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APPENDIX I
Written Test

1. When another car is following too closely (tailgating), it is best to allow greater space margin:

to the right side - 1

to the left side - 2

to both sides - 3

to the front - 4

2. Showing excessive wear on the outside tire treads is a sign of

misalignment - 1

over-inflation - 2

under-inflation - 3

improper wheel balance - 4

3. Communication should be thought of as:

sending information - 1

receiving a message - 2

an exchange of information - 3

providing feedback - 4

4. The amount of alcohol found in a 1 ½ ounce shot of whiskey or 5-ounces of wine is equal to:

four 12-ounce cans of beer - 1

three 12-ounce cans of beer - 2

two 12-ounce cans of beer - 3

one 12-ounce can of beer - 4

5. What is the minimum visibility distance you need at 50 mph under normal conditions with good tires, good brakes and dry pavement?

4-6 seconds - 1

10-12 seconds - 2

1-3 seconds - 3

7-9 seconds - 4

6. You are driving about 45 miles per hour when suddenly you have a choice of braking or making an evasive steering action to avoid a collision. Which maneuver takes less distance?

A braking action will take less distance - 1

A steering action will take less distance - 2

Both the steering action and braking action will take about the same distance - 3

Controlled braking along with steering will take more distance - 4

7. Blind spots are generally thought of as those areas of the highway that cannot be seen by the driver when:

checking mirrors - 1

ground viewing - 2

scanning from side to side - 3

1, 2, 3 - 4

8. Head restraints can offer the best protection if they are adjusted to meet:

the back of your head - 1

the back of your neck - 2

the top of the car seat - 3

9. It's recommended you use low-beam headlights during the day because it makes it easier:

for others to see you - 1

for you to see - 2

to see the edge of the road - 3

to avoid collisions with fixed objects - 4

10. Which is the correct lane-change procedure to follow?

Check inside mirrors, glance over your shoulder, signal, check side mirror - 1

Signal, check over your shoulder, then check side mirror - 2

Check over your shoulder, glance in the mirror, then signal - 3

Check inside mirror, signal, check side mirror, then glance over your shoulder - 4

11. When a school bus has stopped with its red lights flashing, you must:

stop if you are behind the bus - 1

stop if you are driving toward the bus - 2

stop if you meet the bus while it is loading at an intersection - 3

All of the above - 4

12. When interacting with bicyclists and pets, your best response is to:

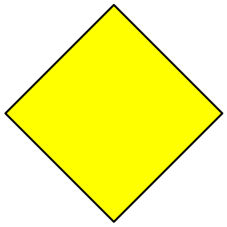
to be more aware of the road conditions - 1

adjust speed and increase your space margin - 2

use different visual search pattern - 3

communicate better - 4

13. Yellow signs with this shape:



- guide drivers to roadside services - 1
- warn drivers of road conditions - 2
- guide drivers to scenic places - 3
- give notice of laws that apply - 4

14. To avoid rear-end collisions in ideal driving conditions, maintain a following distance of at least:

- 1 to 2 seconds - 1
- 6 to 8 seconds - 2
- 4 to 5 seconds - 3
- 3 – 4 seconds - 4

15. When adjusting the seat belt, it is best to:

- leave the shoulder belt slightly loose so you can reach controls - 1
- position the shoulder belt to fit comfortably and snugly and wear the lap belt snugly across the upper thighs - 2
- wear the lap belt as high as possible on the abdomen - 3

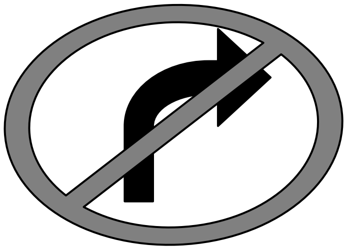
16. When driving in fog, it is best to drive with:

- high-beam (bright) headlights on - 1
- low-beam (dim) headlights on - 2
- four-way flashers - 3
- no lights at all (or parking lights) - 4

17. The best method for stopping a vehicle without ABS on slippery pavement is:

- downshift to a lower gear, then use the brakes - 1
- lock the brakes, release, and then lock them again - 2
- pump the brakes rapidly - 3
- shift to neutral-push brake pedal to a point just short of lockup and adjust as necessary - 4

18. Signs like this mean a driver:



must stop before turning - 1
can't turn right - 2
can't turn left - 3
is coming to a sharp right turn - 4

19. The effect of alcohol on the central nervous system is …

stimulant - 1
depressant - 2
narcotic - 3
hallucinogen - 4

20. Which scanning habit will help you judge speed and anticipate possible changes in direction of other cars?

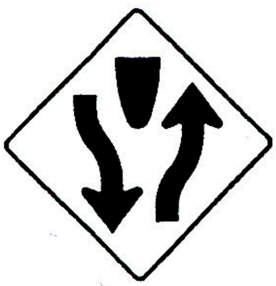
Checking mirrors regularly - 1
Moving your eyes regularly - 2
Ground viewing - 3
Checking over your shoulder - 4

TRAFFIC SIGNS

A.

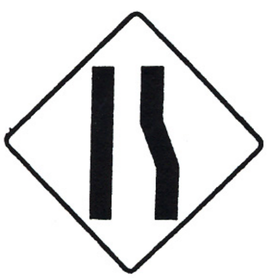
Road work ahead	1
School crossing	2
Pedestrian crossing	3

B.



Divided highway ends	1
Two-way traffic ahead	2
Divided highway begins	3

C.



Merging traffic	1
Divided highway ends	2
Right lane ends	3

D.

Road work ahead	1
Hill	2
Yield	3

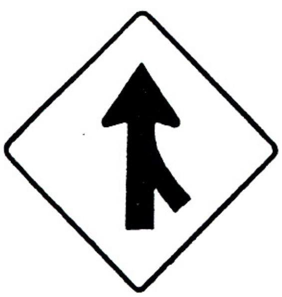
E.

No left turn 1
Do not enter 2
No U turn 3

F.

No left turn 1
No right turn 2
Do not enter 3

G.



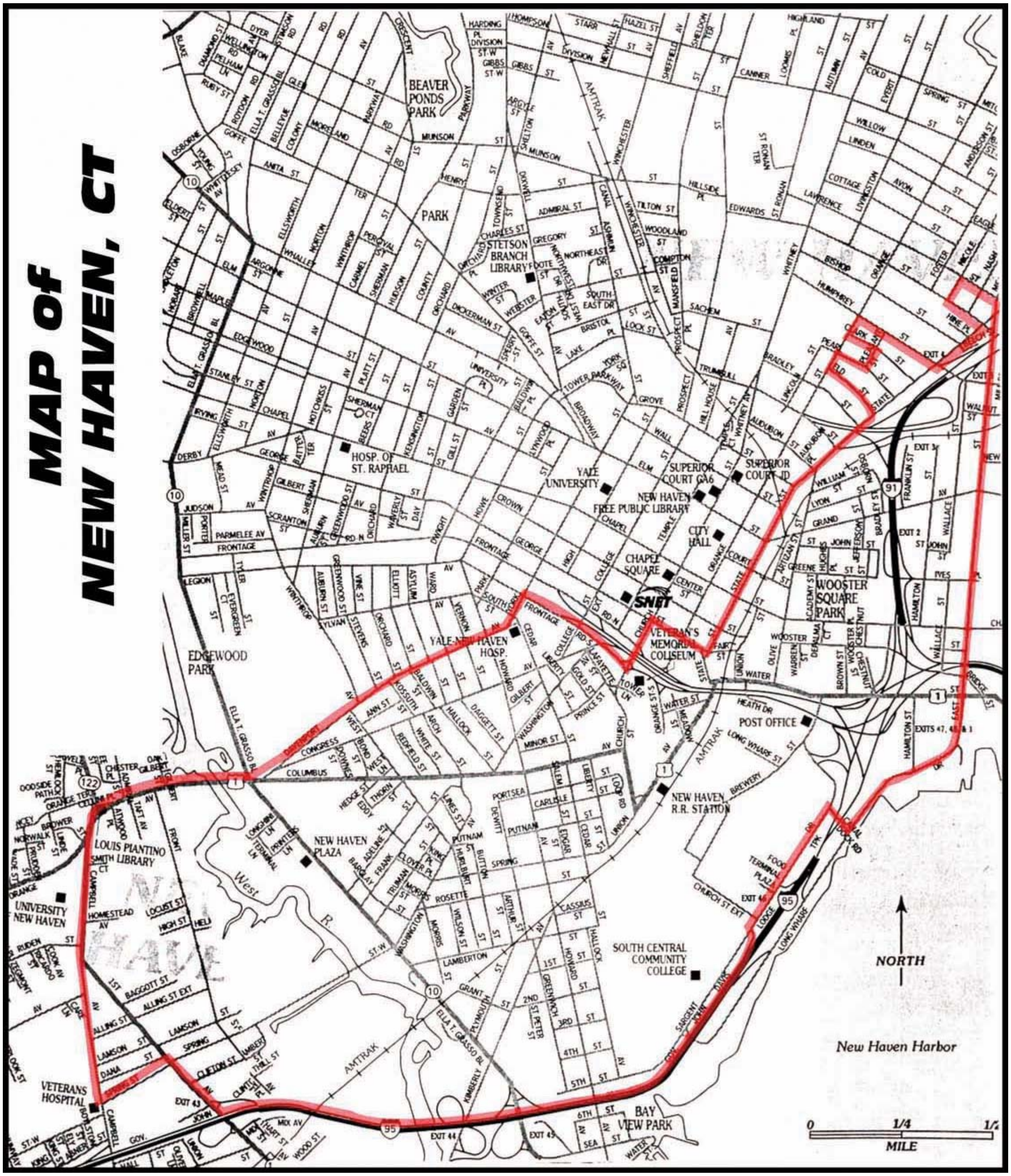
Divided highway ends 1
Right lane ends 2
Merging traffic 3

H.

Yield 1
Road curves ahead 2
Slippery when wet 3

APPENDIX II
Driving Assessment Route Map

MAP of NEW HAVEN, CT



APPENDIX III
Driving Performance Rating Sheet

ID: ___ ___ ___ ___ **SITE:** ___ ___

ASSESSMENT: (1) Baseline (2) Follow-up **ROAD CONDITIONS:** (1) Dry (2) Wet (3) Snowy

DATE: ___ ___/___ ___/___ ___ ___ ___ **WEATHER CONDITIONS :** (1) Clear (2) Rain (3) Snow (4) Foggy

OUTCOME: ___ ___ ___ ___ ___ ___ **(______________)** **EDITOR:** ___ ___ ___

EXAMINER INITIALS: ___ ___ **EDIT DATE:** ___ ___/___ ___/___ ___ ___ ___

ROUTE: 4

HIGHWAY: (1) Yes (2) No

	Performance			Comments
CATEGORY	**0**	**1**	**2**	
1) Scans to sides	0	1	2	
2) Scans to rear/headcheck	0	1	2	
3) Uses mirrors	0	1	2	
4) Uses seat belt	0	1	2	
5) Responds to traffic signals	0	1	2	
6) Respond to vehicles/pedestrians	0	1	2	
7) Grants right of way	0	1	2	
8) Centers car in lane	0	1	2	
9) Safe following distance	0	1	2	
10) Uses directional signals	0	1	2	
11) Positions car for turns	0	1	2	
12) Proper lane selection	0	1	2	
13) Gas to brake reaction time	0	1	2	
14) Appropriate steering recovery	0	1	2	
15) Acceleration	0	1	2	
16) Braking	0	1	2	
17) Shifting	0	1	2	
18) Right turns	0	1	2	
19) Left turns	0	1	2	
20) Backing up	0	1	2	
21) K turns	0	1	2	
22) parking	0	1	2	
23) Low density traffic areas	0	1	2	
24) Simple traffic situations	0	1	2	
25) Medium traffic situations	0	1	2	
26) Limited access highway	0	1	2	
27) Enter	0	1	2	
28) Exit	0	1	2	
29) Merge	0	1	2	
30) Lane change	0	1	2	
31) Speed regulation	0	1	2	
32) Follows directions	0	1	2	
33) Judgment	0	1	2	
34) Decision making	0	1	2	
35) Memory	0	1	2	
36) Attitude/Emotions	0	1	2	

Critical Errors	**YES**	**NO**	**Overall Score**		
Inattention	1	2	Fine, without problem	4	
Lane changes without looking	1	2	Fine, with minor problem	3	
Disobey traffic signs/signals	1	2	Modest problem or restriction	2	
			Major problem, Possibly unsafe	1	

APPENDIX IV
Complete Models

A. Adjusted Complete Case Mixed Model Parameter Estimates and Standard Errors for Road Test Scores

Variable	Parameter Estimate	Standard Error	T Statistic	P-Value
Intervention Group (Intervention vs. Control)	2.868	0.860	3.34	0.001
Baseline Road Test Score	-0.372	0.103	-3.60	<0.001
Recruitment Site	-0.615	1.247	-0.49	0.623
Baseline Road Test Examiner	0.822	1.110	0.74	0.461
Follow-up Road Test Examiner	-0.915	1.428	-0.64	0.523
Enrollment Date	-0.008	0.004	-1.92	0.058

[a] Linear mixed model with a random intercept and with individuals clustered within instructional groups. The outcome is the change in road test score at follow-up relative to baseline.

B. Adjusted Complete Case Mixed Model Parameter Estimates and Standard Errors for Written Test Scores

Variable	Parameter Estimate	Standard Error	T Statistic	P-Value
Intervention Group (Intervention vs. Control)	3.446	0.572	6.02	<0.001
Baseline Written Test Score	-0.643	0.102	-6.32	<0.001
Recruitment Site	0.038	0.694	0.05	0.957
Enrollment Date	-0.002	0.002	-1.11	0.269

[a.] Linear mixed model with a random intercept and with individuals clustered within instructional groups. The outcome is the change in written test score at follow-up relative to baseline