U.S. Department
of Transportation
National Highway
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DOT HS 809 583

May 2003

Model Driver Screening and Evaluation Program

Final Technical Report

Volume II: Maryland Pilot Older Driver Study

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 809 581		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
MODEL DRIVER SCREENING AND EVALUATION PROGRAM FINAL TECHNICAL REPORT VOLUME 2: MARYLAND PILOT OLDER DRIVER STUDY	5. Report Date: May 2003 6. Performing Organization Code: 1478
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9. Performing Organization Name and Address The Scientex Corporation 4817 B Eisenhower Avenue Alexandria, VA 22304 *TransAnalytics, LLC* 1722 Sumneytown Pike Box 328 Kulpsville, PA 19443	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTNH22-96-C-05140
12. Sponsoring Agency Name and Address Office of Research and Traffic Records National Highway Traffic Safety Administration 400 Seventh Street, S.W., Room 6240 Washington, DC 20590	**13. Type of Report and Period Covered** Final Technical Report Oct. 1996 – Mar. 2003 **14. Sponsoring Agency Code**

15. Supplementary Notes

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16. Abstract

This research project studied the feasibility as well as the scientific validity and utility of performing functional capacity screening with older drivers. A Model Program was described encompassing procedures to detect functionally impaired drivers who pose an elevated risk to themselves and others; to support remediation of functional limitations if possible; to provide mobility counseling to inform and connect individuals with local alternative transportation options; and to educate the public and professionals about the link between functional decline and driving safety—all within a larger context of helping to preserve and extend the mobility of older persons. Early in this project, a questionnaire was developed and distributed to Driver License Administrators in the U.S. and Canada to broadly determine cost and time parameters, while identifying legal, ethical, or policy implications that could influence implementation of Model Program activities. Subsequently, a battery of functional tests was developed and pilot tested in Motor Vehicle Administration sites, and in the community. A database of scores on functional ability measures, driving habits information, and crash and violation history was created for over 2,500 drivers in three samples drawn from license renewal, medical referral, and residential community populations. Cost estimates for functional capacity screening and related Model Program activities were developed for research and production settings. A 477-page *Safe Mobility for Older People Notebook* (DOT HS 808 853) was developed to support program initiatives promoting the safe mobility of older persons across all States and Provinces, including an *Annotated Research Compendium of Driver Assessment Techniques for Age-Related Functional Impairments.* A set of guidelines for motor vehicle administrators was also produced to update the 1992 publication by NHTSA and AAMVA of the same title.

17. Key Words	18. Distribution Statement
Driver, Safety, Mobility, Age, Functional Impairment, Functional Testing, Road Test, Licensing, Screening, Vision, Attention, Perception, Physical Ability, Dementia, Epidemiology, Remediation, Education, Training, Counseling, Alternative Transportation, Mobility Options	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	133	

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

ACKNOWLEDGEMENTS

The authors are indebted to Dr. John Eberhard and Ms. Esther Wagner of NHTSA, who together provided the impetus to launch this project and the perseverance to complete it. Their vision and guidance are reflected in each of the products of this research.

Equally critical to bringing the concept of a Model Driver Screening and Evaluation Program to life are all those who supported and collaborated in this effort as members of the Maryland Research Consortium. Thanks go first to Dr. Robert Raleigh, Chief of the Maryland Medical Advisory Board and Consortium director, who has advanced the proposition of "safe mobility for life" immeasurably through his singular dedication and inspiration over the course of this project—and beyond. For her enduring support of Dr. Raleigh and public commitment to the goals of this project, we are also most grateful to Ms. Anne S. Ferro, Administrator of the Maryland MVA.

Next, the day-to-day activities of the Maryland Pilot Study could not have proceeded without support from and coordination by the staff of the Maryland MVA's Office of Driver Safety Research, in particular Mr. Jack Joyce, Senior Research Associate, and Ms. Jane Valencia, Research Associate. Essential technical support for the Maryland Pilot Study also was provided by Mr. Gary Golembiewski , a former colleague; and by Dr. Karlene Ball of the University of Alabama at Birmingham and Dr. Dan Roenker of Western Kentucky University. Key equipment resources used in the Pilot Study were made available through a National Institutes of Health/National Institute on Aging Grant held by Dr. Ball.

A number of Consortium members in the social service and health care arenas made notable contributions to the planning and performance of the Pilot Study. These include Ms. Phyllis Madachy, Administrator for the Howard County, Maryland, Office on Aging, and her associates Ms. Trisha Olsen, Ms. Kenda Sovero, Ms. Barbara Miller, and Mr. Hugh Forton. Occupational Therapists who were key to the success of this project included Ms. Kim Harwood-White, Dr. Anne Long Morris, Ms. Carolyn Isackson, Ms. Janie B. Scott, and Ms. Betty Cox.

Finally, we are thankful for the efforts of the MVA personnel who collected screening data with license renewal drivers in the Glen Burnie, Bel Air, and Annapolis field offices and with residents of Leisure World in Montgomery County, Maryland: Mary Fauver, Tina Ferm, Melissa Johnson, Chuck Nellis, Theresa Rogers, Josie Simmons, Susan Simmerer, Judie Willie, Mary Gray, and Nancy West. In addition, thanks are given to the Driver License Examiners and their managers in the 11 MVA field offices where medically-referred drivers were screened in the Pilot Study. These included Ms. Pamela Minton and Mr. Ronald White (Bel Air Branch office under management of Ms. Linda Colden); Mr. Robert Foote and Mr. Jim Hudson (Cumberland Branch Office, under management of Ms. Lenna Morgan); Ms. Michelle Walls and Mr. Ronald Stafford (Easton Branch Office, under management of Mr. Don Howeth); Mr. Walter Campbell, Ms. Mildred Davenport, and Ms. Mary Joe Lofland (Elkton Branch Office, under management of Ms. Patricia McQuaide); Ms. JoAnn Fleishell, Ms. Sharon Watts, and Mr. Lewis Waugh (Frederick Branch Office, under management of Ms. Betty Thompson); Mr. Paul Duvall, Ms. Liliana Reyes, and Ms. Barbara Walker (Gaithersburg Branch Office, under management of Ms. Natalie Liewllyn); Mr. Al Wolfe and Ms. Cheryl Totten (Glen Burnie Office, under management of Ms. Donna Meadows); Lt. Terry Acre, Mr. Jerry Allen, and Mr. Steve Moyer (Hagerstown Branch Office, under management of Ms. Rebecca Snyder); Ms. Barbara Bates and Mr. Ed Novak (Largo Branch office, under management of Ms. Nancy Elkins); Ms. Robin Russell and Ms. Remonia Finney (Salisbury Branch Office, under management of Ms. Debbie Taylor); and Sgt. Lorraine Dawson, Ms. Ann Marie Haley, Cpl. Thomas Way, and Lt. Beth Wilkerson (Waldorf Branch Office, under management of Ms. Sharon Semler).

MODEL DRIVER SCREENING AND EVALUATION PROGRAM FINAL TECHNICAL REPORT - VOLUME 1: PROJECT SUMMARY AND MODEL PROGRAM RECOMMENDATIONS

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CHAPTER 1: MARYLAND RESEARCH CONSORTIUM

The Maryland Pilot Older Driver Study was conceived and carried out within an infrastructure termed the "Maryland Research Consortium" (MRC). Under the leadership of Dr. Robert Raleigh, Chief of the Maryland Medical Advisory Board (MAB) and Director of the Office of Driver Safety Research at the Motor Vehicle Administration (MVA), the MRC was formed in 1996 to coordinate efforts to more fairly and accurately identify high-risk older individuals, and to help those who need it to improve their skills, change their habits, or find good alternatives to driving. MRC members comprise a multidisciplinary team representing over 25 State and National organizations, including all agencies of Government concerned with transportation, public health, and aging, plus private sector partners.

Through quarterly, full-day meetings, the MRC has provided a forum for a diverse set of stakeholders and research partners both within and outside of the State of Maryland to discuss details of the Pilot Study, and to consider broader, policy issues relating to safe transportation for older persons. This collaboration among Consortium members was crucial for the conduct of this research; it also has defined a working model, or template, for launching a driver screening and evaluation program that could be of value in other States as well.

RESEARCH MISSION

During the initial meetings of the MRC a mission statement was developed and a vision was articulated, through consensus, that summarized the shared goals of Consortium members. Four performance areas also were identified through which efforts to achieve the MRC mission could be organized and directed. These are shown in table 1.

Table 1. Organizing principles for the Maryland Research Consortium for Older Drivers.

MISSION STATEMENT:

To create and offer a program of safe mobility for Maryland Older Drivers.

VISION STATEMENT:

To become the National model for safe mobility for life.

KEY PERFORMANCE AREAS AND GOALS:

1. Identification and Assessment	To identify and assess the ability of older people to remain safely mobile.
2. Remediation/Counseling	To remediate and/or counsel those with functional limitations so that they remain safely mobile, and identify providers of these services.
3. Mobility Options	To inventory and assess existing and potential mobility options, to develop enhanced and new options as needed, and identify how to access these services.
4. Public Information & Education	To educate our citizens and care givers on the public health issues of functional decline and driving safety, and to provide information on how older people may remain safely mobile.

Consortium members' activities were structured into four working groups, one for each "key performance area." Within each group, members developed more a more detailed set of interim objectives and an action plan to meet them. These were working documents that evolved during the course of the Pilot Study; they are presented in appendix A (tables 10, 11, 12, and 13) as initially conceived. The working groups made it possible for Consortium members whose interests were more narrowly focused—though still consistent with the overall mission of the MRC—to identify attainable goals and to identify the people and resources within their own organizations that could be applied to help reach them. A leader within each working group maintained communications among group members and was the primary point of contact with other groups and with the Consortium chair. The progress of the various working groups was reviewed and their action plans were periodically revisited and revised as necessary during regularly scheduled meetings of the Consortium.

PARTNERS AND PARTNERSHIPS

Project staff were directly involved with the Consortium from its inception and relied on the cooperation of its members through performance of all research activities described in this report. Specifically, plans to carry out screening and counseling activities with older drivers in (1) Motor Vehicle Administration (MVA) field offices; (2) a residential community for older adults; and (3) senior centers operated by the Area Agency on Aging were developed in interim meetings between project staff, NHTSA, and appropriate MRC members.

To a varying extent, the involvement of the Consortium members listed below extended beyond project design through all phases of driver recruitment, data collection and analysis, and the development of guidelines for program implementation beyond the Pilot Study.

- ADED/Association of Driver Rehabilitation Specialists
- Administration on Aging
- Allegany County Health Department
- American Association of Motor Vehicle Administrators
- American Association of Retired Persons
- American Automobile Association
- AAA Foundation for Traffic Safety
- American Occupational Therapy Association
- Baltimore County Police Department
- Baltimore Metropolitan Council
- Ecosometrics, Inc.
- Federal Highway Administration
- Federal Transit Administration
- Howard County Department of Planning & Zoning
- Howard County Office on Aging
- Jewish Council for the Aging
- John's Hopkins University (Medical Center; School of Medicine; Dept. Health & Mental Hygiene; Dept. of Emergency Medicine)
- Lions Vision Center, Wilmer Eye Institute
- Maryland Association of Women Highway Safety Leaders
- Maryland Department on Aging
- Maryland Department of Health and Mental Hygiene
- Maryland Department of State Police
- Maryland Department of Transportation
- Maryland Mass Transit Administration
- Maryland Motor Vehicle Administration
- Maryland State Highway Administration
- National Highway Traffic Safety Administration
- National Institute on Aging
- National Public Services Research Institute
- Office of the Secretary, U.S. Department of Transportation
- Queen Anne's County Sheriff's Office
- Sinai Hospital Rehabilitation Center
- The Scientex Corporation
- TransAnalytics, LLC
- University of Alabama at Birmingham/Roybal Center
- University of Maryland School of Medicine, Dept. of Ophthalmology

CHAPTER 2: PILOT STUDY DEVELOPMENT

RESEARCH DESIGN ISSUES

The research activities conducted as part of the Maryland Pilot Older Driver Study were designed to improve the state-of-the-knowledge in two broad areas: (1) the validity of functional tests as predictors of driving impairment associated with crashes and other safety outcomes, and (2) the administrative feasibility of delivering screening and evaluation services in a driver licensing setting and/or in other settings in the community. Specific questions addressed within each of these areas during development of the Pilot Study, and their impact on the research design, are briefly discussed in the following four pages of the report.

Validating Functional Tests as Predictors of Driving Impairment

A test or procedure to detect declines in the functional capabilities needed to drive safely must possess a certain degree of validity to merit application in the licensing or relicensing process. One goal of the Maryland Pilot Older Driver Study was to provide, to as large an extent as possible, the data needed to validate the application of functional performance measures to account for differences in crash and violation experience. With success in meeting this general study objective, evidence supporting more specific conclusions regarding the preliminary identification of cutpoints, or pass/fail criteria for individual screening procedures, could be sought. The research design guiding data collection and analysis in the Pilot Study incorporated a number of key assumptions about test validation, as elaborated below.

<u>Single Variable Versus Multiple or Combination Variable Predictors</u>. It is an understandable desire of State agencies to identify a screening protocol that can yield the most information about the risk of driving impairment, in the shortest time. This desire suggested, as one option, that data collection and/or analysis should be structured in a stepwise fashion. In this approach, the measure indicated by prior research to be the strongest predictor of driving impairment might be obtained first; then, *if* performance was below some threshold, another measure would be obtained, and so on. Or, even if all measures were obtained, a stepwise analysis technique might be employed where one variable would be entered into a regression equation first, followed in turn by other variables that were weighted less strongly, until bringing additional variables into the equation no longer produced any gain in explaining differences in the outcome measure. Either course could lead to a relatively more rigid model for driver screening and evaluation, where predictors of driving impairment are formally linked (failure results from this score on measure A *and* that score on measure B *or* this score on measure C, etc.), and there is less reliance on the role of clinical judgment in reaching decisions about fitness to drive.

This approach was rejected for several reasons. First, the interrelationships between different broad domains of functional ability important for safe driving—i.e., physical, mental, and visual abilities—are not well defined; nor, in many cases, have the relationships within domains been reliably quantified, especially with regard to the array of perceptual-cognitive (mental) abilities of interest in the Pilot Study. It was a fundamental assumption in this research that a gross deficit in *any* of the targeted aspects of functional performance could result in a significant increase in the risk of driving impairment. In addition, to combine measures inevitably results in a loss of information. A clinician may, after many evaluations, choose to group certain indicators of functional status together to reach a decision about fitness to drive. But this preserves access to all available information regarding an individual's functional status, and allows the physician, occupational therapist or other professional greater flexibility in applying clinical judgment in determining a person's overall driving health.

Accordingly, in the Maryland Pilot Older Driver Study all included functional measures were obtained for all research participants, within the limits of what was technically and logistically possible, and analyses of the relationships between functional status and crash and violation experience were performed on an individual measure-by-individual measure basis.

Accounting for Potential Selection Biases Yielding an Unrepresentative Test Sample. One of the most common deficiencies in the design of traffic safety research projects, and greatest threats to the validity of a study's outcomes, is collecting data from a test sample that results in an unrepresentative, or biased, estimator of the performance of the broad population of interest. The population of interest for products of this research includes all older persons who wish to retain driving privileges. It was therefore crucial to understand—and hopefully preclude—any systematic differences between the obtained sample and a completely random sample in carrying out measures of functional status in the Pilot Study.

This is not to say that the performance of identified subgroups of older persons was not of interest in this research. In particular, data were desired to describe functional abilities among a group of presumed "superfit" or well elderly who live in a residential community or continuing care retirement community (CCRC), and also for older persons at the other end of the spectrum, i.e., those who have been referred for evaluation specifically because of a suspected medical problem or condition. But neither of these groups is representative of the broad population of normally aging drivers, and thus cannot serve as the primary source of data for analyses to establish relationships between functional status and crash and violation experience that are applicable for driver screening.

The preferred design for the Pilot Study dictated a purely random selection of drivers who would be compelled, for research purposes, to undergo functional screening. Unfortunately, this proved to be not feasible under existing statutes in Maryland.

Accordingly, sample selection in the Maryland Pilot Older Driver Study incorporated random in-person contacts, carefully stipulating that study participation would have no impact on license status. Drivers contacted could refuse to participate, however. Documentation of those who accept versus those who decline, with subsequent analyses to test for differences indicating a bias in the likelihood of causing crashes or committing violations, was adopted as the methodology for this research. Samples of convenience among retirement community residents and the population of medically-referred drivers were also obtained.

Criteria for Judging the Significance of Research Results. One measure of the validity of a screening technique for predicting driving impairments associated with increased crash risk is the level of statistical significance that can be demonstrated when accepted analysis techniques are applied to test the strength of such relationships. It can be further argued that the best choice for the cutpoint in a given functional measure is the score where the strongest predictor-outcome relationship, quantified in terms of statistical significance, is obtained. When research results are to be applied in real world settings, however, the significance of a study's findings may be gauged as much or more by an entirely different set of criteria. In one example, a statistically significant test result may be obtained when there are very small differences in measurements, given a sufficiently large number of observations, but have no *operational* significance whatsoever. Conversely, when criterion events are rare, as in the case of motor vehicle crashes, a difference that fails to reach statistical significance could still have a major impact on an administrator's decisions about program content or resource allocation.

Even more confusing can be the application of composite indices of the strength of relationship between a predictor and an outcome, where concurrent changes in several different variables contributing to the overall test statistic value can obscure the meaning of a change in the composite measure. This problem was anticipated in the design of this research because of plans to use calculated "odds ratio" values to help identify the most promising screening tools. Consistent with recent trends in research evaluating interventions for preventable injuries—including motor vehicle crashes (e.g. Diller, Cook, Leonard, Reading, Dean, and Vernon, 1999; Vernon, Diller, Cook, Reading, and Dean, 2001)—this statistic in its planned application in the Pilot Study expresses *the odds of being in a crash if you fail a test compared to the odds of being in a crash if you pass.* As discussed later in more detail, odds ratio calculations involve four separate quantities that are combined multiplicatively, such that a higher overall odds ratio value does not necessarily mean that a test was more effective in detecting impaired (i.e., crash involved) drivers.

Finally, it has long been emphasized that random and uncontrollable factors account for substantial variance in the incidence of motor vehicle crashes (see Peck, McBride, and Coppin, 1971). And in addition, even those drivers who are at greater risk of crashing due to functional impairment may be affected by a diminished capability *other than* the one a specific test is designed to detect.

Accordingly, analysis and interpretation of data in the Maryland Pilot Older Driver Study was geared to the search for patterns and trends with overarching significance for the validation of functional testing in the detection of impaired drivers. This was a descriptive exercise designed to supplement, not to replace, the statistical tests and techniques designed to quantify the strength of relationship between specific predictors and crash and violation outcomes. In particular, evidence was sought to validate the application of functional testing through its ability to disaggregate crash-involved drivers into separate and discriminable groups: those who are at increased risk because of a specific functional ability being measured, and those who have been involved in a crash because of other factors.

Administrative Feasibility of Delivering Screening Services

State-level involvement in driver screening and evaluation activities will be guided, inevitably, by their feasibility of implementation. Given procedures deemed valid and that also are accepted by the public, an agency may calculate projected program costs based on the equipment, materials, and staff needed to administer them. These costs in turn will be driven by the time to complete screening procedures for each driver; the level and qualifications of the staff who conduct screening; the amount of training required by test administrators; the facilities and physical infrastructure necessary to support testing; the specific hardware and software components of the test protocol; and any supplemental expenses associated with specialists such as occupational therapists who may be desired on site to provide education and counseling services to drivers in conjunction with screening. On the other side of the equation are savings relative to existing program activities due to, for example, a reduction in the number of more costly interventions once a screening program for early detection of impaired drivers is in place.

In this research, the administrative costs were documented as closely as possible, and otherwise estimated, by MVA staff providing oversight to data collection activities in the Pilot Study. An estimation of cost savings produced by having functional screening information available, to help resolve cases where an on-road examination would otherwise be required to make a fitness-to-drive determination, also was developed by the MVA during the course of this research.

Prior to embarking on full-scale implementation of the screening activities—initially in three MVA field offices and eventually involving facilities and personnel statewide—data from a “pre-pilot” feasibility study were analyzed to refine functional test procedures. The “pre-pilot” study was conducted in a storefront office location in Salisbury, MD, by ophthalmic technicians employed by Johns Hopkins University (JHU) to perform data collection and interviews with an established test sample as part of the longitudinal Salisbury Eye Exam study; they were not otherwise affiliated with this project. The JHU technicians were trained in the use of candidate driver screening procedures by members of the research team. Goals of the "pre-pilot" study included documentation of problems in administering screening tests and identification of enhancements to the data collection protocol. A target test length of 15 minutes or less for the Gross Impairments Screening (GRIMPS) protocol was desired.

The “pre-pilot” study was performed over a four-month interval from April to July 1998. During this period, 363 older persons with valid licenses who reported themselves to be active drivers were screened by the JHU technicians, using a candidate test battery and data collection protocol. Sample demographics were distributed as follows: 54 percent were male, and 46 percent were female; 82 percent were Caucasian, and 18 percent were other races; the age of those tested ranged from 68 to 88, with a mean age of 75.7 and a standard deviation of 4.9 years.

The “pre-pilot” study results defined the measures to be included in the Maryland Pilot Older Driver Study. Modifications of selected test methods and improvements to instructions and scoring procedures were suggested by the JHU technicians; when implemented, a 15-minute test length for the battery of functional ability measures comprising GRIMPS was achieved. These measures are described in detail later in the report.

TEST SITE AND SAMPLE SELECTION

The selection of test sites and recruitment of samples for the Maryland Pilot Older Driver Study proceeded in tandem. The research design initially called for four sites/samples in this study. But as described below, data collection at one site type—Senior Center—was discontinued due to practical considerations and only three of the sites/samples—License Renewal, Residential Community, and Medical Referral—yielded data that were subsequently analyzed to examine the relationships of interest in this research. Materials used to recruit test subjects for the Pilot Study are presented in appendix B.

License Renewal Sample

The largest and most critical sample of drivers tested in this research was obtained in field offices of the Maryland Motor Vehicle Administration (MVA). By design, a random sample of older drivers was sought to yield reliable population estimates of performance distributions on each of the functional measures of interest in this research, and to define relationships of functional ability with crash involvement. Without a random sample, there was concern that selection bias could restrict the ranges and/or skew the distributions of the measured functional abilities. In particular, a sample bias in favor of those with lower crash experience could potentially distort analysis outcomes, such that obtained relationships between functional ability and crash risk would appear unrealistically weak.

Unfortunately, candidate study participants could only be asked, not compelled, to join this research effort, thus ruling out a purely random sample and opening the door to potential selection bias as noted above. Several steps were taken during sample recruitment to mitigate against this threat. First, all older persons appearing at MVA field offices on randomly selected days were approached by project staff with a request for study participation, but only *after* completing license renewal; each individual already had a new, valid license in his/her possession, and was assured, in writing, that participation in the research activities would not affect license status. In addition, the license numbers (Soundex numbers) for all persons approached—"accepters" and "decliners" alike—were recorded to permit later analyses of any differences between these groups that could suggest a lack of representativeness of the obtained test sample. Key comparisons between those accepting and declining participation in the study are reported below, before presenting a detailed description of the License Renewal Sample.

First, the age distributions of the drivers who accepted and who declined when contacted in a MVA office with a request to participate in the study are presented in table 2. As shown, the mean, median, and standard deviation values were nearly identical. A *t*-test confirmed that there was not a significant age difference between these distributions ($t = 1.24$, $p < 0.22$).

Next, the crash and violation experience of the drivers accepting and declining participation in the study was examined. Six event types were included, connoting varying levels of safety threat. *All crashes* (excluding alcohol-related events) were counted; *at-fault crashes* (as per police report) were counted; and an intermediate category of *unknown fault crashes* was also counted, where the driver was potentially at fault but there was insufficient evidence to confirm fault status in the opinion of the investigating officer. Convictions for *all moving violations*, for *moving violations excluding speeding*, and for *moving violations excluding speeding and occupant restraint violations* were counted, for the respective groups.

Table 2. Age comparison for groups of drivers who accepted and declined to be screened.

Statistic	Driver Group	
	Declined Screening	Accepted Screening
N of cases	2098	1876
Minimum Age	55.00	55.00
Maximum Age	90.00	96.00
Median Age	68.00	68.00
Mean Age	68.59	68.28
Standard Deviation	7.95	7.92

The analysis interval was keyed to the date of contact for each individual. It extended one year prior to this date, retrospectively, based on the desire to capture as many crashes as possible for analysis, coupled with a clinical judgment[1] that a period of relative stability of functional status for to 12 months into the past could be assumed for most people. The analysis interval also extended 2 to 3 years into the future from the date of contact. The variable analysis interval for prospective data resulted from the fact drivers were contacted regarding study participation over a period of more than a year, while a common "end date" at which analyses were begun was applied to everyone. In summary, the analysis period for each driver bracketed his or her date of contact, with prospective experience accounting for approximately twice as much exposure as retrospective experience.

The relative experience of the comparison groups for each event type is presented in table 3. As shown in this table, those who accepted the request to be screened, though slightly fewer in number, actually demonstrated higher group counts in every crash category analyzed. Using chi-square tests, this difference was found to be statistically significant for all crashes ($X^2 = 4.79$, $p<.03$) and for the event category including at-fault plus unknown fault crashes ($X^2 = 5.14$, $p<.02$). The respective groups were not significantly different for any of the other measures; although, the drivers accepting screening were convicted of fewer moving violations than those who declined during the analysis interval.

Table 3. Event counts for groups of drivers who accepted and declined to be screened.

Event Type	Driver Group	
	Declined Screening	Accepted Screening
All crashes (except alcohol related)	93	111
Unknown fault and at-fault crashes (except alcohol related)	50	67
At-fault crashes (except alcohol related)	39	43
All moving violations	197	196
All moving violations (except speeding)	146	102
All moving violations (except speeding and occupant restraint)	46	31

These data were taken as satisfactory evidence that, at least with respect to crash experience, there was no basis upon which to infer a "volunteer bias" such that more at-risk individuals were avoiding screening. Thus, the drivers who accepted the request for study participation are hereafter described as the License Renewal Sample, and conclusions drawn

[1] Robert Raleigh, M.D., Chief, Medical Advisory Board, Maryland Motor Vehicle Administration.

from analyses of their functional performance and crash and violation experience serve as the basis for generalizations regarding implications of project findings to the entire (older) population of interest.

The 1,876 drivers in the License Renewal Sample consisted of 1,027 males and 849 females. A more detailed breakdown of drivers by 10-year age group and gender are presented in table 4.

Table 4. Detailed age and gender breakdown for drivers in the License Renewal Sample.

Age Group	Males	Females	Total
55-64	352	310	662
65-74	426	354	780
75-84	231	174	405
85-94	18	10	28
95+	0	1	1

The geographic distribution of the License Renewal Sample was dictated by the location of the particular MVA field office in which a given driver was recruited into the study. Drivers were recruited to participate in the screening activities, after completing their license renewal or other business, from November, 1998 to October, 1999. Through their transactions with the MVA, the age of potential study participants was typically revealed to study recruiters; thus, recruitment efforts could be focused on individuals 55 or older.

Driver contacts were made in three office locations which, based on census data, were classified by the research team as representative of relatively more rural, suburban, and urban driving environments. These were, respectively, the Bel Air office, Harford County, MD; Annapolis office, Anne Arundel County, MD; and Glen Burnie office, just outside the City of Baltimore, MD. Demographic information provided by drivers indicated that the areas in which 95 percent of the License Renewal Sample lived and originated their travel by personal vehicles could be accounted for as follows: Harford County, 39 percent; Anne Arundel County, 30 percent; and Baltimore City and County, 26 percent.

Residential Community Sample

One potentially important setting with regard to the implementation of screening activities, from the standpoints of both personal mobility and public health and safety, are residential communities comprised mostly or entirely of older persons. Accordingly, a sample of drivers for the Maryland Pilot Older Driver Study was obtained at the Leisure World facility in suburban Montgomery County, MD.

Leisure World is one of the largest senior independent living communities on the East coast of the U.S. Geared to the "well elderly," its residents live in 4,600 homes, apartments, and condominiums whose prices range from the $150,000's to the $300,000's, with monthly fees averaging $600. This community was also therefore assumed to represent a sample of drivers who were likely to be more fit and socially active than the overall population, for its age cohort. Vehicles are registered to 6,500 of its approximately 8,000 residents.

To facilitate recruitment at Leisure World, the MVA proposed sending a mobile office to the community on a monthly basis. This would provide a convenient service to residents, who could transact business that they would otherwise have to travel to a fixed office location to conduct. Leisure World's Executive Board approved the proposal, further agreeing to a *quid pro quo*: residents who availed themselves of the vehicle registration, titling, license renewal, and related services now provided on-site by the MVA must agree to participate in the research project, completing driver screening activities, counseling about functional ability and driving health, plus follow up data collection to document changes in driving habits.

The resulting Residential Community Sample recruited in this fashion consisted of 266 drivers, 102 males and 164 females, ranging in age from 56 to 92. The mean age of this sample was 77.1, with a standard deviation of 6.8. A more detailed breakdown of drivers by 10-year age group and gender for this sample is presented in table 5.

Table 5. Detailed age and gender breakdown for drivers in the Residential Community Sample.

Age Group	Males	Females	Total
55-64	3	8	11
65-74	23	57	80
75-84	62	83	145
85-94	14	16	30
95+	0	0	0

Medical Referral Sample

A sample of drivers referred to the MVA for medical evaluation by the MAB was also included in the study. In addition to providing information about the relationships of interest in this research from a group of drivers who *a priori* could be assumed to evidence a higher incidence of impairing conditions, including these drivers permitted an evaluation of the added value of functional status data in reaching clinical judgments about fitness to drive relative to conventional medical review procedures.

All drivers age 55 and older who were referred from any source between October 2000, and October 2001, for MAB evaluation were candidates for this study. For this group, screening could be performed on a compulsory basis. Excluding alcohol offenders, 530 individuals were referred for suspected medical impairment during the specified period; 59 drivers or 11 percent failed to appear, and another 105 were not in the desired age range. As a result, 366 people were selected into the Medical Referral Sample for this study. This total included 209 males, 154 females, and 3 individuals for whom gender was not coded. Driver ages in this sample ranged from 55 to 95, with a mean age of 76.8 and a standard deviation of 9.4 years. A more detailed breakdown of the sample by 10-year age group and gender is presented in table 6.

Table 6. Detailed age and gender breakdown for drivers in the Medical Referral Sample.

Age Group	Males	Females	Total
55-64	30	21	52
65-74	42	30	72
75-84	94	65	160
85-94	42	38	81
95+	1	0	1

Drivers in this sample were referred from a variety of sources. The largest share of the sample (35%) was “self-referred,” inasmuch as they checked one or more boxes on their renewal forms indicating a medical condition or symptom that is a basis for evaluation in Maryland. Almost as many drivers, 33 percent of the sample, were referred by police. Sixteen percent of referrals came from health care professionals (12% from physicians and 4% from occupational therapists). Family members and friends together were the source of 7 percent of referrals. Other citizensЬ whose complaints were authenticated before the MAB required a driver to undergo medical evaluationЬ were the referral source for 4 percent of the sample. One percent of the sample was court-referred. The remaining 14 drivers, or 4 percent of the Medical Referral Sample, were obtained from miscellaneous sources apart from the categories listed above.

Senior Center Sample

The research design for the Pilot Study also included data collection in a Senior Center. This venue was desired to examine the feasibility of combining screening and counseling activities in a familiar and supportive setting that was accessible to the general public, and which did not include any direct involvement by the Motor Vehicle Administration that might, for some people, raise concerns about restriction or loss of driving privileges. The Howard County, Maryland, Office on Aging (HCOA) subsequently agreed to serve as a Pilot Study site. As detailed below, early experience at this site determined that driver functional screening as required to meet the objectives of this research could *not* feasibly be completed. Data collection activities were subsequently curtailed, and no performance data obtained in the Howard County Senior Center were included in the later analyses of functional status and crash/violation involvement. However, because the experience with data collection at the Senior Center factored into project conclusions about screening program feasibility, a summary of this experience is provided below.

The HCOA, in collaboration with project staff, made a decision to offer a service to its customers titled *“Getting Around - Seniors Safely on the Go.”* By design, customers would participate only on a voluntary basis. Senior Centers have an established relationship of trust with the senior community, and are therefore well positioned to provide a non-threatening site for older drivers to learn about the relationship between functional changes and driving ability, while becoming better informed about transportation alternatives in their community. Keeping seniors connected to the community, regardless of the mode of transportation, was the central theme of the program. All prospective program participants were explicitly told that their names and license numbers would be held in confidence, i.e., regardless of screening outcome, this information would not be shared with the MVA. The older drivers choosing to participate in the program received feedback regarding their performance on the functional screening measures, including the provision of counseling about how to maintain or improve driving skills;

information describing alternative transportation resources; and recommendations for further consultations with other health professionals or driving specialists if screening results indicated probable driving impairment.

A sample size of 650 drivers over age 65 was the targeted level of involvement for the Senior Center in this research. Other goals included the use of "peer screeners," older persons who would be trained in the administration of functional tests and would, in turn, perform the actual data collection with customers who volunteered to be program participants. In addition, the feasibility of using local occupational therapists (OT's) to provide feedback and counseling on-site to older drivers after they completed screening was to be determined.

The HCOA embarked on an ambitious marketing plan to attract customers to participate in screening and counseling activities. Press releases, advertisements, and direct mailings were used to recruit participants, and articles were published in a number of newspapers—the *Senior Connection* (an HCOA newspaper with 6,000 readers), the *Baltimore Sun*, the *Washington Post*, and *ZIP Publications*, which publishes three Howard County community newspapers with a high senior readership. Cable spots were aired on GTV, the Howard County Government channel. Fliers describing the program were distributed on an ongoing basis at social and cultural events in the county and surrounding areas. The HCOA Administrator made numerous personal appearances, speaking reassuringly about the anticipated benefits of the program to older drivers and reiterating that license status would in no way be affected by program participation. Finally, HCOA staff engaged in outreach activities to potential referral sources, including area police departments and health care providers.

After several months HCOA staff could confirm that significant portions of the senior community were aware of the program; but, their customers did not believe that participation would not affect their driver's licenses or insurance. The following concerns figured most prominently in forums which afforded the possibility of feedback from the target population[2].

- "This information will affect my license."
- "This information will be shared with my insurance company."
- "If I'm not safe driving, I don't want anyone to know it."
- "If I go for screening, it's an admission that something may be wrong with me."
- "My family may find out."
- "I've never had a driving problem—why should I go?"

During a 10-month interval, from March 1999 to January 2000, 113 drivers (73 females and 40 males) between the ages of 51 and 92 chose to participate in screening and counseling activities in a Senior Center in Howard County. The mean age of the participants was 72.9 years, with a standard deviation of 7.3 years. The small projected size coupled with highly self-selected nature of the sample that could be anticipated through the planned period of data collection did not support a decision to proceed with continued, aggressive marketing activities; also, staff time and costs associated with program administration, including a $40 per hour consulting fee for the included occupational therapist services, were difficult to justify. Thus, despite an enduring commitment at HCOA to the program goals of *"Getting Around - Seniors*

[2] *Pers. comm.*, Ms. Phyllis Madachy, Administrator, Howard County, Maryland, Office on Aging, (5/12/1999).

Safely on the Go," the formal involvement of the Senior Centers in Howard County, Maryland, as test sites in this research was discontinued.

Test Sites

The sites at which data were collected in the Pilot Study varied according to test sample, with some sites serving multiple samples. This section identifies the locations and describes characteristics of the sites used for the respective study samples. An overview of all locations serving as data collection sites is presented in figure 1.

License Renewal Sample. Screening for the License Renewal sample was conducted in three of the MVA full-service field offices: Bel Air, Harford County; and Glen Burnie and Annapolis, Anne Arundel County (see figure 1). At each site, a private testing room was provided at least 3.6 m by 3.6 m (12 ft by 12 ft) in size. The testing room contained two desks and two chairs, two full sets of all materials needed to conduct the functional screening, and two computers suitable to administer the Useful Field of View Subtest 2 and the Dynamic Trails test. Each testing room was illuminated by overhead fluorescent fixtures; there were no windows in any of the testing rooms.

At the Bel Air test site, a room located behind the photo counter that was off limits to the public, was used to conduct screening. This room contained two doors that could be closed for privacy. Although the room was closed off from the counter activities, counter personnel were allowed to enter and pass through the room, if necessary, to perform other tasks unrelated to the screening data collection in progress. At the Glen Burnie and Annapolis field offices, a conference room was dedicated to functional screening activities. There were no interruptions from MVA personnel at these sites.

Residential Community Sample. Data collection for the Residential Community sample was performed at Leisure World in Montgomery County, Maryland. A large conference room was provided at one of the "activity buildings" within the facility to conduct the functional screening measures on those days when the MVA mobile office was scheduled for a visit. The room accommodated a waiting area, and three screening stations including computer facilities. Two counseling stations were also provided where individuals received feedback on their functional status and its implications for driving after completing the screening battery. Temporary partitions were used to divide the large room into separate areas for the screening stations and the counseling stations.

Medical Referral Sample. Functional screening for the Medical Referral sample was conducted in 11 of the MVA full-service offices located across the state. At each site, a private conference/training room was dedicated to screening activities. The test site locations included: Bel Air , Harford County; Cumberland, Allegany County; Easton, Talbot County; Elkton, Cecil County; Frederick, Frederick County; Gaithersburg, Montgomery County; Glen Burnie, Anne Arundel County; Hagerstown, Washington County; Largo, Prince George's County; Salisbury, Wicomico County; and Waldorf, Charles County (see figure 1).

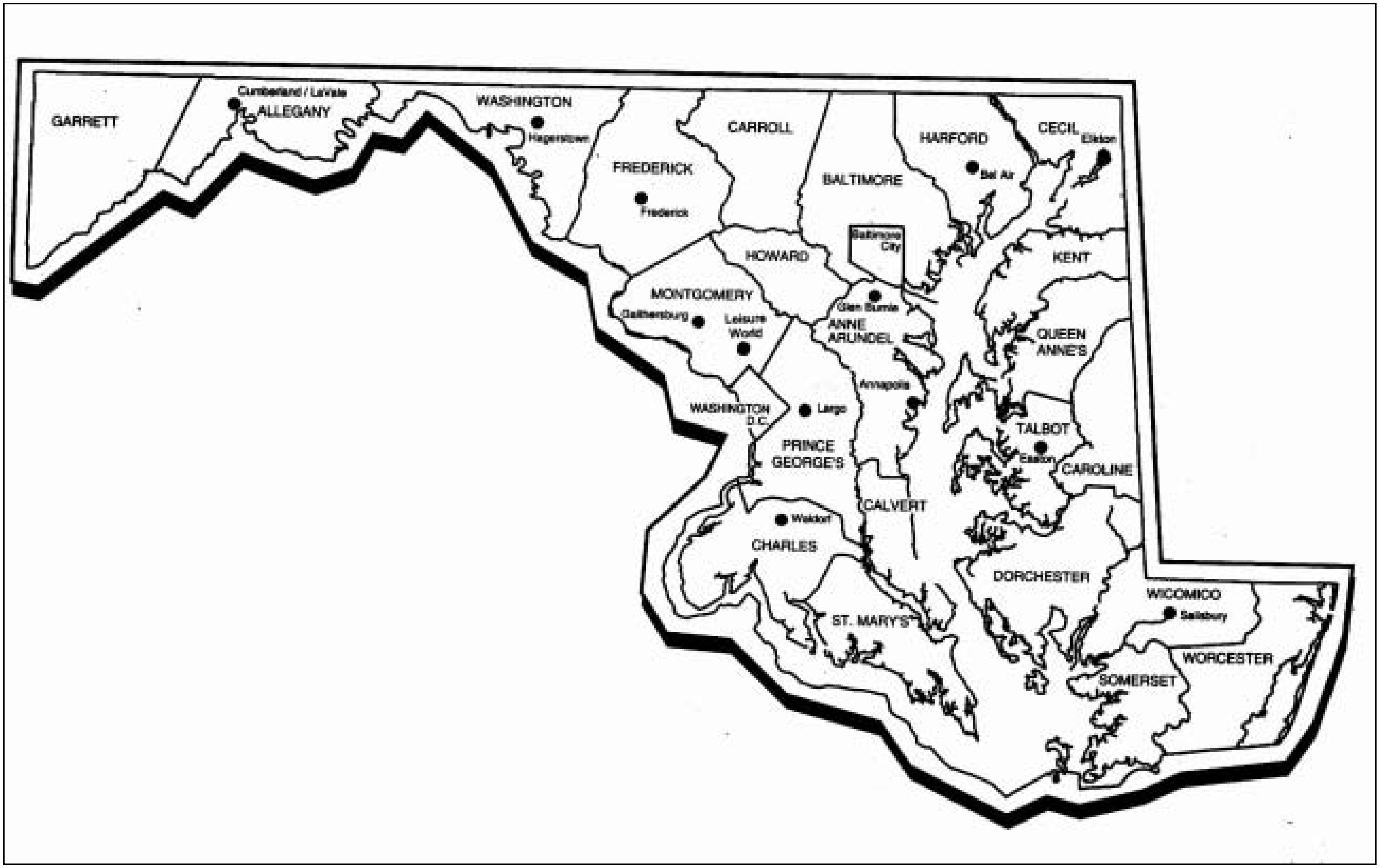

Figure 1. Location of test sites in Maryland Pilot Study.

The Bel Air and Glen Burnie sites were the same used for screening the License Renewal sample in these locations. These testing environments were described above. The sizes and characteristics of the rooms used for testing in the remaining nine MVA offices were also consistent with these locations. In all cases except Bel Air, the testing rooms were restricted to screening only, without any potential for interruption of data collection activities.

TRAINING OF DATA COLLECTION PERSONNEL

The same personnel collected functional screening data for the License Renewal and Residential Community samples in this research. These were "line personnel" selected by the Driver Safety Research office of the Maryland MVA. In contrast, the functional screening measures were administered to the Medical Referral sample by MVA employees designated as "driver license examiners" by the organization. The training provided to each set of data collectors is described below.

First, ten employees were selected to perform data collection for the License Renewal sample. These prospective screeners were chosen based on the following criteria: they were judged by their supervisors to be highly motivated; and, they expressed interested in participating in the project. It was explained by their supervisors that, if selected, this would become a regular duty for 3 of their 5 days of work each week for the duration of the study. The Principal Investigator requested individuals with good "people skills;" however, less than half were involved in a current position that involved interaction with the public, with only two serving as counter staff. All personnel selected were full-time employees at the MVA.

The candidate test administrators were trained by project staff in a group setting, over a 2-day period in November 1998. During the first day, an overview of the project was provided by the Chief of the Maryland Medical Advisory Board (MAB). Next, a videotape produced by project staff was shown. The videotape showed a 10-minute functional screening protocol being conducted, and then broke each test down into segments to further describe materials needed, script to be used to deliver instructions, proper procedures for conducting the test, and scoring procedures. During the second day, screeners were paired to practice the functional screening procedures on each other. Project staff provided constructive criticism with encouragement to perform all included measures in a consistent and uniform manner, as per the instructions delivered earlier.

Test administrators were observed in their field test sites during the first two days of actual data collection, to provide one-on-one, hands-on training to ensure that the procedures were conducted in accordance with the required protocol. The functional screening materials distributed to each field office contained a videotape showing how each procedure should be conducted and scored, as well as an instruction sheet containing the test set up, the script, and scoring instructions that each test administrator was to follow exactly.

Random, periodic visits were conducted during subsequent weeks to monitor data collection procedures. Some variability between test administrators in the conduct of the screening measures was observed during these visits, and one procedure in particular showed variability from one test to the next by the same administrators. Accordingly, refresher training sessions were conducted in March 1999, at each test site, to reinforce the standardization of procedures used during screening, and to introduce a change in the problematic procedure that was successful in eliminating within-screener variability in test administration technique.

When screening for the Residential Community sample was begun in July 1999, it was determined by MVA officials that a subset of the test administrators performing screening for the License Renewal sample would also conduct these procedures. Thus, a brief period of familiarization with the new setting was required, to adapt procedures previously performed in a small, private room to the test stations separated by dividers in the large, activity room provided for this purpose by Leisure World. No additional training specific to the materials, instructions, administration or scoring of the functional measures was provided, however.

Project staff, in consultation with MVA officials, reviewed the performance of the line personnel at the conclusion of data collection for the License Renewal and Residential Community samples. At this time an issue was raised as to whether better accuracy and consistency in test administration could be achieved by employees already experienced in driver evaluation activities. A decision was made to conduct data collection for the Medical Referral sample—which followed the other samples—using driver license examiners at the MVA, to inform project conclusions regarding not only the effectiveness but also the cost and feasibility of alternate staffing approaches to implement a screening program. The training provided to the MVA driver license examiners participating in the pilot study is described below.

Functional screening for the Medical Referral sample was performed by driver license examiners in all 11 full-service Maryland MVA field offices identified earlier (see figure 1). These individuals were MVA personnel who otherwise conduct closed-course and on-road driving exams in Maryland. In September 2000, full-day training sessions were conducted for 2 groups of 15 examiners in the Glen Burnie headquarters office, one session for each group on successive days. In this training format, the morning consisted of an overview of the project's history and goals, and an orientation to functional abilities as they relate to safe driving ability. Based on feedback provided to project staff, such background information aids test administrators when they must explain the relevance of the screens to inquiring drivers, while also providing justification for their efforts to the examiners, themselves. Concluding the morning segment, a 10-minute videotape produced for the project was shown. Introduced by the MAB Chief, the tape showed a demonstration of the functional screening protocol being conducted on a fit older person by a project staff member also serving as the trainer. This individual then demonstrated the full battery of screening measures on one examiner, breaking down each procedure into its specific components: set-up, materials needed, exact script to use in delivering instructions, and how to score driver performance.

The afternoon segment of the training provided to the driver license examiners was devoted to one-on-one training, practice, and feedback. Examiners paired off in groups of two, allowing one examiner to practice administering the test to the other, with observation and feedback by the trainer.

After this group of driver license examiners returned to their respective field office locations, the trainer made a site visit to each office. During this visit a half-day, follow-up training session was conducted for the 2-3 individuals serving as test administrators at that site.

CHAPTER 3: PILOT STUDY DATA COLLECTION

The measures obtained during the Maryland Pilot Older Driver Study included low-cost "first-tier" indicators of functional status; selected computer-based tests offering potentially greater specificity and/or more objective and standardizable measurement capabilities; and questionnaire responses describing (self-reported) driving habits and health problems of study participants. The materials and procedures involved in collecting the functional performance and questionnaire data for the identified study samples are described below. Key driving abilities associated with each included measure are also noted.

FUNCTIONAL SCREENING MEASURES AND SCREENING PROCEDURES

The pilot study was designed to examine the validity and evaluate the administrative feasibility of measuring functional status as a driver screening and evaluation program activity. Thus, multiple criteria were applied in defining a battery of candidate measures of perceptual-cognitive and physical functions important for safe driving. These included brevity; low cost; and the ability to be administered by either professionals or volunteers, with limited training, in diverse settings; plus an expectation that the selected procedures would be the most valid indicators of gross changes in functional status for key driving abilities, based on a synthesis of prior research.

The goal of assembling a battery of *gross* indicators of functional ability deserves emphasis. There was a very explicit recognition that the selected measures could lack the sensitivity and specificity claimed by more sophisticated tests administered by specialists under controlled conditions. But the need in this research to identify the most scientifically valid *and* practical tools for program administrators was paramount; these considerations jointly served as the defining attributes of the gross impairments screening (GRIMPS) battery applied in the Maryland effort.

The GRIMPS battery included five perceptual-cognitive and four physical abilities measures, as described in the following pages. As an adjunct to the GRIMPS battery, one component of the Useful Field of View test protocol was included in the pilot study, under the sponsorship of the National Institute on Aging.[1] To conform to the time-of-testing limitations associated in this research with "first-tier" screening, the full protocol (see page 21)—which can require 20 minutes or more to complete—was abbreviated to provide the type of functional assessment deemed most valuable in the context of this study.[2] Briefly, the Useful Field of View Subtest 2 was used; this subtest, instead of examining differences in the size of drivers' area of visual attention, measured the peripheral target duration required for correct detection by a driver, at a single angle of eccentricity. This procedure is described in more detail below.

Perceptual-Cognitive Measures

Five tests were chosen to measure perceptual-cognitive abilities: the Motor-Free Visual Perception Test (Visual Closure subtest); Delayed Recall; a Scan Chart test to detect visual

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[1] Provided for use in the Maryland Pilot Older Driver Study by the Roybal Center for Applied Gerontology at the University of Alabama at Birmingham, in collaboration with Western Kentucky University.

[2] As *per* Dr. Karlene Ball, Director, Roybal Center for Applied Gerontology.

neglect; the Trail-Making test (Part B); and a PC-based variant of the Trails B procedure using a dynamic traffic scene instead of a blank background.

First, the Visual Closure subtest of the Motor-Free Visual Perception Test (MVPT/VC), was used to detect poor visual pattern perception and as a measure of the ability to visualize missing information. The MVPT is a multiple-choice test that measures a person's ability to visualize incomplete figures when only fragments are presented (Colarusso and Hammil, 1972). This ability is important to the driving task, insofar as drivers must recognize a sign or other traffic control device that is only partly visible, or quickly perceive the safety threat represented by a vehicle or pedestrian that is partially obstructed (e.g., by a building or parked car) at the side of the road, and may be about to move into the driver's path.

The MVPT stimulus booklet for the Visual Closure practice item and Visual Closure stimulus items 22 through 32 are required to administer this test. To begin, the test administrator shows the examinee an example containing a practice figure and four alternative figure fragments (see figure 2). He/she points to the four alternative figures, saying, "*If you finished drawing these figures, which one would look just like the one above? Please point to the correct alternative.*" After the examinee responds, the examiner points to the correct alternative, then to the stimulus figure, saying, "*Yes (No), if we added these lines, this one would look just like this.*" Then the examiner proceeds to the actual test items stating "*Now I'd like you to do the same thing for the figures I'm about to show you.*"

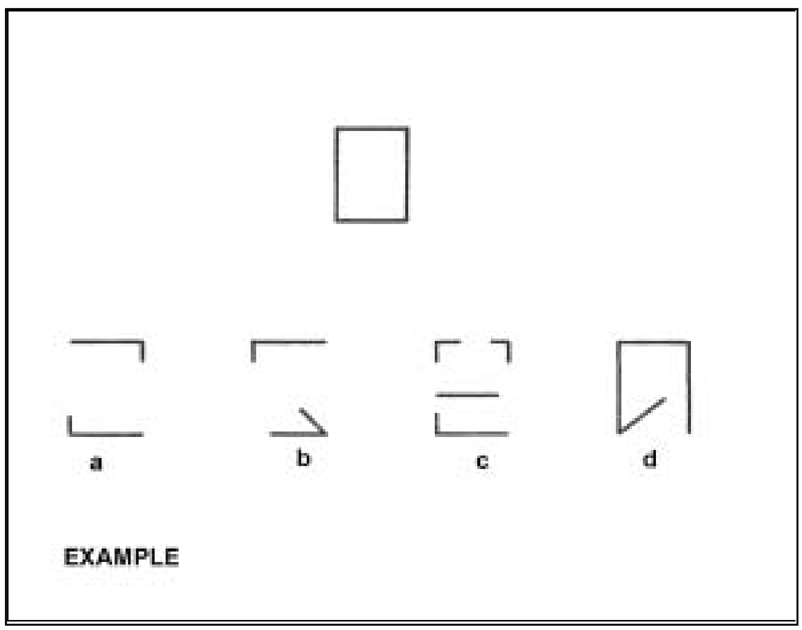

Figure 2. Practice item for MVPT/VC showing target stimulus and four response alternatives.

The MVPT/VC test includes eleven test items, each showing a target figure above four alternatives as in the example in figure 2. The only response required from the examinee is that he or she *point* to whichever one of four alternatives is correct. The examinee is not allowed to trace any figures. The test administrator encourages the examinee to look at all four alternatives before making a final decision. This is not a timed test, and the examinee must be given a reasonable amount of time (about 15 or 20 seconds) to answer each test item. No confirmation or feedback was given for the examinee's responses. The test administrator scores the responses by marking the appropriate space on an accompanying scoring sheet, then presents the next item, until all eleven responses have been obtained. At the conclusion of the test, the test administrator records the total number of incorrect responses given by the examinee. This procedure was designed to be completed by most examinees within 3 minutes.

The Delayed Recall test, from the Mini-Mental Status Examination (Folstein, Folstein, and McHugh, 1975), was used in GRIMPS as a measure of working memory. Working memory is important to safe driving because it allows a driver to recognize and remember the meaning of traffic control devices and roadway features; to remember and apply rules of the road and safe driving practices; and to perform navigational tasks that require the sequential recall of route-following instructions while actively searching for navigational cues and meeting moment-to-moment demands for hazard detection and vehicle control.

In performing this brief (~30 sec) test, the examinee was required to repeat back as many of a probe set of three words presented earlier in the Cued Recall test as possible, when requested by the test administrator. As per MMSE procedures, the Cued-Recall test was used to confirm understanding of the 3-word probe set that the examinee was required to remember for later recall. The probe set ('bed', 'apple', 'shoe,' or one of three equivalent alternative word sets) was initially presented by the test administrator, who stated, *"I'm going to say 3 short words now as a memory test. Please repeat them back to me."* If the examinee could not repeat all 3 words, they were presented again, up to a maximum of 6 times. After successful repetition by the examinee, the test administrator said, *"I will ask you again later to remember these same 3 words and say them to me."* Delayed Recall was measured, approximately 10 minutes later after a number of intervening procedures in the test battery had been completed, by asking the examinee to recall same memory (probe) set repeated earlier. Performance was scored as the number of items recalled correctly.

The Scan Chart test developed for this project was based on the Brain Injury Visual Assessment Battery for Adults (BiVABA) ScanBoard (Warren, 1990), following the recommendation by an Occupational Therapist and Certified Driving Rehabilitation Specialist (OT/CDRS) active in the MRC that a screening procedure was needed to rule out neglect of one side of the visual field (hemianopia) while driving. This is a deficit associated with recovering stroke/cerebral vascular accidents (CVA's). The research literature also documents driving impairment resulting from age-related effects combined with the effects of visual field losses in older patients with CVA's (Szlyk, Brigell and Seiple, 1993).

The Scan Chart developed for GRIMPS measured 140 cm by 22 cm (55 in by 8.5 in), and contained 10 common symbols arranged in 2 rows of 5 columns each (see figure 3). With the chart held at eye level, one arm length in front of the examinee by the test administrator, the examinee must identify each shape without turning his or her head (i.e., scanning is accomplished by eye movement only). Specifically, the test administrator stated, "*Without moving your head, scan the chart and identify each shape you see. Please name all the shapes you see in any order that you wish.*" The examinee's verbal report indicates a normal scanning

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Figure 3. Scan Chart developed for GRIMPS.

pattern vs. hemi-neglect. A normal scan pattern of a cognitively-intact individual may be any of three: (1) rectilinear (left to right/top to bottom); (2) clockwise; or (3) counterclockwise. Drivers with impaired scanning capabilities demonstrate disorganized, random and/or abbreviated or truncated strategies. Those with hemi-neglect often show an asymmetrical pattern, initiating visual search from the right side rather than the left and confining all search efforts to the right side. Also, whereas intact persons do not overlook or repeat a stimulus on this test, those with impaired scanning abilities may commit both of these errors. The test administrator scored performance as normal, versus erratic (haphazard pattern) or neglect (two or more shapes ignored) on this procedure. Administration time for the Scan Chart test was gauged at under one minute.

The Trail-making test, Part B, was used to measure participants' abilities to perform a directed visual search and to divide attention effectively (Reitan, 1958). This is a continuous demand when navigating a route in the information-rich, visually complex driving environments common to cities and suburbs. As per clinical applications of this procedure, Part A was administered first; as described below, this afforded examinees practice on the aspect of the test devoted to directed search for an ordered sequence of test stimuli, before introducing the divided attention aspect of the test.

Specifically, in the Trail-making test the examinee uses a pencil to connect a sequence of numbers (integers) or a mix of numbers and letters, printed on a blank piece of paper, in ascending order as quickly as possible. Part A of the test contains only numbers; Part B contains numbers and letters that must be connected in an alternating fashion. Performance is timed. If an error is made during the test, it is pointed out by the test administrator, who instructs the examinee to continue with the test from the last correct connection. The clock does not stop during error correction. In both Part A and Part B, the time-to-complete all items is the examinee's score, measured to the nearest second. Only Part B was scored for GRIMPS. Longer times connote poorer performance on this test; the maximum value scored for this procedure was 6 minutes, at which point the test was discontinued.

As applied in GRIMPS, Part A was abbreviated to contain only the numbers 1-8 instead of 1-25 as used in clinical applications. This shortened the test administration time while still providing examinees some understanding of what they would be expected to do in the Trails B procedure. First, examinees received the following instructions for the (abbreviated) Trails A procedure: *"Now I will give you paper and pencil. On the paper are the numbers 1 through 8, scattered across the page. Starting with 1, use the pencil to draw a line to connect each number to the next higher number. I will time how fast you can do this. Ready? Go."* After this was completed, the examiner placed a practice version of Trails B containing only four numbers and four letters in front of the examinee and said, *"Now you will do the same thing, only this time with numbers and letters, like you see in this example. This time, start with 1, then draw a line to A, then continue the line to 2, then to B, then 3-C, 4-D, alternating back and forth between numbers and letters."* This practice was not timed. After pointing out any errors and insuring that the examinee understood the test requirement, the test administrator said: *"On the other side of this sheet of paper the numbers 1 through 13 and the letters A through L are mixed up in the same way. Starting with the number 1, draw a continuous line that alternates between numbers and letters, until you finish with the number 13. I will time how fast you can do this."* The test sheet was then turned over, and the test administrator said, *"Ready? Go,"* while directing the examinee to place his/her pencil at the starting point (number 1). The Trails B test sheet is shown in figure 4. The planned duration to provide instructions and to conduct the abbreviated Trails A procedure, the Trails B practice exercise and the actual Trails B screening measure, together was 5 to 6 minutes.

A variant of the Trails B procedure was developed for GRIMPS to further increase the divided attention demands of the test. This "Dynamic Trails" procedure used a PC to present a similar mix of numbers and letters, but they were overlaid on a background that showed moving traffic, versus the blank background used in the paper-and-pencil version of the test. The dynamic traffic scene was stored on the hard drive of the computer as an MPEG file. Examinees' responses were registered on a touch screen using a light pen. If an error was made, an audible buzz sounded, and the computer prompted the examinee to return to the last correct letter or number in the sequence, which was identified for the examinee. This protocol was designed to remove an element of subjectivity in the way instructions are delivered and errors are corrected by test administrators.

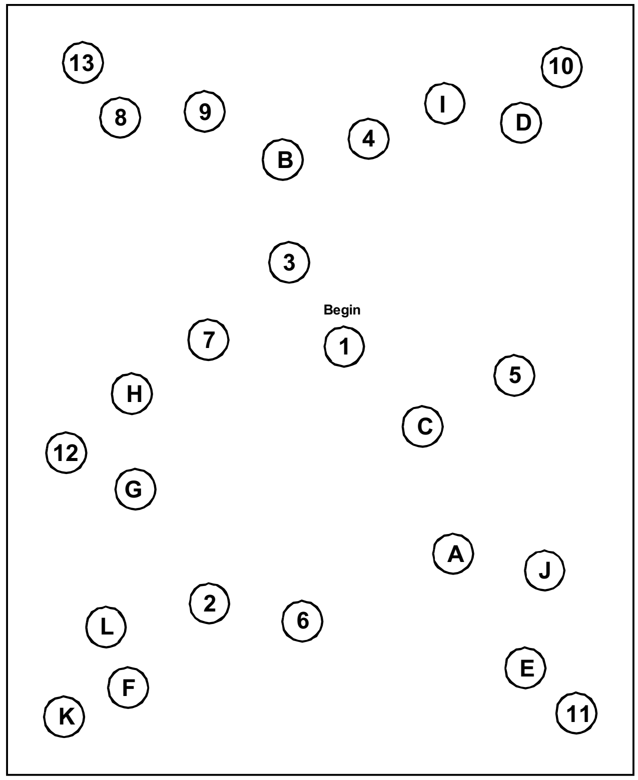

Figure 4. Test sheet used to administer the Trail-making test, Part B. (cf.Reitan, 1958).

A shorter set of test stimuli was used for the Dynamic Trails procedure, containing only the numbers 1-7 and the letters A-G. This reduced the anticipated test duration to under 3 minutes. A data file of the examinee's performance was generated which included the time-to-complete, as well as the exact time of every response during the test (including error responses); plus identifying information entered by the test administrator.

The final perceptual-cognitive measure applied to collect functional status information in the Maryland Pilot Older Driver Study was subtest 2 of the Useful Field of View battery that has been shown through prior research to be significantly related to crash involvement (Owsley, Ball, Sloane, Roenker, and Bruni, 1991; Owsley, Ball, McGwin, Sloane, Roenker, White, and Overley, 1998). Aspects of visual attention addressed by this procedure include the detection, localization and identification of suprathreshold targets in complex displays. Using a PC-based test apparatus that displays central and peripheral targets within a 35-degree radius visual field, three variables can be manipulated—target presentation duration, the competing attentional demands of the central and peripheral detection tasks, and the salience of the peripheral targets.

The complete Useful Field of View protocol includes three subtests that, together, provide a measure of the percentage reduction of the maximum 35-degree radius field. An abbreviated version of the first subtest, which measures processing speed capability and vigilance, was used as practice for the second subtask, which measures divided attention capabilities; this was the specific measure of interest for this study. During the practice, examinees were required to identify a centrally-located object which varied in duration, by pressing an icon of a truck or a car (whichever was presented) on the touch-screen display, after the target was presented. Subtest 2 required this same identification; but in addition, the examinee was required to locate a simultaneously-presented peripheral target of varying eccentricity (these could appear in eight locations, spaced near the edge of the computer screen every 45 degrees around the central target) as quickly as possible. The response format for subtest 2 is presented in figure 5. Subtest 3 was not used in this research. Differences in response latency measured via a touch screen for targets presented in a visual field of constant size was therefore the dependent variable acquired in the Maryland research, not differences in the size of drivers' "useful field of view" *per se*.

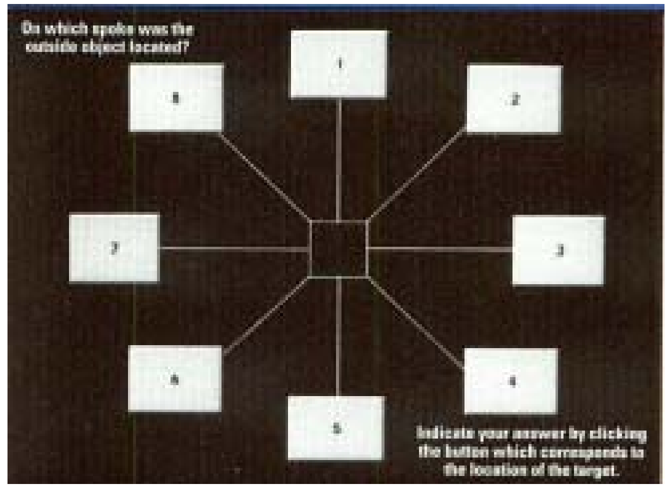

Figure 5. Response format for the Useful Field of View subtest 2.

Examinees used a light pen to identify central targets and to locate peripheral targets. They were given a chance to practice with the device before being tested—an important control to minimize differences between drivers on Subtest 2 due to a "practice effect." The instructions for the example exercise were as follows: "*For this test, you will see an object—either a car or a truck—inside of the box in the middle of the screen. The object will stay on for a short period of time and then disappear. You will need to decide whether it was a car or a truck and then touch the light pen on the car or truck icon on your screen in the answer section."* After the examinee completed the practice session, he/she was given the opportunity for more practice or to begin the test. The instructions for Subtest 2 were as follows: *"The car or truck icon will again be presented in the middle of the screen, and will disappear. After the object disappears you will see another object presented on one of the 8 spokes radiating from the center of the screen. You will need to identify whether the object in the center was a car or a truck, by touching your answer with the light pen, and then touch the light pen to the location where the second object was presented on one of the 8 spokes."* The length of the display varied in duration, depending upon performance; it was adjusted until a 75% correct threshold was attained. Accordingly, the examinee's score which was the briefest duration of peripheral target presentation that could be correctly identified, in milliseconds; this measure was recorded to a data file by the computer. It was anticipated that the instructions, practice, and completion of Subtest 2 as described above could be accomplished in approximately 5 minutes.

Physical Measures

Measures of physical ability incorporated into GRIMPS included tests of lower limb strength, endurance, and coordination; and upper body flexibility. These procedures, as they were administered in the Maryland Pilot Older Driver Study, are described below.

Leg strength, endurance, and coordination were measured using two different but related procedures: the Rapid Pace Walk and the Foot Tap tests. Each procedure was designed to be completed in less than 1 minute. The physical abilities targeted in these tests were those needed to sustain pedal control without fatigue and to quickly and accurately shift back and forth from the accelerator to the brake pedal when circumstances demand it. Also, a gait that is slowed significantly could be indicative of a higher risk of falling, which is related to crash risk as well (Marottoli, Cooney, Wagner, Doucette, and Tinetti, 1994).

For the Rapid Pace Walk, an examinee walked along a 3-m (10-ft) path marked with tape on the floor then returned along the same path to starting point, as quickly as possible. The instructions to the examinee were as follows: "*I want you to walk along the side of this tape line to the end, turn around, and walk back here <u>as quickly as you can</u>.*" The test administrator demonstrated the walk and path, then said: *"I am going to time you. Go as fast as you feel safe and comfortable. If you use a cane or walker, you may use it if you feel more comfortable. Ready, begin*." Timing started when the examinee picked up the first foot, and stopped when the last foot reached start/finish point. The total time to traverse the 3-m (10-ft) path up and back (total of 6 m [20 ft] walked) was manually recorded by the test administrator, using a stopwatch.

For the Foot Tap test, a 75-mm (3-in) binder was used. The open binder was placed on the floor in front of a chair, where the examinee was sitting, oriented such that the rings were crosswise in front of the examinee, and such that the examinee could place his/her foot flat on the floor beside the rings while seated in the chair with the (right) foot extended slightly forward of the knee. The examinee was instructed: "*Please place your feet on each side of this binder. Now move your left foot under the chair so it will be out of the way."* The test administrator then tapped across the rings, alternately touching the floor on each side, as an example, while continuing with the following instructions: "*When I say go, move your right foot back and forth, lifting it over the rings, alternately tapping the floor on each side of the binder. Tap each side five times for a total of 10 taps. I will time how quickly you can do this. Ready? Go."* The test administrator manually recorded the time to complete the foot tapping task with a stopwatch.

To measure upper body flexibility, the GRIMPS battery included an Arm Reach and a Head-Neck Rotation test. Each procedure was designed to be completed in less than 1 minute. Upper body flexibility is needed to turn the steering wheel quickly in an emergency, and to look to the sides and over the shoulder to the rear to check for approaching traffic when merging and changing lanes.

For the Arm Reach test, an examinee was asked to raise each arm as high as possible over his/her head. To pass, the arm had to be raised so that the elbow was above shoulder height. Instructions for this procedure were as follows: *"Please raise your right arm as high as you can over your head. You may put your arm down... Now please raise your left arm as high as you can over your head."* The test administrator recorded "pass" and "fail" scores manually, for each arm.

For the Head Neck Rotation test, the examinee sat in a chair equipped with a seat belt; this restricted his/her ability to pivot at the waist to look to the rear instead of turning the head, neck, and upper torso, as required when driving. The test administrator checked the seat belt to insure that it was tightly fastened, then moved to a position 3 m (10 ft) behind the examinee at a pre-marked location and held up a cardboard clock face with the hands set to either the 3:00 or 9:00 position. The instructions to the examinee were as follows: *"Just as you would turn your head and upper body to look behind you to back your car or change lanes, please turn and read* *the time on the clock face I am holding behind you."* If the examinee could not turn far enough in one direction to read the clock, he/she was asked to try turning the other way. The test was scored as a "pass" if the examinee could read the clock. The test administrator manually recorded the "pass" or "fail" outcome.

MOBILITY QUESTIONNAIRE

Self-report data describing driving habits and providing categorical estimates of the level of driving exposure were obtained for the study samples in the Maryland Pilot Older Driver Study using a "mobility questionnaire." The Mobility Questionnaire sought information about avoidance of specific driving situations, plus mobility-related health issues such as falls, or difficulty in walking or in climbing stairs, that have been correlated with crashes in previous research (Sims, Owsley, Allman, Ball, and Smoot, 1998; Koepsell, Wolf, McCloskey, Buchner, Louie, Wagner, and Thompson, 1994; Marottoli, Cooney, Wagner, Doucette, and Tinetti, 1994). The data collection instrument is shown in figure 6.

The intent behind the development and application of the Mobility Questionnaire was to characterize the study samples in terms of their self-imposed limitations in the amount of miles driven, and/or in the situations they choose to drive, and if possible, to identify relationships between such self-regulating behaviors and the indicators of functional status and the safety measures obtained in the pilot study. Notwithstanding inherent problems with the precision and reliability of self-report data, the responses of the older drivers to the questionnaire items could provide valuable insight into the extent to which safety problems linked to functional decline might be mitigated by self-regulation.

The Mobility Questionnaire was administered after completion of the functional testing battery for the License Renewal and Medical Referral samples, and either before or after functional testing for the Residential Community sample depending upon whether participants in this study group had to wait to be screened. Responses were recorded on the paper form shown in figure 6, then were entered into a spreadsheet program for later analysis.

"I want to ask some questions about your driving habits, but first, I need to get some general information about you."

NOT FOR MARYLAND MVA USE
First Name:____________________________ **Middle Initial:** ______ **Last Name:** ______________________________

Gender: ____(1) Male _____(2) Female **Date of Birth (YYYY, MM, DD):** ______________________________

Race:
____(1) African-American
____(2) American Indian
____(3) Asian
____(4) Caucasian
____(5) Hispanic
____(6) Other

Driver's License Number: ____________________________

Employment Status:
____(1) Unemployed
____(2) Working Part Time
____(3) Working Full Time
____(4) Retired

"Now, I have some questions about how much you drive."

1.How many days per week do you normally drive? (circle one). 1 2 3 4 5 6 7

2.How many total miles do you drive in a normal week? ________

3.About how many miles per year do you drive? (circle one)

less than 1,000	1,001 to 2,500	2,501 to 5,000	5,001 to 7,500	7,501 to 10,000	10,001 to 12,500	12,501 to 15,000	15,001 to 17,500	17,501 to 20,000	20,001 to 25,000	25,001 to 30,000	30,001 or more
______	______	______	______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9	10	11	12

"These next questions are about when and where you drive. Answer these questions based upon your driving habits within the last 3 months. I want you to respond to each question with one of these answers: 'Always, Usually, Sometimes, Rarely, Never.'"

(Present the driver with the card that lists the response choices. For each statement, circle the number below the chosen frequency estimate.)

	Always	Usually	Sometimes	Rarely	Never
4a. Do you avoid driving at night?	5	4	3	2	1
4b. Do you avoid making left turns across oncoming traffic?	5	4	3	2	1
4c. Do you avoid driving in bad weather (rain, snow, fog, etc.?)	5	4	3	2	1
4d. Do you avoid driving on high-traffic roads?	5	4	3	2	1
4e. Do you avoid driving in unfamiliar areas?	5	4	3	2	1
4f. Do you pass up opportunities to go shopping, visit friends, etc., because of concerns about driving?	5	4	3	2	1

"The last set of questions addresses various health issues, plus habits and preferences that may have a bearing on how well your transportation needs are met."

5. Have you fallen to the floor or ground in the past 3 years? ____ (1) yes ____(0) no
(NOTE: A trip or stumble doesn't count)

6. Would you have difficulty walking one block or climbing one flight of stairs? ____ (1) yes ____(0) no

Figure 6. Mobility questionnaire.

CHAPTER 4: PILOT STUDY DATA ANALYSIS AND RESULTS

The findings of the Maryland Pilot Older Driver Study are presented in this section, including data analysis summary tables, graphs and figures, and statistical test results. Additional detail, typically in the form of raw data tables, is deferred to report appendixes.

Separate subsections are devoted to each of the following analysis topics:

- Extracting and filtering Motor Vehicle Administration (MVA) safety data to create a primary database for analyses relating drivers' functional status to crashes and convictions, and determining the period of time—relative to each individual's test date—during which driving history variables should be analyzed.
- Describing the distributions of functional status measures for each screening procedure, for each study sample.
- Describing the study samples in terms of how much they drive and their propensity for self-regulation of their driving behavior, based on subjective responses to the Mobility Questionnaire, while examining the reliability of these self-reports and their variability with respect to key safety outcomes.
- Describing and testing the strength of the association between crash involvement and functional status, measured with the various included screening procedures.
- Describing and testing the strength of the associations between convictions and functional status, measured with the various included screening procedures.

At the end of this section, information bearing on the feasibility of test administration is summarized, including an account of time and resources committed by Maryland MVA staff during the pilot study, and research team observations concerning difficulties encountered during data collection.

EXTRACTING MOTOR VEHICLE ADMINISTRATION SAFETY DATA

This section of the report identifies the sources of crash and (moving) violation data that served as the primary safety outcome measures, and the steps involved in creating analysis files to describe frequency distributions of these events and to test the strength of their relationships with functional status as measured by the screening procedures applied during the pilot study.

Creation of Primary Analysis Database

Primary data collection and database design was performed by staff at the MVA. The process of obtaining driver records began with the development of a master list of "Soundex" numbers; this is the Maryland driver's license number. The Soundex for each subject was acquired at the time of screening and keypunched into a local database along with screening results. The Soundexes from that compilation were first submitted to an MVA cross-reference table to identify any that may have changed since screening. Since the first character in the Soundex is derived from the driver's last name, an individual's Soundex changes whenever he/she changes his or her name. Further, after the initial request was made for unique Soundexes in the Maryland state database, the local database was periodically updated with the current Soundex to maintain up-to-date crash and conviction records.

Conviction records were extracted from the Maryland Motor Vehicle Production Database which is the principal data repository for the licensing agency. The updated Soundex list was submitted to the MVA Production Database to determine which Soundexes were valid. When Soundexes as recorded in the local database were determined to be invalid, an individual review of the driver's record was made to correct the numbers used for tracking the individual. A unique list of updated and valid Soundexes was then resubmitted to the MVA Production Database for data extraction.

Crash records were extracted from the Maryland Automated Accident Reporting System (MAARS) Database. MAARS originates as a paper crash report submitted to the Maryland State Police by any one of the more than 125 police jurisdictions within the State of Maryland. The contents of the paper report that can be stored in a database are keypunched by a unit of the State Police. A copy of the MAARS data is supplied to the Maryland State Highway Administration (SHA) where the location of the crash is edited to provide a reference to the highway system. MVA submits requests to SHA to make extractions.

The validity of the Soundex number for study participants was paramount, as this was the linking variable between databases containing the analysis outcomes of primary interest in this research. Where questions existed about the validity of an individual Soundex, all available evidence pertaining to that individual subject was reviewed to confirm/correct the Soundex. Validity for the License Renewal sample—most critical because it was the source of data for analyses relating driver functional status to safety outcomes—was assessed by comparing Test Date to Issue Date, along with date of birth and gender.

The analyses addressing functional status and safety, as noted earlier, were based upon data acquired from the License Renewal sample. These data were manually recorded for the most part, but also included measures derived from automated test procedures administered on a PC. Manually recorded screening data were typically entered locally at each test location from paper records, and stored centrally through the same network connection. Data products from automated screens were stored both locally and centrally through a network connection for each test device.

Some aspects of compiling the analysis database differed among the samples. For the Medical Referral sample, data collected manually at MVA offices around the state were sent to MVA headquarters, where they were keypunched centrally into MS Access tables by agency staff. In addition, the Medical Referral database included separate entries for one of its outcome measures—the determination of driving fitness by the examining physician (Daily Duty Doctor). Normally, during the MAB review process this determination is based solely upon driving history and medical history information, But in this study, the added effect of access to functional screening data—if any—was evaluated. The first entry by the examining physician was therefore made before functional data from the screening measures were revealed; the second was made *after* this information became available to the physician. This permitted later analysis of how functional screening data may influence a Medical Advisory Board's decision-making process.

Once data were entered into Access tables for all samples—License Renewal, Medical Referral, and Residential Community—the MVA sent out preliminary versions for review by research team members. This review identified errors and other needs for changes by MVA to facilitate subsequent analyses. A final version of the database was then assigned a version number and sent to members of the research team for analysis. Version numbers were critical in this process because crash and conviction information must be regularly updated. The interval between crash and conviction updates for the study samples coincides with other modifications to the subject databases or a specific request by users of the data system.

Initial Data Processing

Additional steps were involved after the project database was received from MVA, before planned analyses could proceed. Generally, data were imported into Access as text and converted to numerical, date, or logical (yes/no) format as appropriate. Since Access permits conversion to a more suitable format at almost any time, data were maintained in their original format until the final table of to-be-analyzed data was created. Original data tables as received from MVA were not altered during this process.

Initial data processing was performed using Microsoft Access 97. The Access tables were first linked together using the Soundex numbers as the key variable for each driver in the database. See appendix C for Access data structure and variables. Variables were selected from the Access tables and some variables were recoded prior to creating a rectangular file for analysis, i.e., where each row contains all data for one driver.

At this stage of processing, filters were applied to the exhaustive records for each driver in the MVA database to: (1) exclude crash events associated with the use of alcohol; and (2) restrict the observation period during which crash and conviction data would be compiled for each driver to test relationships with functional status indicators obtained during screening. In the first instance, filtering was justified because of a desire to—within the limits of the data quality afforded by State police reports—identify incidents where fault could be attributed specifically to a measured decline in functional ability. While alcohol use by a crashing driver does not rule out negligence or performance failure due to functional decline, of course, the confounding of these factors makes it impossible to reliably assess their relative contributions.

Next, within the domain of crash incidents *without* any indication of alcohol involvement, additional sorting was performed according to MVA system codes that distinguish crashes where fault has been assigned from crashes where fault is unknown in the judgment of the investigating officer. It is likely that in at least some instances where fault status was coded as "unknown," the driver was at fault[1]; single-vehicle, run-off-road crashes are sometimes coded in this category. Finally, a third crash category connoting an even lower probability of fault may also be inferred,

[1] *Pers. comm.*, Mr. Jack Joyce, Driver Safety Research Office, Maryland Motor Vehicle Administration, January 8, 2002, conversation with the Principal Investigator.

from the absence of either of these codes. The result of this sorting process was to define three levels of (non-alcohol-related) crash involvement as primary safety outcomes in this research: *(1) at-fault crashes; (2) crashes where fault was assigned or where an "unknown" code was assigned;* and *(3) all crashes.* The subsequent interpretation of study results was keyed, in part, to this analytic approach.

In a related processing activity, data identifying convictions for traffic violations on each driver's record were sorted according to their judged importance in understanding the relationship between functional status and safety. First, events coded in Maryland's system as "moving" violations were separated from all other violation codes including, for example, convictions for licensing matters (hearings, suspensions), parking infractions, and so forth. Within the category of moving violations, additional sorting was performed with the intention of excluding behaviors that are not prevalent among older drivers, based on the technical literature, or that may have been included in this category due to some peculiarity of the State's coding system but hold less credibility as the potential cause of a crash. This sorting activity defined three conviction categories for the present analyses: *(1) all moving violations; (2) moving violations excluding speeding convictions;* and *(3) moving violations excluding speeding convictions and convictions for occupant restraint violations.*

The relative proportions of convictions comprising each category analyzed are displayed in figure 7. The (grouped) violation types remaining in the analyses after setting aside speeding and occupant restraint violations are also indicated.

One remaining filter that established boundaries on the to-be-analyzed dataset was the amount of time each driver's crash and violation experience was observed. There were two competing priorities in setting such boundaries—capturing as large an interval of experience as could reasonably be associated with differences in functional ability, as measured in the pilot study, and equalizing observation periods across all drivers in the (License Renewal) sample.

On the first point, choices included looking only at prospective data (crash and violation experience after each driver's date of testing) or, also including some extent of retrospective experience in the observation period; and if retrospective data were to be included, how far in the past could (differences in) drivers' functional ability reasonably be gauged by their performance on the included screening measures? In consultation with the Chief of the Maryland Medical Advisory Board[2] it was determined that one year of retrospective data would be evaluated, while duplicating selected analyses using only prospective data to look for differences in the pattern of results that might alter any of the study's conclusions. A query was subsequently written in Access to bracket each driver's screening date with one year of experience before his/her test date and as much time after the date as allowed by the final extraction of crash and violation information from the Maryland system.

[2] *Pers. comm.*, Dr. Robert Raleigh, Medical Advisory Board, Maryland Motor Vehicle Administration, November 27, 2001, conversation with the Principal Investigator.

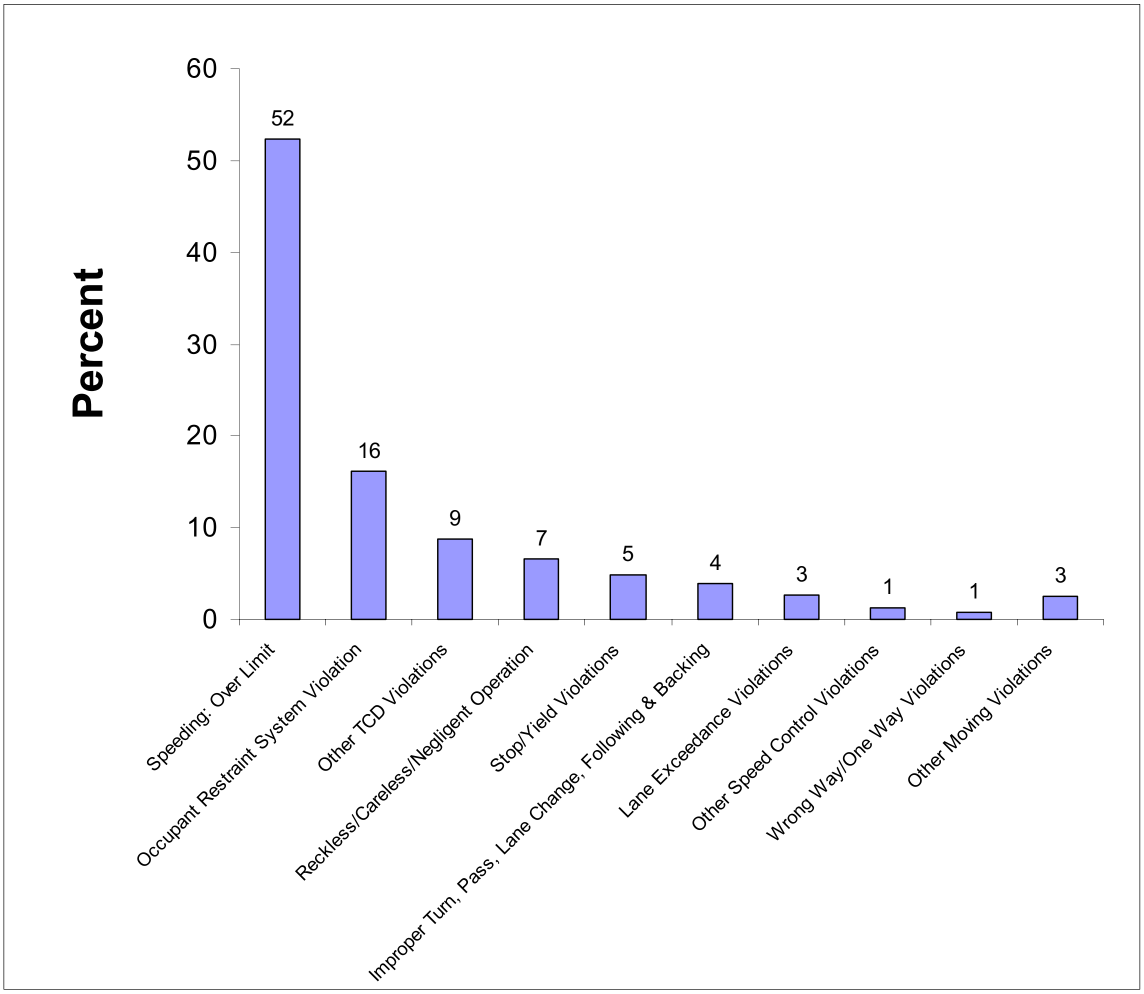

Figure 7. Categories of moving violations in Maryland database, by percent.

On the second point, it was inevitable given the period required to complete data collection procedures in this study that a longer period would be available in which to observe the experience of some drivers than others. This interval could be equalized if analyses were restricted to just the period of time following the last driver screened; but more than a year of prospective data would be disregarded for drivers tested earlier in the study with this approach, and the power of the analyses would decrease because of the reduced number of observations. The critical issue here is whether the variability in driving experience observation intervals inherent in the pilot study design is random with respect to crash-involved versus non-crash-involved populations.

In consideration of this possibility, the relative distributions of observation times for drivers in the License Renewal sample with and without crashes during the planned analysis interval were examined, at the level of "months after test date." These distributions are displayed in figure 8. The mean number of (full) months after test date for which driving experience data were available for drivers involved in crashes was 20.2, with a standard deviation of 2.6; for drivers who were *not* involved in crashes, the mean number of months after test date for which driving experience data were available was 19.9, with a standard deviation of 2.9. In other words, the observation interval was nine days longer, on average, for drivers in the crash-involved group than for drivers in the non-crash-involved group. A t-test between these means was not significant (p<.27). This outcome, and the closely overlapping distributions shown in figure 8, supported a decision to proceed with the planned analyses knowing that the interval in which the (prospective) crash and conviction data could be compiled would vary as *per* the earliest versus the latest test dates for the drivers in this sample.

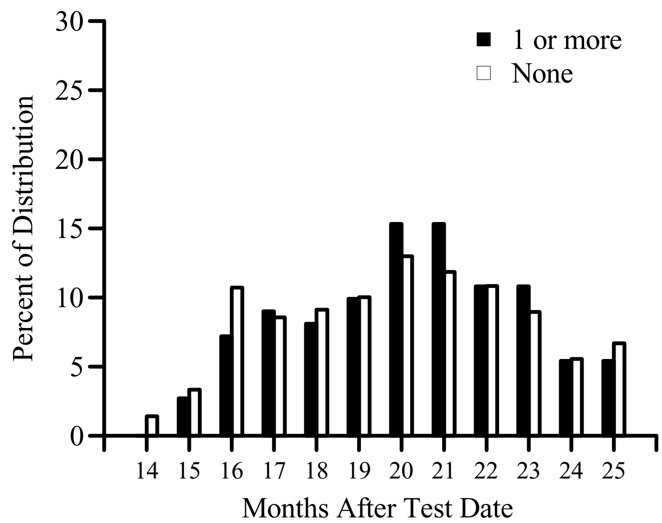

Figure 8. Lengths of observation intervals for drivers with 1 or more crashes versus no crashes.

Final Data Processing

The descriptive data summaries and analyses relating safety outcomes to functional performance were performed using SPSS SYSTAT (v. 9.01). Access tables were imported into SYSTAT using Open Database Connectivity (ODBC) Database Capture feature within SYSTAT. Once the data were successfully imported, SYSTAT was used to exclude outliers, recode variables, and create variables for analysis.

The following data filters and variable recodes were performed first *(with actual variable names provided in parentheses)*:

- Age limit *(AgeTest)*: Only drivers that were 55 or older were included in the analysis.
- Test Sample *(Sample)*: Four groups were created in the data set:
  - > 0 = Declines: These individuals declined to participate in the study when approached at license renewal.
  - > 1 = License Renewal: These individuals agreed to be tested when approached at license renewal.
  - > 2 = Residential Community: Drivers recruited at Leisure World.

> 3 = Medical Referral: Drivers referred for various reasons and by multiple sources to the Medical Advisory Board for examination.

- Rapid Pace Walk *(WalkTime)*: Times above 15 seconds were treated as missing.
- Foot Tap *(FootTap)*: Times above 15 seconds were treated as missing.
- Trails B *(TrailsB)*: Scores above 6 minutes were treated as missing.
- Dynamic Trails *(DynaSeconds)*: Outliers (individual button presses greater than 100 seconds) were treated as missing. If the number of errors for a particular button press was 3 or more, the button press was treated as missing. If the mean button RT was over 60 seconds or the number of errors was 14 or more, it was treated as missing.
- Useful Field of View *(UFOV)*: All response latencies exceeding 500 msec were recoded as 500 msec.
- Scan Test *(ScanTest)*: Erratic (2) and neglect (3) were recoded to Fail (0)
- Arm Reach *(ArmRchPF)*: Passing scores for left and right arm reach (both required) were coded as (1).
- Head/Neck Rotation *(HeadNeck)*: Passing scores were coded as (1)
- Delayed Recall *(DRIncorrect)*: The number of items recalled incorrectly was calculated from delayed recall correct (DRCorrect) scores.

In order to calculate odds ratios (O.R.s), pass/fail criteria had to be established for the performance measures, and safety outcome measures had to be recoded using a (-1) to indicate an occurrence of an adverse event (i.e., crash or conviction). As discussed in a later section, the highest O.R. for which cell counts permitted valid analyses established candidate criteria for cutoffs for the included measures.

The outcome variables *(with actual variable names provided in parentheses)* were calculated as follows:

- All Convictions *(CONVB1A3)*: Includes all moving violations 1 year before testing and up to 25 months after testing.
- All Convictions except Speeding *(CONVNSB1A3)*: Excludes speeding convictions.
- All Convictions except Speeding and Occupant Restraint *(CONVSOB1A3)*: Excludes speeding and occupant restraint convictions.
- All Crashes *(CRSHB1A3)*: Includes all crashes 1 year before testing or up to 25 months after testing, excluding alcohol-involved crashes.
- At-Fault and Unknown Fault Crashes *(CRSHB1A3UAF)*: Includes only crashes coded as "U" (unknown) or "Y" (at-fault) in the fault variable.
- At-Fault Crashes *(CRSHB1A3AF)*: Includes only crashes coded as "Y" (at-fault).

DATA ANALYSIS AND RESULTS

Functional Status Summaries for Study Samples

In this section, figures and text descriptions summarize performance on the various functional screening measures, for each study sample. Age distributions are also shown below, for review purposes.

The following pages display the percentage of the distribution that scored at each possible level of performance for each measure. This permits the performance of the License Renewal, Residential Community, and Medical Referral samples to be compared directly despite the different numbers of participants in each group. Tables containing descriptive statistics for each screening measure may be reviewed in appendix D.

Sample Age Comparison

Age distributions of study participants, separately presented for each sample in an earlier section, are contrasted below. These data provide insight into certain performance differences between groups of drivers that are apparent in the functional screening data summaries that follow. Specifically, the ages on the date of testing for each study participant are shown in figure 9 for 5-year groups beginning at age 55. As indicated, the License Renewal sample most closely approximates a normal distribution, while the Residential Community sample, and especially the Medical Referral sample, are skewed somewhat toward older ages. For means and standard deviations of these age distributions, see the earlier discussion in *Test Site and Sample Selection*.

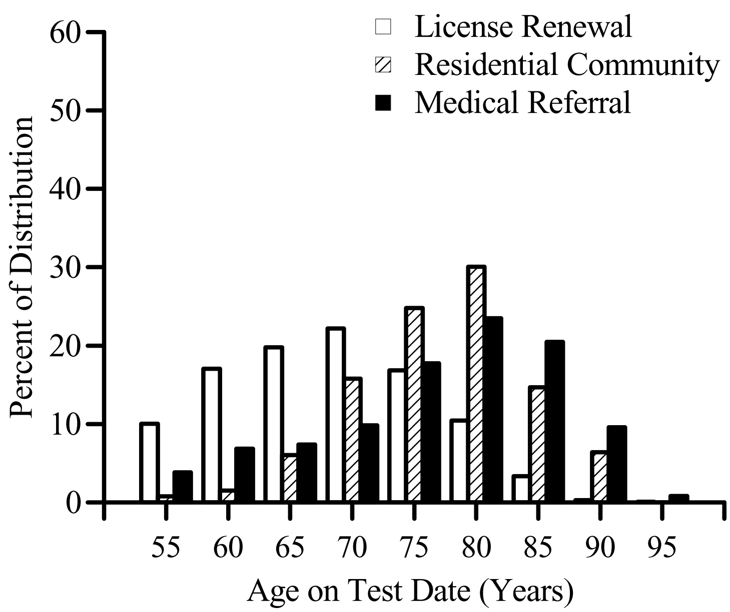

Figure 9. Age distribution by study sample.

Performance Distributions for Functional Measures

The following series of plots summarize the screening data collected for each functional measure, for each study sample: License Renewal, Residential Community, and Medical Referral. Results for the perceptual-cognitive measures are reported first, then the physical measures. To display data for all three samples within the same plot, it was necessary to use a common y-axis. Because of differences in the number of drivers in each sample, the counts within each bar were first normalized to the number of drivers. This permitted results to be displayed as a percent of the distribution scoring at each level represented on the x-axis. It should be noted that performance degrades for all measures moving toward the right along the x-axis.

Motor Free Visual Perception Test/Visual Closure Subtest (MVPT/VC). Figure 10 shows the distributions of the respective study samples on the MVPT/VC measure of perceptual-cognitive function. The horizontal axis is the number of *incorrect* responses, out of 11 trials. Descriptive statistics for this measure are presented in table 14 in appendix D.

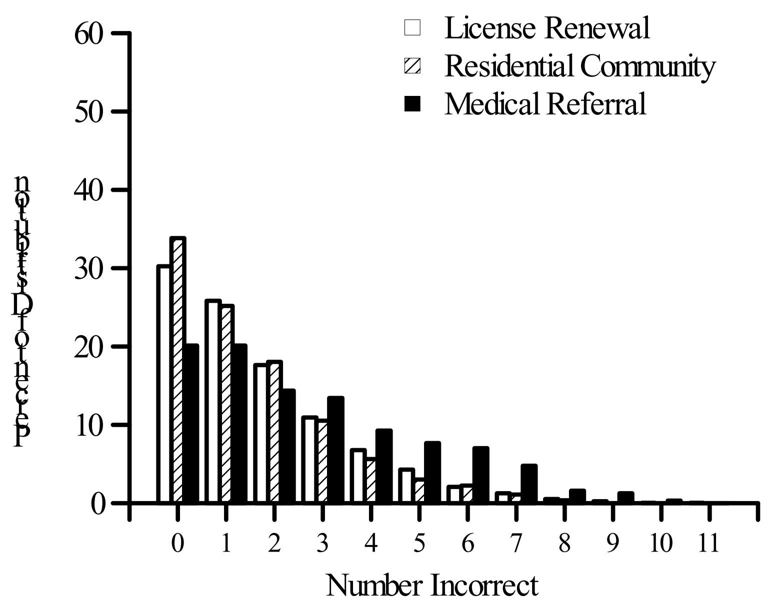

Figure 10. Performance on MVPT/VC Subtest for each study sample.

There are two noteworthy aspects of this plot. First, the Medical Referral distribution shows a higher proportion of drivers with more than 2 incorrect responses. This occurs despite the fact that the mean age for the Residential Community and the Medical Referral samples are essentially the same (only 1 year difference in mean age). Second, the drivers from the License Renewal and Residential Community performed similarly despite the fact that the mean ages of these samples were very different; (68 versus 78 years, respectively. In fact, a slightly higher percentage of drivers in the Residential Community sample had zero errors on this test than drivers in the License Renewal sample. This dissociation of age and functional performance illustrates the problems associated with the use of (chronological) age alone as a predictor of driving impairment.

Delayed Recall. Figure 11 presents the distributions for Delayed Recall, a measure of a driver's working memory obtained approximately 10 minutes after the Cued Recall procedure during which the memory probe set was repeated. Performance is measured as the number of items correctly recalled after the intervening interference period (out of 3).

The most noteworthy aspect of the results for Delayed Recall is that about 20 percent more of the drivers in the Medical Referral sample missed 2 or more items, compared to the other samples. The License Renewal and Residential Community samples performed similarly—over half of those tested in each of these samples did not miss any of the recalled words. Descriptive statistics for this measure are presented in table 15 in appendix D.

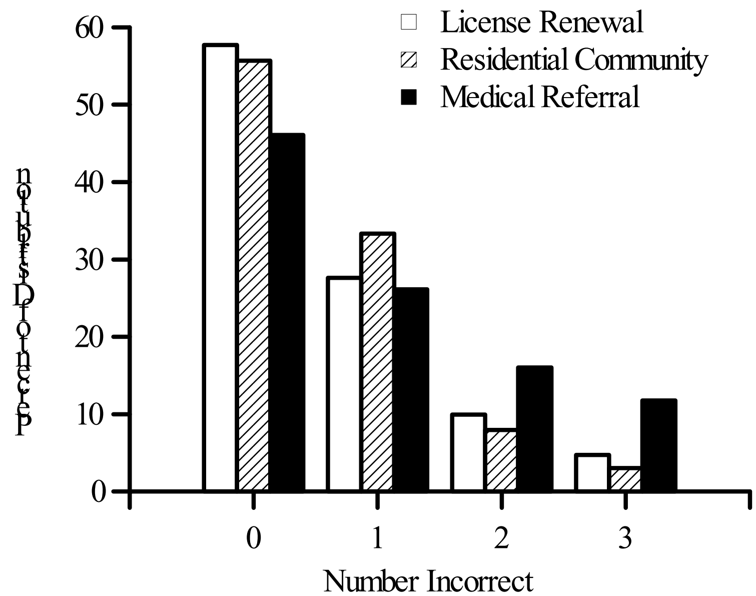

Figure 11. Performance on the Delayed Recall measure for each study sample.

Useful Field of View, Subtest 2. Figure 12 is a plot of the results for the Useful Field of View, Subtest 2. As noted earlier, this is a speed-of-processing test, with a divided attention requirement, where the field of view is actually held constant. It is a timed test, where the speed of response is scored in milliseconds, as plotted on the x-axis.

The apparent anomaly showing a high proportion of responses clustered at the 500 millisecond latency is due to an artifact of the scoring algorithm. If a person requires longer than 500 milliseconds to successfully discriminate the stimuli in this procedure, his or her score is entered as 500 milliseconds and the test is discontinued; thus, the actual range of responses for this measure is unknown.

The differences among the samples on this measure are most pronounced at the peaks of the distributions. The peak (or "best" performance) of the License Renewal distribution is 50 msec, whereas the peak for the Medical Referral distribution is 500 msec, i.e., the "worst" level of performance scored. At both extremes, Residential Community sample scores fall between the other two samples. No systematic differences between the samples

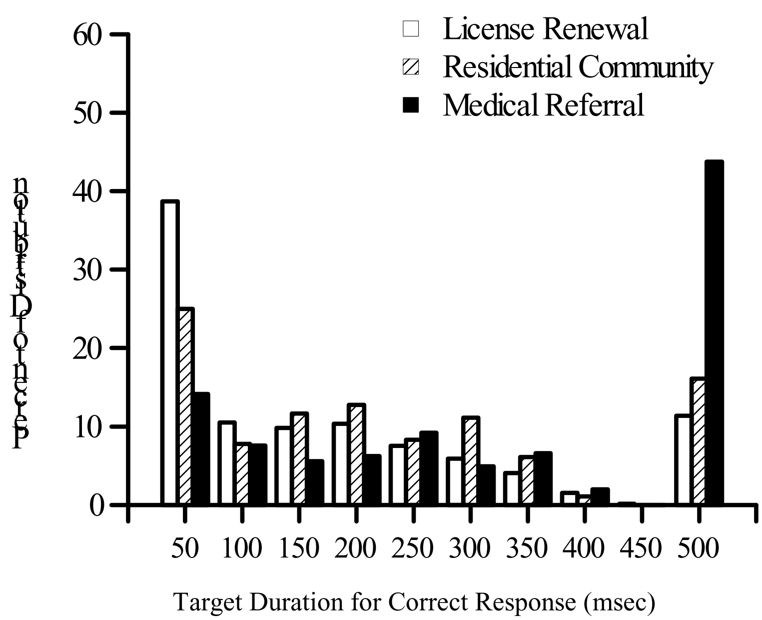

Figure 12. Performance on the Useful Field of View, Subtest 2 measure for each study sample.

are apparent at intermediate scores. Descriptive statistics for this measure are presented in table 16 in appendix D.

Trail-making, Part B. The distributions for this perceptual-cognitive measure are shown in figure 13. The x-axis, labeled completion time, indicates the number of seconds drivers required to connect the (25) items in the correct order. The maximum time allowed to complete the test was 6 minutes (360 seconds).

For all samples, performance on Trails B peaked at about 100 seconds. However, the License Renewal and Residential Community distributions are clearly skewed toward briefer completion times (intact functionality), while drivers in the Medical Referral sample displayed the full range of capabilities measured by this procedure. As a result, over half of the scores lie *above* 100 seconds for the Medical Referral group whereas over half of the scores for the other 2 groups lie *at or below* 100 seconds. Descriptive statistics for this measure are presented in table 17 in appendix D.

Dynamic Trails. Next, the results for the Dynamic Trails test are summarized in figure 14. This procedure was derived from Trails B, including a more distracting background for the letter and number stimuli but fewer items (14 instead of 25); this may explain the faster completion times.

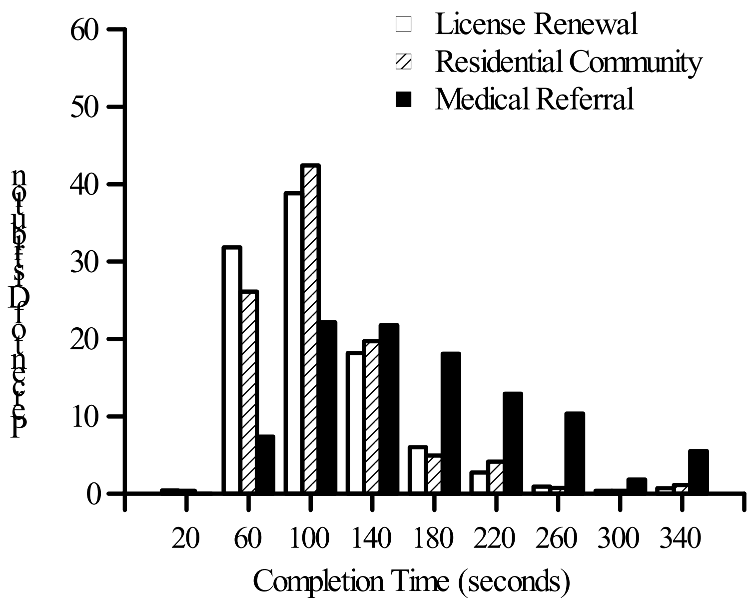

Figure 13. Performance on the Trail-Making, Part B measure for each study sample.

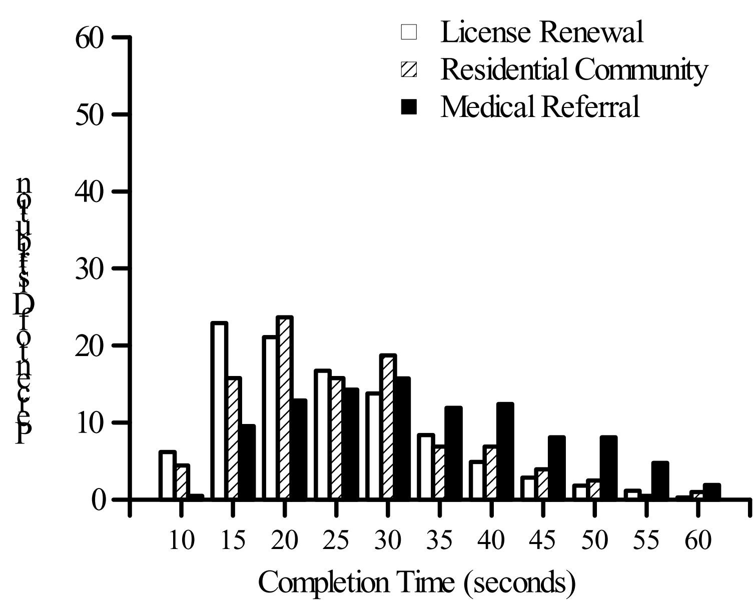

Figure 14. Performance on the Dynamic Trails measure for each study sample.

As shown, the shift in the peaks, as well as the overall shape, of these distributions closely match performance using the paper-and-pencil test protocol. Descriptive statistics for this measure are presented in table 18 in appendix D.

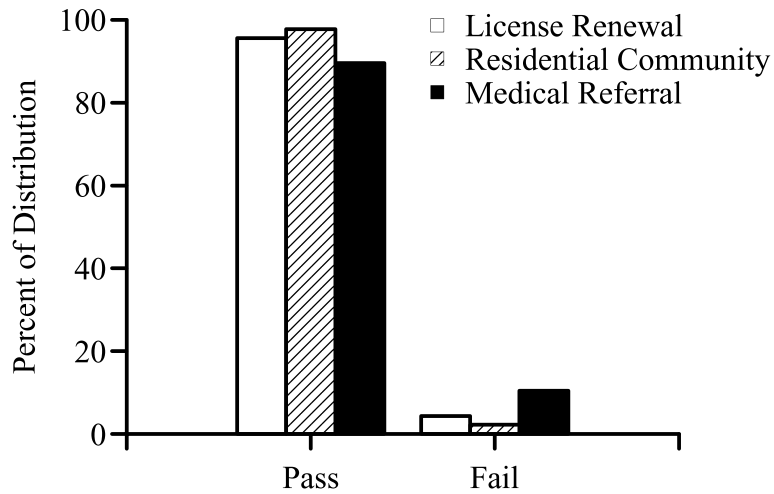

Figure 15. Performance on the Scan Test measure for each study sample.

Scan Test. The remaining measure of perceptual-cognitive ability screened for visual neglect or other scanning deficits. Scan Test results are presented in figure 15. As indicated, the overwhelming majority of drivers in all three samples passed this test. The highest failure rate, for drivers in the Medical Referral group, was 14 percent. Because of observed inconsistencies in the administration of this procedure, it is unknown whether the measure lacks sensitivity or whether differences were washed out by measurement error. The principal difficulty was that, without actually restraining head movement, the testing requirement that drivers scan the chart with eye movements only could not be met on a consistent basis. Descriptive statistics for this measure are presented in table 19 in appendix D.

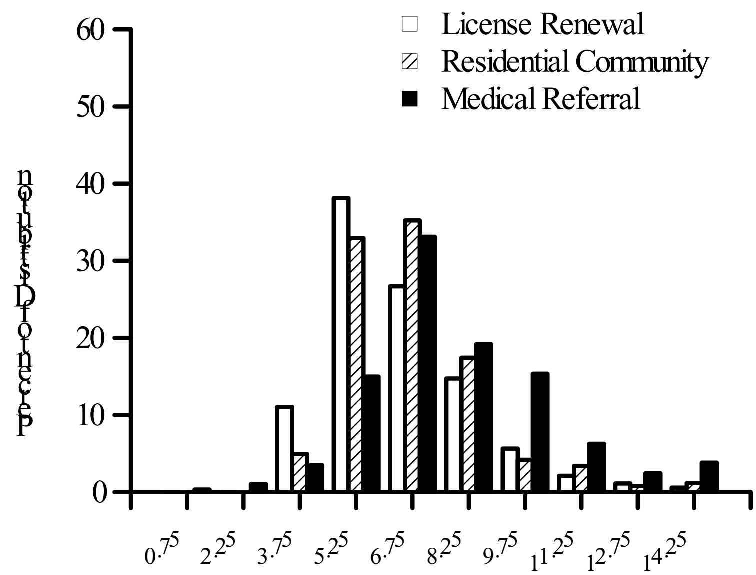

Figure 16. Performance on the Rapid Pace Walk measure for each study test sample.

Rapid Pace Walk. Turning to the results for measures of physical abilities, performance on the 20-foot Rapid Pace Walk is shown for each sample in figure 16. Descriptive statistics for this measure are presented in table 20 in appendix D.

The License Renewal sample demonstrated the fastest mean time (6.5 sec) to complete this measure. These drivers also evidenced the lowest proportion of individuals showing exaggerated decline in this functional ability. The

Residential Community sample was similarly skewed toward "intact" functional status, but consistent with their relatively advanced age, the entire distribution was right-shifted along the x-axis. The Medical Referral sample, by comparison, was the slowest on average (7.8 sec), and also showed a marked increase in the proportion of those tested whose lengthy completion times indicated an exaggerated decline in this ability.

Foot Tap. Figure 17 presents performance distributions for the Foot Tap measure. As for the Rapid Pace Walk, the mean completion times are similar for the License Renewal and Residential Community samples, while drivers in the Medical Referral sample, on average, were a full second slower.

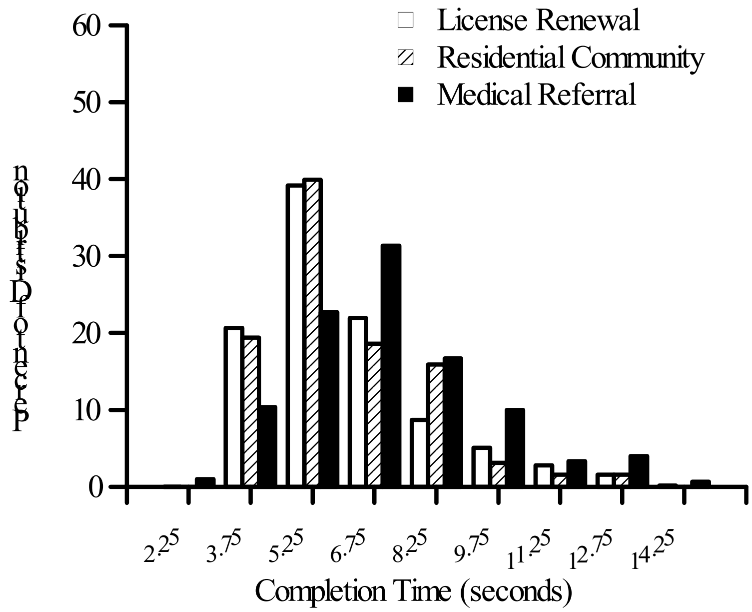

Figure 17. Performance on the Foot Tap measure for each study sample.

The similarities in the patterns of results for Foot Tap and Rapid Pace Walk are consistent with a presumption that these measures address common functional abilities. In fact, the calculated correlation between these measures in the License Renewal sample was $r = .48$. Descriptive statistics for the Foot Tap measure are presented in table 21 in appendix D.

Head/Neck Rotation. The results for the Head/Neck rotation measure are presented in figure 18. Most drivers passed this measure but there are some noteworthy differences among the samples. As anticipated, the poorest performing sample is the Medical Referral group, in which 37 percent of drivers failed. The License Renewal group demonstrated slightly less decline in this ability than the Residential Community group; but

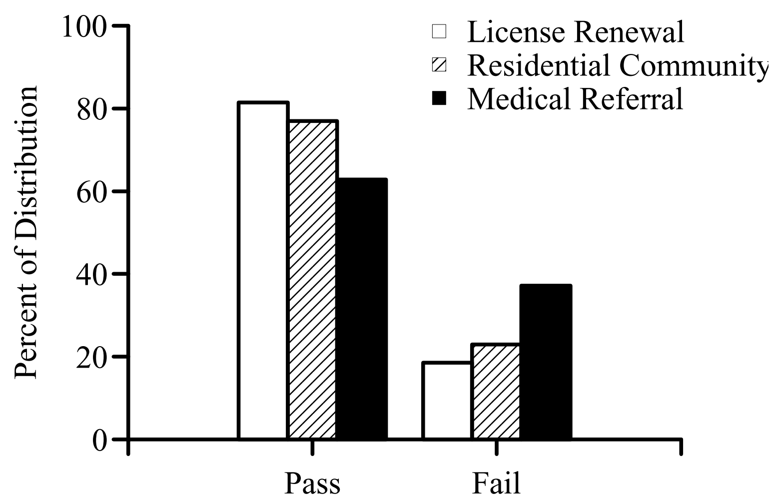

Figure 18. Performance on the Head/Neck Rotation measure for each study sample.

again, these drivers were nearly 10 years younger, on average. Descriptive statistics can be found in table 22 in appendix D.

Arm Reach. Figure 19 plots the data for the Arm Reach measure. As a reminder, drivers performed the test separately for the left and right arms. These results were then combined to create a single pass/fail measure, i.e., drivers had to pass both left and right arm reach tests to receive a passing score.

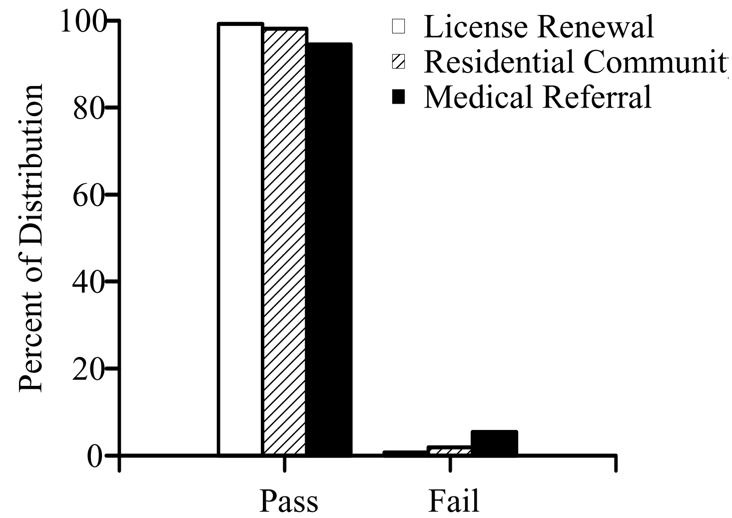

Figure 19. Performance on the Arm Reach measure for each study sample.

Similar to the results for the Scan Test reported above, virtually all drivers screened obtained a passing score on this measure. In this case, however, no serious methodological problems were evident in test administration; this was simply not a sensitive measure. Descriptive statistics for this measure are presented in table 23 in appendix D.

The descriptive data summaries presented in this section have underscored the importance of measuring functional ability without regard to chronological age—inarguably, samples alike in age differ substantially on perceptual-cognitive and physical measures related to safe driving ability, while the performance distributions of samples of older drivers almost a decade apart in mean age are nearly congruent, on multiple measures. Results of the critical analyses relating differences on each functional measure to crash and violation experience for the population-based sample in this study, the License Renewal group, follow a summary of the Mobility Questionnaire responses.

Driving Habits Reported by Test Samples

This section summarizes the data obtained using the Mobility Questionnaire, characterizing the study samples in terms of their self-imposed limitations in the amount of miles driven, and/or in the situations they choose to drive in. As displayed in appendix E, the following subjective measures were obtained:

- How many days per week do you drive?
- How many miles per week do you drive?
- How many miles per year do you drive?

- How often do you avoid nighttime driving?
- How often do you avoid left turn maneuvers?
- How often do you avoid driving in bad weather?
- How often do you avoid driving in heavy traffic?
- How often do you avoid driving on unfamiliar roads?
- How often do you pass up opportunities to go shopping, visit friends, or other activities because of concerns about driving?

Numerical estimates were obtained for questions addressing weekly driving exposure, while a categorical estimate of miles driven was obtained for annual exposure. For questions beginning, "How often do you …," responses were obtained using a rating scale containing the following 5 options: *Never, Rarely, Sometimes, Usually,* or *Always*. The figures below reveal differences between the study samples for each qualitative measure. Detailed descriptive statistics can be found in tables 24, 25, and 26 of appendix E for the License Renewal, Residential Community, and Medical Referral sample responses, respectively.

Exposure Responses

Figure 20 presents the results for self-reports of the typical number of driving days per week for each sample. In every group, the largest percentage of drivers makes at least one trip via personal automobile every day of the week. The Medical Referral group members were least likely to drive every day, and correspondingly more likely to drive only one, two, or three days per week.

Figure 20 also indicates that the Residential Community group—though considerably older, on average, than the License Renewal sample—chose to drive at comparable levels based on this measure.

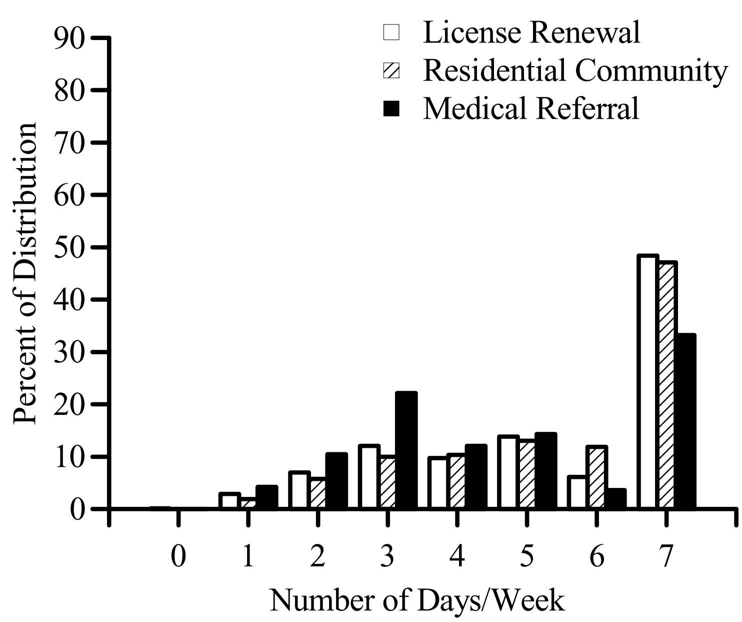

Figure 20. Self-reported number of driving days per week for each study sample.

Figure 21 presents the results for the estimated number of miles driven per week. The Medical Referral group, which reported driving fewer days per week, also included more people who reported driving the fewest miles per week. For every group, however, the distribution was strongly skewed toward limited driving exposure as one-half or more of respondents indicated that they drove less than 100 miles or less per week.

Figure 22 presents the results for the estimated number of miles driven per year. Consistent with the previous measure, Medical Referral drivers tended to report driving fewer miles per year; the peak of their distribution was 1,000 miles/year, and self-reported exposure fell sharply at the 5,000 miles per year level. In contrast, the peak in self-reported annual miles driven by the License Renewal and Residential Community groups was 5,000, and roughly one-third of the distributions for both of these samples fell in the 10,000-15,000 miles per year range.

An internal check on the reliability of the self-reported exposure measures was performed by calculating the correlation between each driver's estimates of miles driven on a weekly versus an annual basis. For all drivers age 55 and over sampled in the pilot study, $r = .65$. The License Renewal sample was of particular interest, since it provided the data upon which analyses relating functional status to safety outcomes were performed; for this group—which comprised the largest number of study participants by a wide margin—the calculated r value was a nearly identical .64.

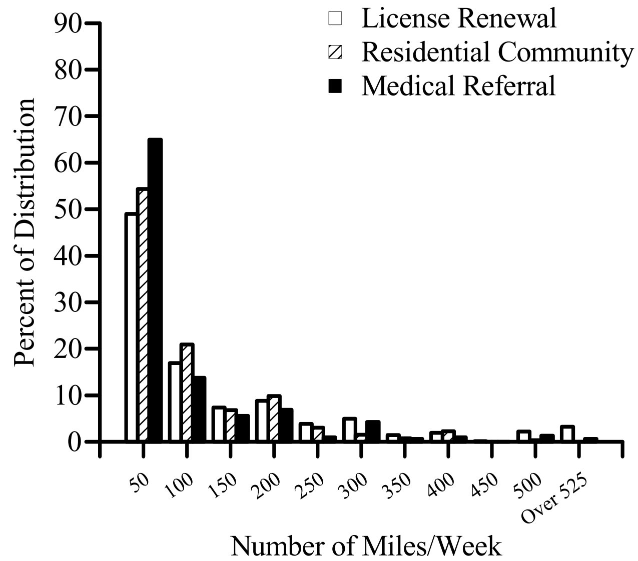

Figure 21. Self-reported number of miles driven per week for each study sample.

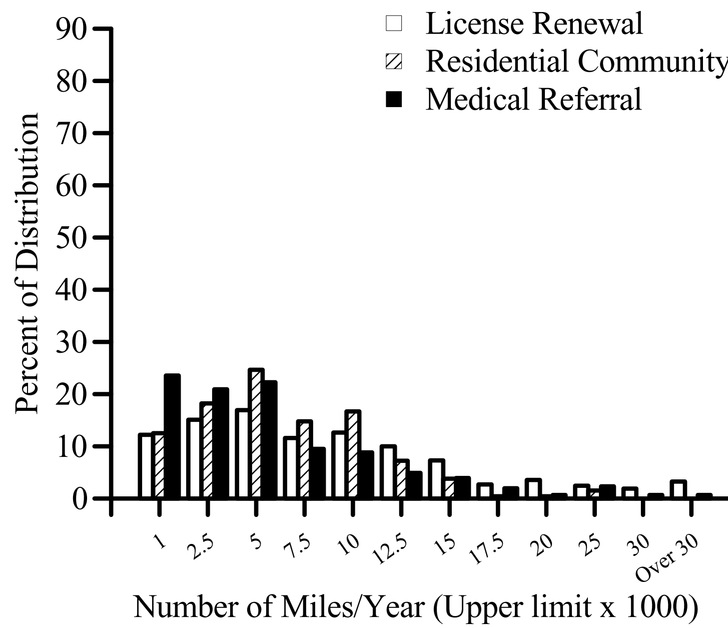

Figure 22. Self-reported number of miles driven per year for each study sample.

This r value implies an overall level of agreement between these measures—which represent two different ways of asking the same question—that is moderate to good. A finer examination of the reliability of drivers' exposure estimates involves direct comparison of the annual-miles-driven figures with an extension of the miles per week estimates (i.e., multiplied by 52). This multiplication was performed, then the product was divided by the estimate of annual miles driven for each person in the License Renewal sample. A "percent error" score was yielded by this procedure that reveals the discrepancy between drivers' estimates of miles driven when asked the same question in two different ways. As shown in figure 23, over 10 percent of the sample provided responses characterized by over 100 percent error, and a 50 percent error rate was demonstrated in over 40 percent of the responses. The implications of this finding are discussed in the report's Conclusions section.

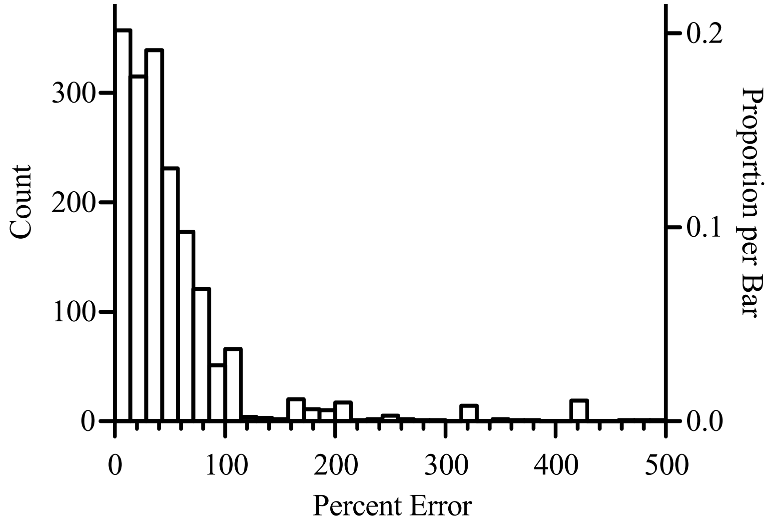

Figure 23. Discrepancy between drivers' estimates of miles driven on a weeklv versus annual basis.

Avoidance Responses

Next, some insight into the extent that older drivers may self-regulate their exposure and the situations they avoid most often is provided by the subjective responses that are summarized in figures 24 through 29.

Nighttime driving. First, figure 24 shows how often the drivers in each sample avoid driving at night. The Medical Referral sample, which also experienced the largest degree of functional decline based on the present screening battery, contained the highest proportion of drivers—almost 1/3—who reported that they "Always" limit their nighttime driving. At the opposite

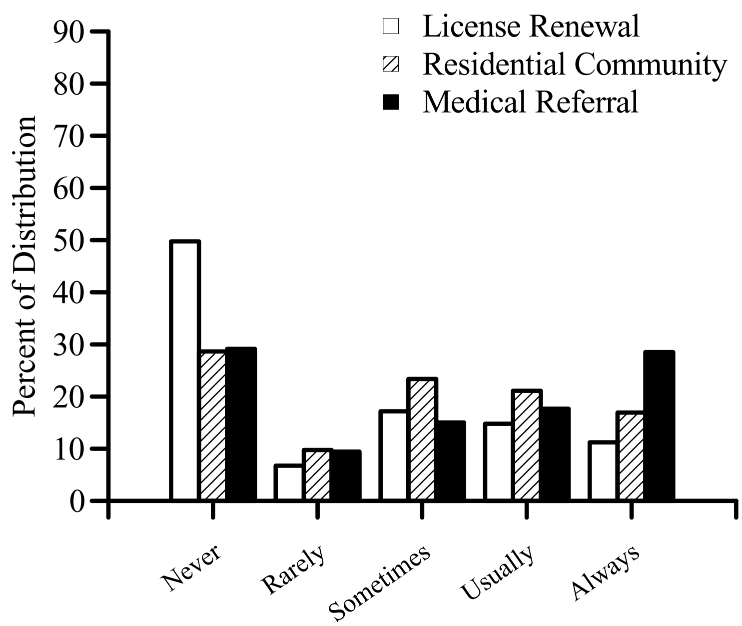

Figure 24. Self-reported frequency of avoidance of driving at night for each study sample.

extreme, the License Renewal sample contained the highest proportion of drivers reporting that they “Never” limit their nighttime driving.

Left turns. Next, figure 25 shows results for the frequency of left turn avoidance by sample. The majority of drivers in each of the three samples report “Never” avoiding left turns. There are some slight differences in proportions among the 3 samples; namely, a larger proportion of drivers in the License Renewal sample report “Never” avoiding left turns, followed by drivers in the Residential Community and then the Medical Referral sample. However, there do not appear to be any systematic trends for drivers reporting results other than “Never” on this measure.

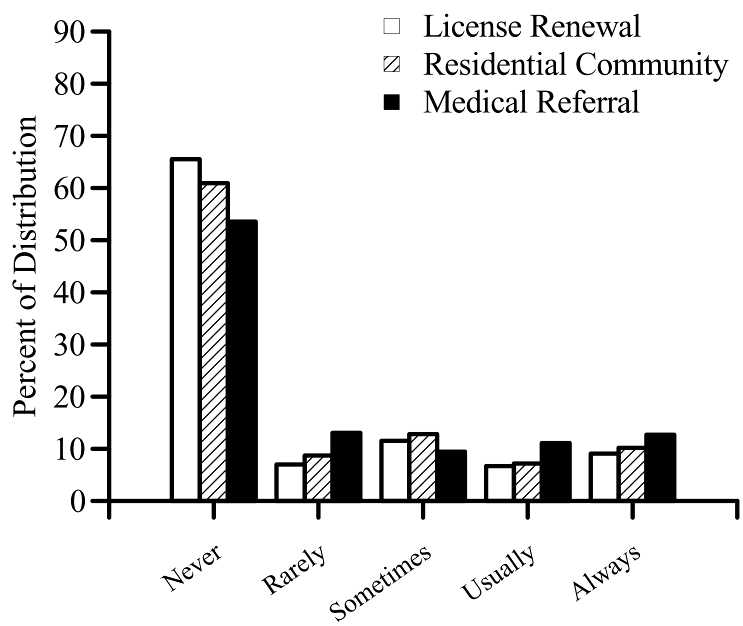

Figure 25. Self-reported frequency of avoidance of left-turn maneuvers for each study sample.

Bad weather. Figure 26 presents the results for avoiding driving in bad weather. The differences among the three samples are small and not systematic for those responding “Rarely,” “Sometimes,” and “Usually.” At the endpoints, however, some clear distinctions emerge. As per prior responses, the License Renewal sample had the highest proportion of drivers who responded “Never,” followed by the Residential Community and then the Medical Referral sample. At the opposite end of the scale, the largest

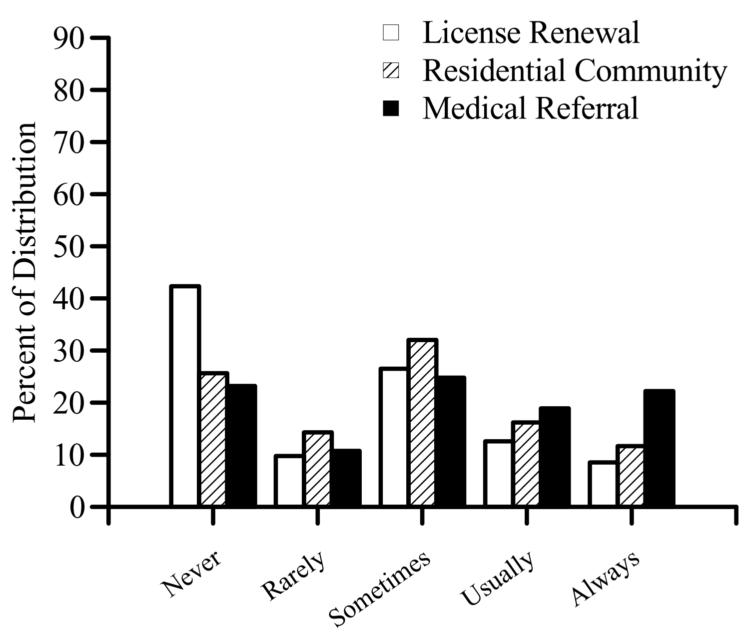

Figure 26. Self-reported frequency of avoidance of driving in bad weather for each study sample.

proportion of drivers responding "Always" were in the Medical Referral group, followed by the Residential Community and then the License Renewal sample.

Unfamiliar roads. Figure 27 shows the frequency of avoiding unfamiliar roads. The most frequent response among all three samples was "Never." The License Renewal sample had the highest proportion of drivers responding "Never" whereas the Medical Referral group had the highest proportion of drivers responding "Always." This pattern of results is very similar to that for bad weather avoidance.

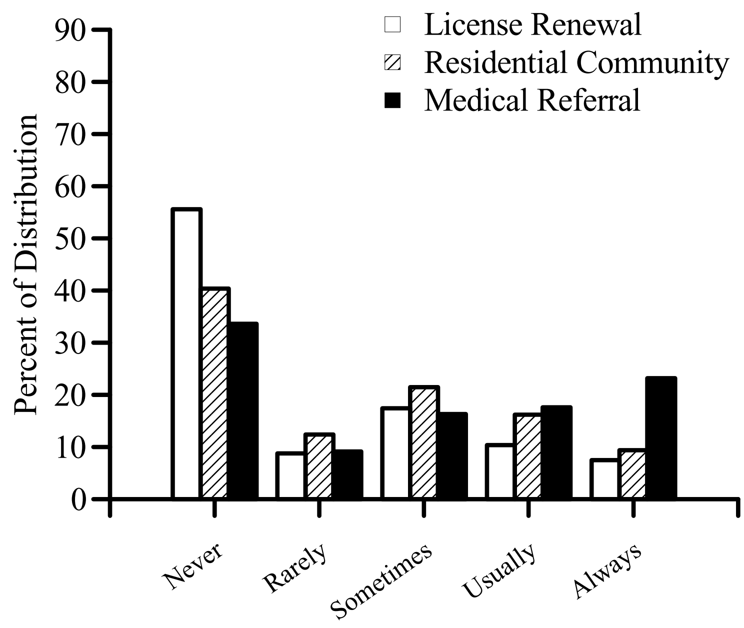

Figure 27. Self-reported frequency of avoidance of driving on unfamiliar roads for each study sample.

Heavy traffic. Self-reports of the frequency of heavy traffic avoidance are presented in figure 28. It is interesting to note that on this measure the Residential Community most closely matches the responses of the Medical Referral sample. In any case, the License Renewal sample has the highest proportion of drivers who "Never" avoid driving in heavy traffic.

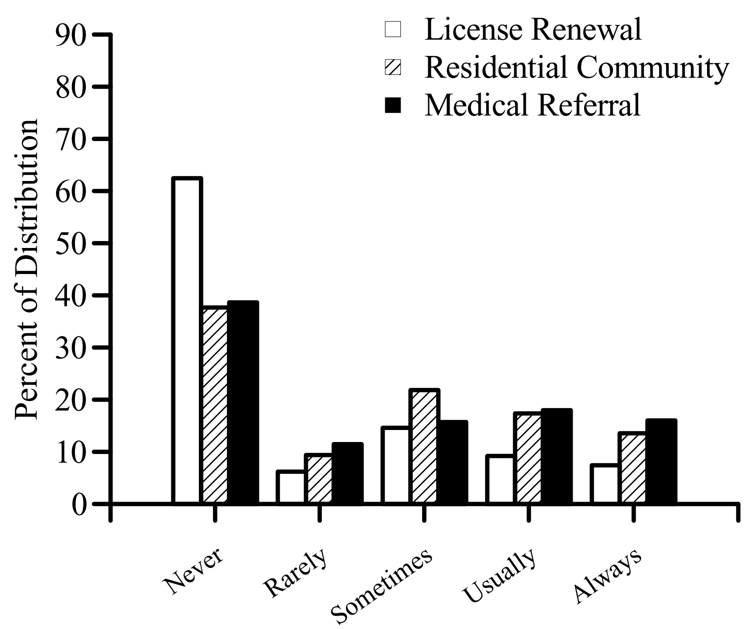

Figure 28. Self-reported frequency of avoidance of driving in heavy traffic for each study sample.

Social opportunities. Finally, figure 29 presents the results for the frequency with which drivers pass up social opportunities because of concerns about their driving. The overwhelming majority of drivers from all three samples reported that they "Never" pass up such opportunities. Also, the proportion of drivers indicating that they "Never" pass up opportunities to drive shows the same pattern seen before where the proportion of drivers is highest for the License Renewal, next highest for Residential Community drivers, and lowest for Medical Referral drivers.

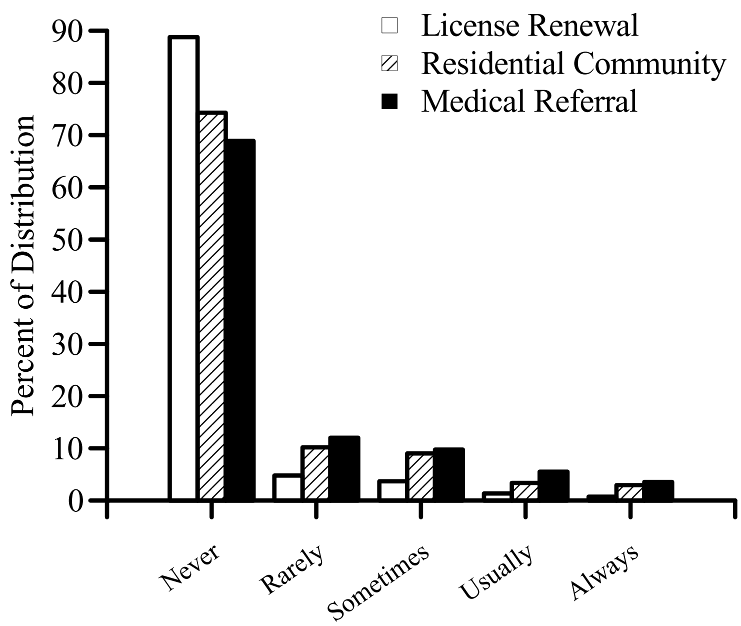

Figure 29. Self reported frequency of passing up opportunities to go shopping, visit friends, etc., because of concerns about driving, for each test sample.

The subjective data summarized in this section have provided a useful contrast between groups of drivers with known differences in their age characteristics and functional status. First, these data showed that the similarity between groups in terms of functional ability is more important than their proximity in age, *vis a vis* the reported frequency of driving and the number of miles driven. In both cases, the sharpest distinctions observed among the self-reports were between those of the Medical Referral group and the other two samples.

A somewhat different picture emerges from inspection of the self-report data regarding avoidance of problem driving situations. In these comparisons, responses from the samples closest in age composition—the Residential Community and the Medical Referral groups—were more alike and were in contrast to the responses of the younger, License Renewal group with regard to how often the identified situations were "Never" avoided. Still, the Medical Referral group was consistently higher than the others with respect to how often these drivers said they "Always" avoid the identified situations.

These data reinforce other research findings and anecdotal reports indicating that self-regulation among older drivers is common. This supports a stance that, while safety-relevant functional deficits may be significant from both a statistical and operational perspective, these deficits may not manifest themselves in predicted increases in crash rates due to mediating effects of self-regulation. At the same time, the qualitative results summarized above provide only the most general insight into the questions of whether the "right" drivers (i.e., most functionally impaired) are self-limiting their exposure, and in what situations, and by how much.

Relationships of Screening Measures With Crash Data

This section quantifies and tests the significance of the statistical relationships between the functional screening measures and the crash data extracted from the Maryland Motor Vehicle Administration files. These associations were calculated according to the conventions for measuring, sorting, and summarizing functional status and safety outcome data described previously in this report.

The strength of relationship between functional status and crash risk was assessed primarily through the use of the "odds ratio" calculation. A brief explanation of this analytic technique, assumptions that must be met for its valid application, and its relationship to another potentially useful approach ("relative risk") follow. Analysis results are then reported.

Analysis Techniques

Odds Ratio Calculations. Odds ratios are calculated by taking the ratio of "experimental event" odds to "control event" odds. The experimental event in the present application occurs when a driver "fails" a particular screening measure, whereas a control event occurs if the driver "passes," based on some criterion or cutpoint. Also included in this calculation are the event classification outcomes—crash versus no crash. Using traditional signal detection terminology, it may be demonstrated that each driver in the sample falls into one of four groups as shown in figure 30. For each of these groups, the odds of being involved in a crash are then calculated according to the formula shown in this figure (cf. http://www.jr2.ox..ac.uk/cebm/docs/oddsrats.html). For future reference, it should be noted that the numbers of drivers in cells labeled *b* and *d* in figure 30 will always vastly exceed the number of drivers in cells *a* and *c*, because motor vehicle crashes remain (relatively) rare events.

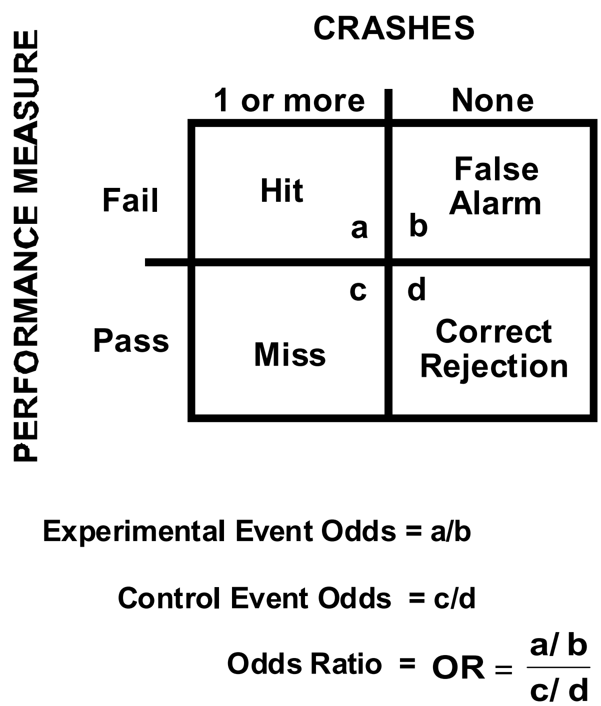

Figure 30. Explanation of odds ratio calculation.

In this context, the practical meaning of the odds ratio (OR) is to express how much more likely it is that drivers will be involved in a crash if they *fail* a test than if they *pass* the test. For example, an OR value of 3 means that you are three times more likely to be involved in a crash if you fail a test than if you pass the test. Also worth mentioning is the relationship between OR and "relative risk." While subtle differences exist in calculating these measures, for rare events (i.e., crashes) they yield equivalent results (http://www.cche.net/usersguides/overview.asp).

Although the odds ratio has been used effectively in a number of contexts, it is important to note a few limitations to the validity of this calculation. First, OR cannot be calculated when any of the cell values are zero. Paradoxically, this includes instances where the measure is a *perfect predictor*, i.e., where there are no "misses" (where a driver passes the test but still has a crash) or "false alarms" (where a driver fails the test but remains crash-free). Second, an OR calculated for data with less than 5 counts in any cell in the matrix shown in figure 30, is statistically unreliable and easily susceptible to misinterpretation.

Finally, even when requirements for a valid OR calculation are met, the resulting values can be quite misleading. Since the OR calculation relies on four different cell counts, a high value can result from a *relatively high* number of hits *or* correct rejections. Conversely, the calculated OR can be high due to a *relatively low* number of false alarms *or* misses. Understanding the predictive value of an OR outcome requires an investigation of actual cell counts, a comparison of raw data distributions, and the investigation of multiple pass/fail cutpoints. Interpreting an OR value without explicit reference to these analysis attributes is problematic. Often, the pattern of change in calculated OR values across different cutpoints is most revealing of the relationship between predictor and criterion measures. The plots presented in this section, the accompanying data tables in appendix F, and the chi-square tables in appendix G are designed to satisfy requirements for a meaningful interpretation of calculated odds ratios.

In the following pages, three plots with bar graphs are presented to express the results of the OR calculations for every continuous measure in the functional screening battery. The three plots correspond to the three crash outcome measures—*all crashes*, *at-fault plus unknown-fault crashes*, and *at-fault crashes only*—as defined earlier in the report. Each plot contains the distribution of crash-involved and non-crash-involved drivers in the License Renewal sample, for a particular measure of functional ability. The heights of the bars allows direct comparison of the crash and non-crash distributions of drivers who "failed" a given test, calculated separately at each of a number of possible cutpoints within the range of performance on that test. The *y*-axis, labeled Percent of Distribution, is common for all plots. For the *x*-axis, movement from left to right connotes decreasing performance (or increasing functional impairment) for all measures. The *x*-axis varies among the plots, however, according to the units in which performance is measured (e.g., time, distance, percent correct) and the overall range of performance, for each continuous measure; for binary (pass/fail) measures, every response alternative is marked on the *x*-axis. The values labeled on the *x*-axis in each data plot thus define the range of all possible cutpoints for a given screening measure that were evaluated in these analyses.

For each measure, OR was calculated at every possible cutpoint represented in the plot. The resulting OR calculations were then graphed as a continuous line, using the right vertical axis to indicate OR value. In this context, the term "cutpoint" means that everyone who scored *at that level of performance or worse* failed the test; to pass the test a driver must perform *better than* the cutpoint. Therefore, no OR value could be calculated for the best level of performance on each functional measure, because no one passed according to the operational definition above. With no passes, the denominator in the odds ratio calculation formula (see figure 30) is zero.

The line representing calculated OR value thus begins at the second-best level of performance, or first possible cutpoint, marked along the *x*-axis in each plot. Also, in every plot a dashed line, connoting an OR of 1.0, is included for reference. At this level, a driver is as likely to be crash-involved when passing a test as he/she is when failing the test; and the OR effectively has no predictive value. Exact OR values for the data represented in the plots, keyed to each potential cutpoint marked on the *x*-axis, are presented in appendix F.

Significance Testing. Levels of significance of calculated OR values were assessed using chi-square (G2) tests. Test statistics were calculated by SPSS/SYSTAT for relationships between functional performance measures and at-fault crashes. However, not all possible cutpoints were evaluated; typically, the significance level attained at the cutpoint where the peak valid OR value was calculated for a given measure is what is reported in the following write-up of analysis results. Chi-square tables are presented in appendix G.

As a general finding, it was observed that an OR value of approximately 2, or greater, was associated with a statistically significant (p<.05) chi-square test result. Sample sizes and the respective distributions of crash-involved versus non-crash-involved drivers—gauged in terms of their relative proportions at different degrees of functional impairment—also exert strong influence on G^2 test results, as noted below where appropriate.

Results of Crash Analyses

Motor Free Visual Perception Visual Closure Subtest (MVPT/VC). Figure 31 contains the results for the MVPT/VC. The top plot relates functional performance to crash involvement, using "all crashes" as the safety outcome measure. The middle

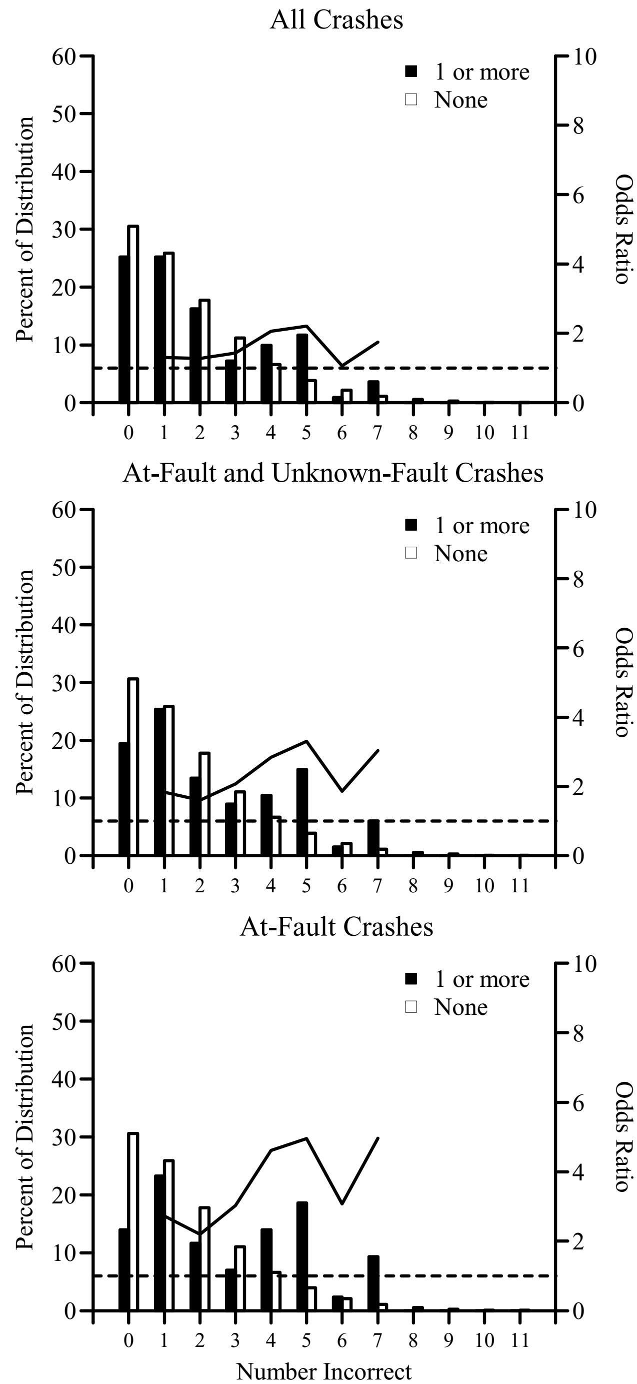

Figure 31. MVPT/VC performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

plot relates functional status to the more restrictive outcome measure of "at-fault and unknown fault" crashes, and the bottom plot shows the distributions of License Renewal sample drivers with and without "at-fault" crashes at each level of functional ability measured by this test. In all cases, declining functional ability is indicated by an increasing number of incorrect responses, moving to the right along the *x*-axis.

Inspection of this figure reveals stronger relationships moving from the top to the bottom data plot; this is associated with a progressive increase in the peak OR value from 2.21 for "all crashes" to 4.96 for "at-fault" crashes only. The peak OR (4.96), associated with a cutpoint of 5 incorrect responses, is statistically significant (G2 = 26.48, df=1, p<.001). It is also interesting to note that, in all three plots the proportion of drivers who are crash-involved begins to exceed the proportion who are crash-free at the same level of functional performance—four incorrect responses.

Finally, it may be observed that the distributions of crash-involved drivers appears bimodal, especially for at-fault crashes, while the percentages of non-crashing drivers falls off in a linear fashion with declining functional ability.

The data plotted in figure 31 are presented in tables 27, 28, and 29 of appendix F. The chi-square test results noted above, with corresponding cell counts, can be found in table 48 of appendix G.

Delayed Recall. Figure 32 shows the relationships between performance on the Delayed Recall procedure and the three indices of crash involvement analyzed here.

As shown, the association between functional performance and crash

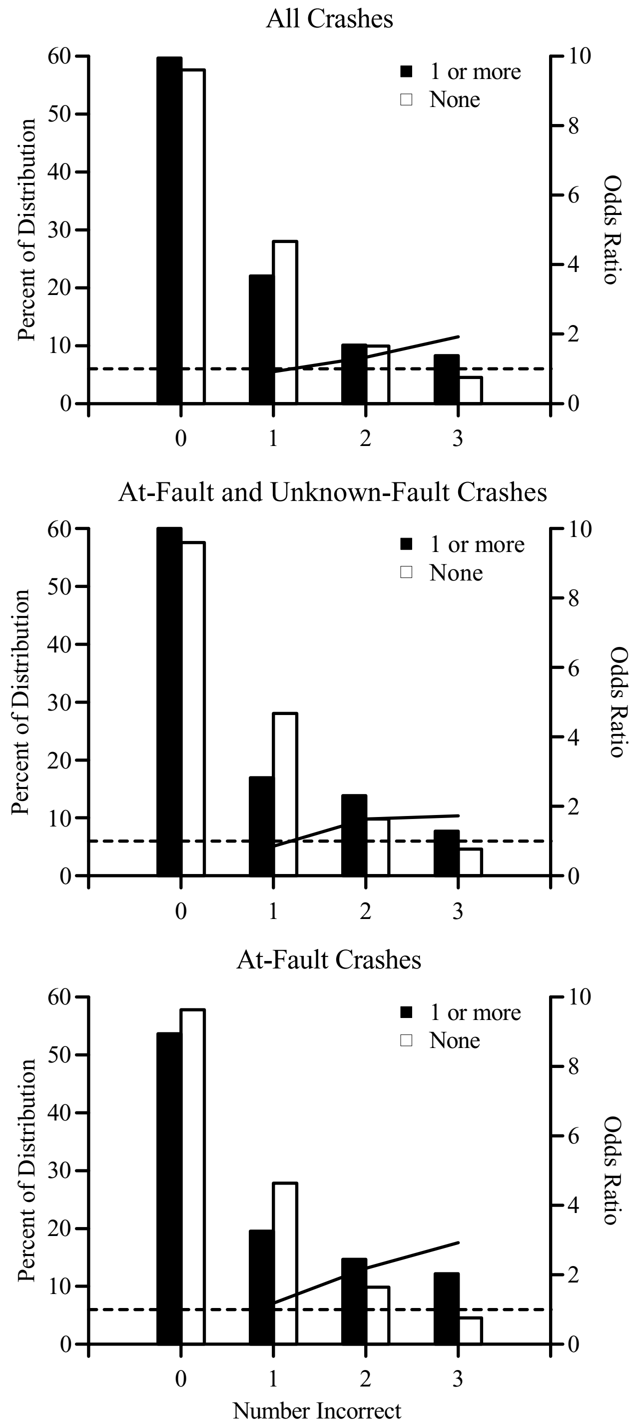

Figure 32. Delayed Recall performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

involvement, revealed through calculated OR values at each of the four possible levels for this measure, indicates elevated crash risk with a greater loss of working memory. The association is progressively stronger moving from "all crashes" to "at-fault" crashes only. In the latter case, for drivers who missed all 3 items crash risk was elevated by 2.92 times, which was statistically significant at *p*<.02 (G^2 = 5.25, df=1). At the same time, the proportion of the sample who were crash involved began to exceed those who were crash free at the level of two incorrect responses, suggesting this as a potential cutpoint for this measure.

The data plotted in figure 32 are presented in tables 30, 31, and 32 of appendix F. The chi-square test results noted above, with corresponding cell counts, can be found in table 49 of appendix G.

<u>Useful Field of View, Subtest 2</u>. Figure 33 contains the results for the Useful Field of View, Subtest 2. The plots in this figure allow comparison of the distributions of crash-involved and non-crash-involved drivers at each target duration for this measure. It may be noted that poorer performance is signified when drivers need longer durations to correctly identify the target; and, each value on the *x*-axis is actually the midpoint of a 50 msec interval.

While the performance level at which the proportion of crash-involved drivers exceeds non-crash-involved drivers is 250 msec, the peak OR of 2.48 for this measure obtains at a slightly longer duration, 300 milliseconds. The calculated OR is statistically significant (G^2 = 6.95, df=1, p<.01) at the latter cutpoint (which is an interval with lower boundary set at 275 msec).

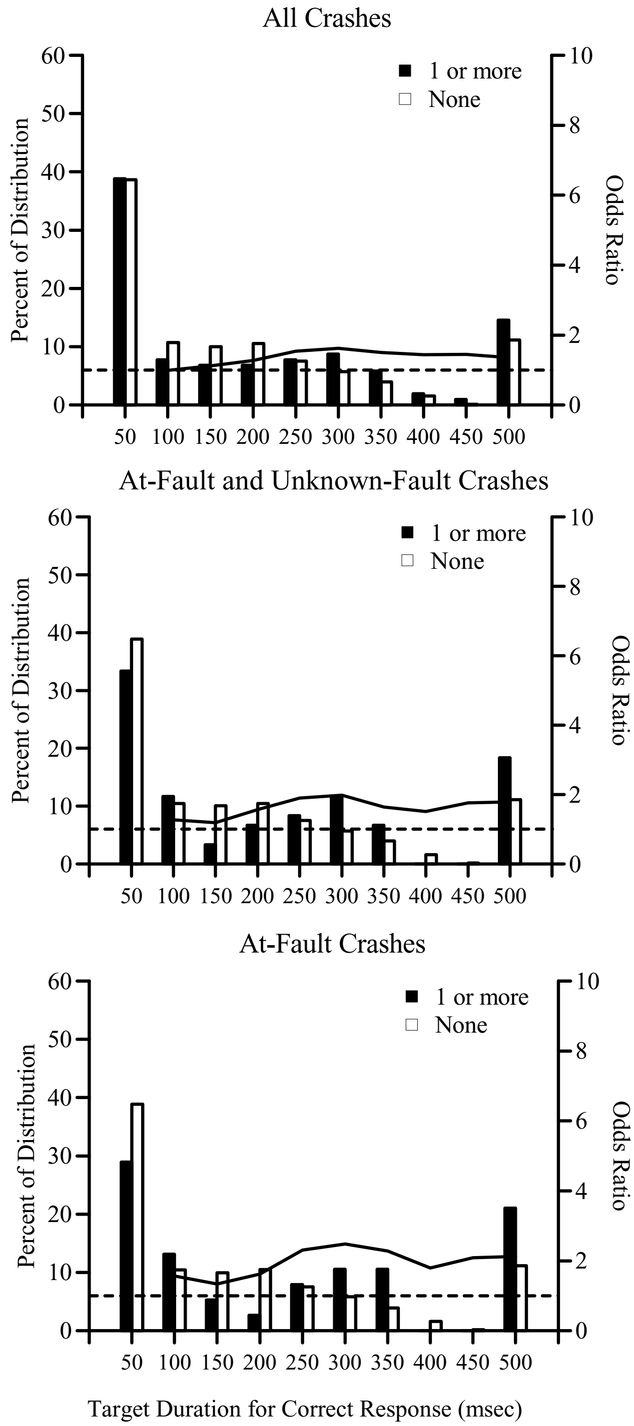

Figure 33. Useful Field of View, Subtest 2 performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

Though less pronounced than MVPT/VC, the plots for Subtest 2 of the Useful Field of View measure also suggest a multimodal shape for the crash-involved group, most noticeably for at-fault crashes. Interpretation is complicated by the spike at 500 msec; as noted earlier, this is an artifact of the measurement technique, inasmuch as all responses at this target duration and longer were coded with the same value.

The data plotted in figure 33 are presented in tables 33, 34, and 35 of appendix F. The chi-square test results noted above, with corresponding cell counts, can be found in table 50 of appendix G.

Trail-making, Part B. The results for this paper-and-pencil test of perceptual-cognitive ability are displayed in figure 34. As observed in the related, Useful Field of View (Subtest 2) plots displayed previously, the curve relating safety outcome to functional status is essentially flat using "all crashes." Also, the values on the *x*-axis in this figure are again actually the midpoints of intervals; each interval is 40 msec long.

A strong consistency observed in these data is that the proportion of drivers in the sample who were crash-involved began to exceed those who were crash free at the 100 second performance level, across all crash categories. This suggests that 100 seconds may be the best candidate for a cutpoint on this screening measure.

The results reported in the middle plot show a somewhat stronger association overall but do not show any clear peak for the calculated OR. It isn't until the bottom plot for at-fault crashes that the OR shows a clear peak (3.50) at the 100 second level. Drivers were over 3½ times

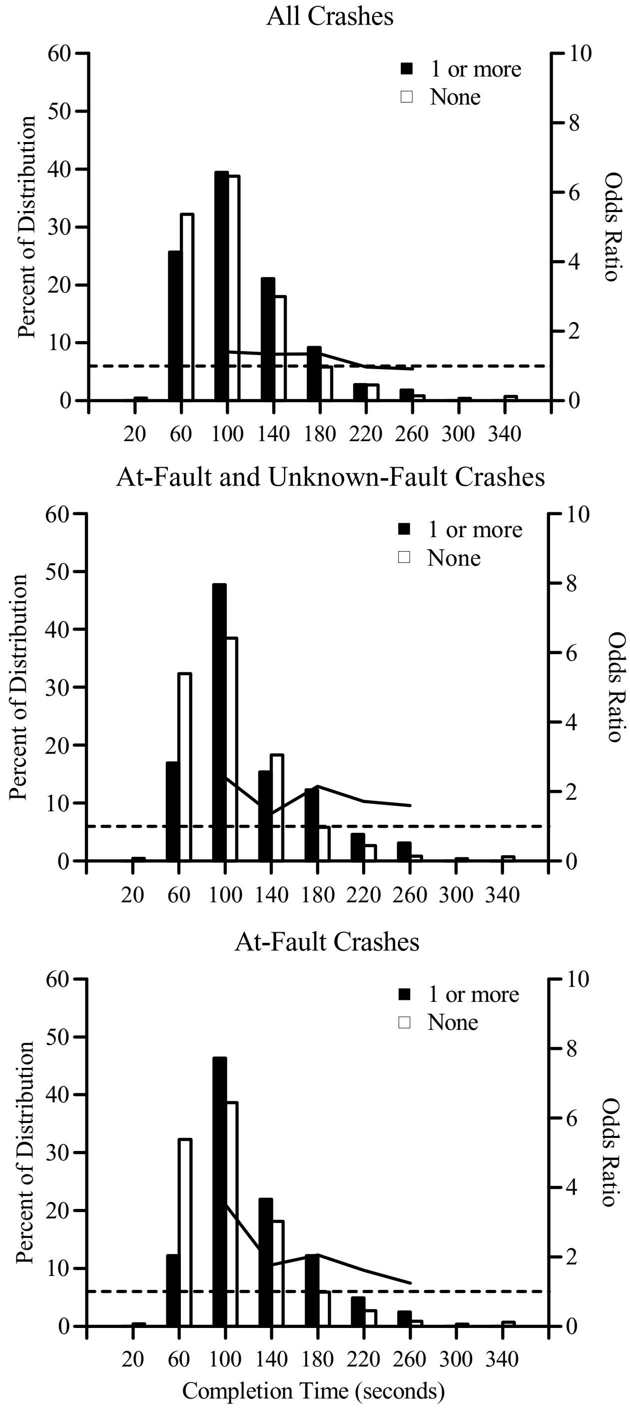

Figure 34. Trail-making, Part B performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

more likely to be involved in an at-fault crash if their score was 80 seconds (i.e., the lower bound of this analysis interval) or longer on this measure, a statistically significant outcome (G2 = 7.72, df=1, p<.01).

The data plotted in figure 34 are presented in tables 36, 37, and 38 of appendix F. The chi-square test results noted above, with corresponding cell counts, can be found in table 51 of appendix G.

Dynamic Trails. Figure 35 plots the results for Dynamic Trails. This automated test was related to the paper-and-pencil Trail-making (Part B) measure but was shorter, with fewer test items, and also potentially more distracting, with moving traffic in the background instead of a blank page.

A peak valid OR of 1.45 was calculated for this measure at a test completion time of 25 seconds, for the "at-fault" crash category. This outcome was not statistically significant (G2 = .57, n.s.). In part, this outcome may reflect the fact that the sample size (n = 777) for this particular measure was only about half of that attained for the other procedures in the screening battery. Also, as reported anecdotally by test administrators at the MVA field data collection sites, participants had the greatest difficulty understanding the instructions on how to perform this procedure.

To the extent justified by data collection with a larger study sample, choosing a candidate cutpoint for this measure is problematic. At 20 seconds, the percentage of crash-involved drivers first exceeded crash-free drivers in the analyses of at-fault crashes; but the largest differentials between the two distributions were observed at a test completion time of 30 seconds, for all crash categories.

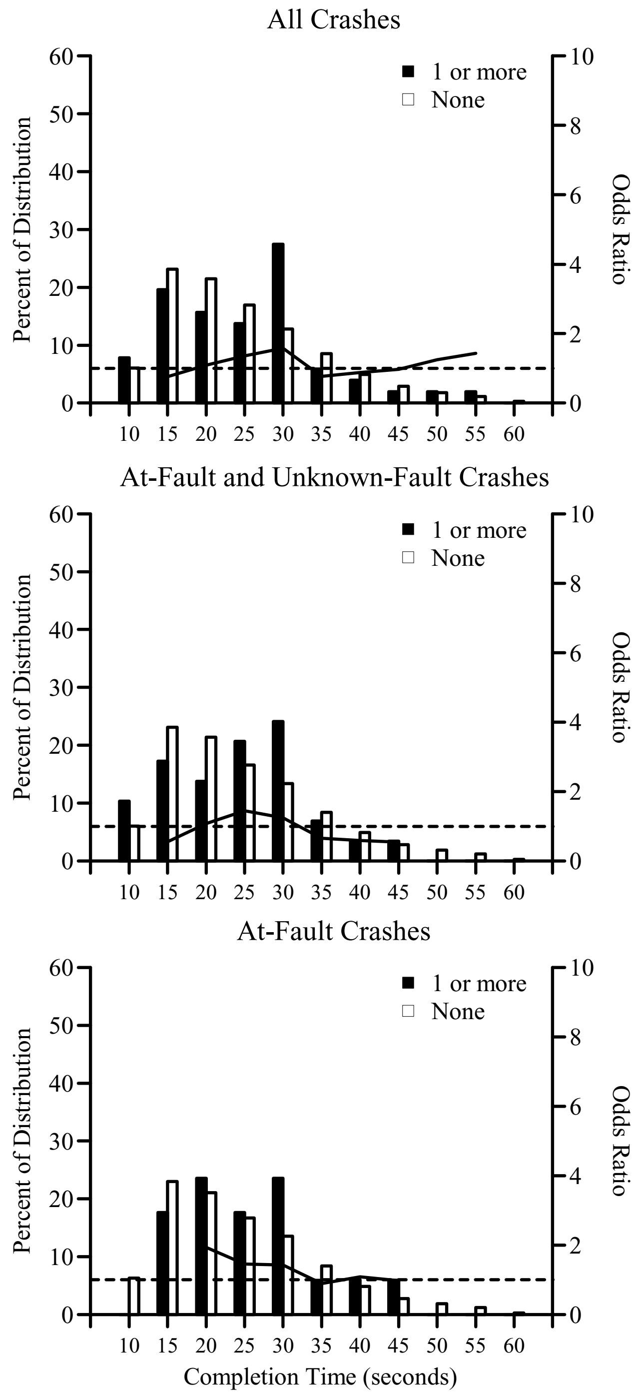

Figure 35. Dynamic Trails performance distributions and odds ratios for analyses including all crashes, at-fault and unknown - fault crashes, and at-fault crashes only.

The data plotted in figure 35 are presented in tables 39, 40, and 41of appendix F. The chi-square test results noted above, with corresponding cell counts, can be found in table 53 of appendix G.

Scan Test. The remaining measure of perceptual ability, the Scan Test, was scored simply on a pass/fail basis. With only one criterion possible, OR calculation is irrelevant to cutpoint determination.

For this measure, 95.6 percent of all drivers in the analysis sample—whether crash-involved or not—passed. Whether this was due to insensitivity of the measurement procedure or whether these results reflect a true measurement of generally "intact" functional ability is unclear. Either way, the very small percentage of drivers failing the measure precludes reliable estimates of statistical significance. Specifically, the sample would have to be much larger, and/or the criterion to pass the test more stringent and more consistently implemented, to obtain a reliable cell count of drivers with at least one crash who failed the test (see earlier discussion of assumptions and limitations of the odds ratio technique).

Rapid Pace Walk. Figure 36 presents the plots for the Rapid Pace Walk measure. Again, a pattern of results is shown where the relationship between safety outcome and functional status appears progressively stronger moving from "all crashes" to "at-fault" crashes.

A statistically-significant ($G2 = 6.11$, df=1, $p<.01$) peak OR value of 2.64 was calculated for this analysis, for the "at-fault" crash category, at the performance level designated 9.75 seconds. A second

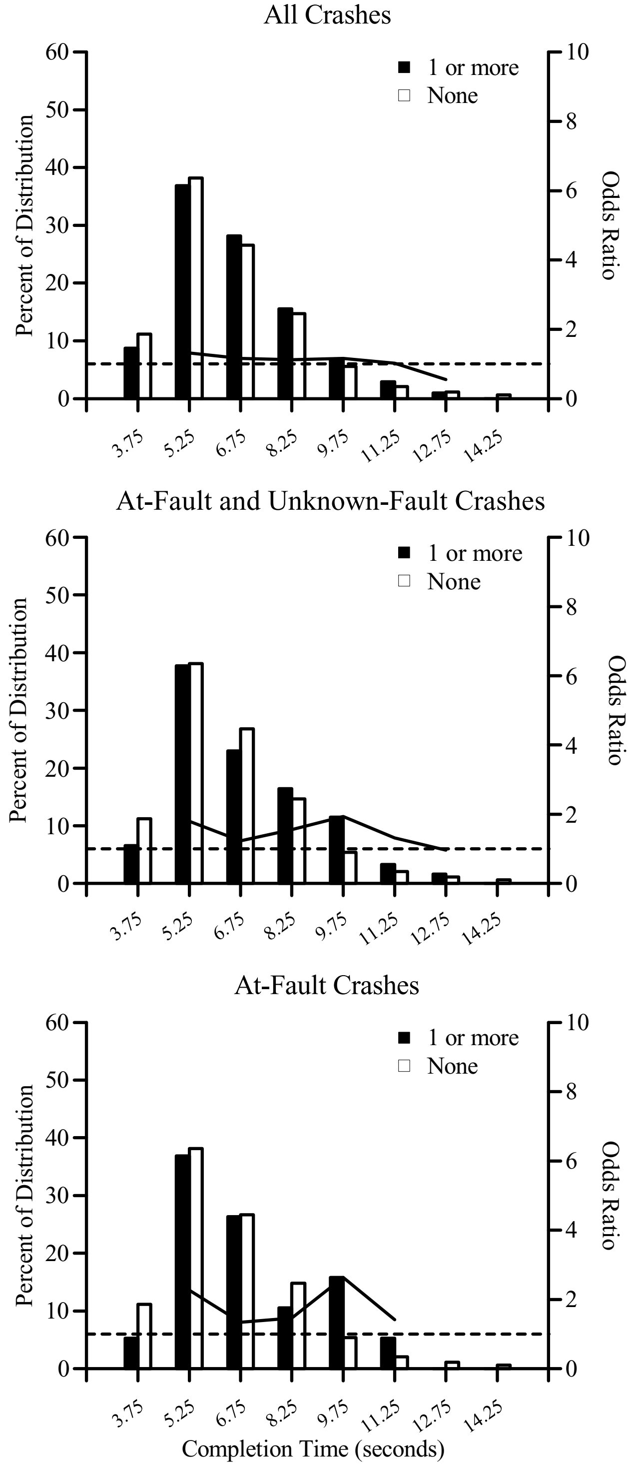

Figure 36. Rapid Pace Walk performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

peak appears in this plot at the shorter time of 5.25 seconds, however, showing evidence of the same type of bimodal distribution of functional performance scores among crash-involved drivers that was observed earlier for MVPT/VC (while the crash-free driver distribution remains linear).

As in the earlier timed measures, each value on the *x*-axis is the midpoint of an interval; in this case each interval is 1.5 seconds long. Thus the two values noted above connote analysis intervals that begin at 9.0 and 4.5 seconds, respectively. The data plotted in figure 36 are presented in tables 42, 43, and 44 of appendix F. The chi-square test results and cell counts can be found in table 53 of appendix G.

Foot Tap. Data plots of the results of the Foot Tap measure are presented in figure 37. Each value on the *x*-axis is actually the midpoint of a 1.5 second analysis interval.

As shown, there is a tendency toward higher OR's at faster times, which was somewhat unexpected. Also apparent in figure 37 is a close overlap in the distributions of crash-involved and non-crash-involved drivers, in all three plots. As a result, there are no statistically-significant differences here, even at the peak OR value of 1.50 calculated at the performance level designated 5.25 seconds in the analysis of "at-fault" crashes ($G2$ = 0.98, n.s.).

The data plotted in figure 37 are presented in tables 45, 46, and 47 of appendix F. The chi-square test results and cell counts can be found in table 54 of appendix G.

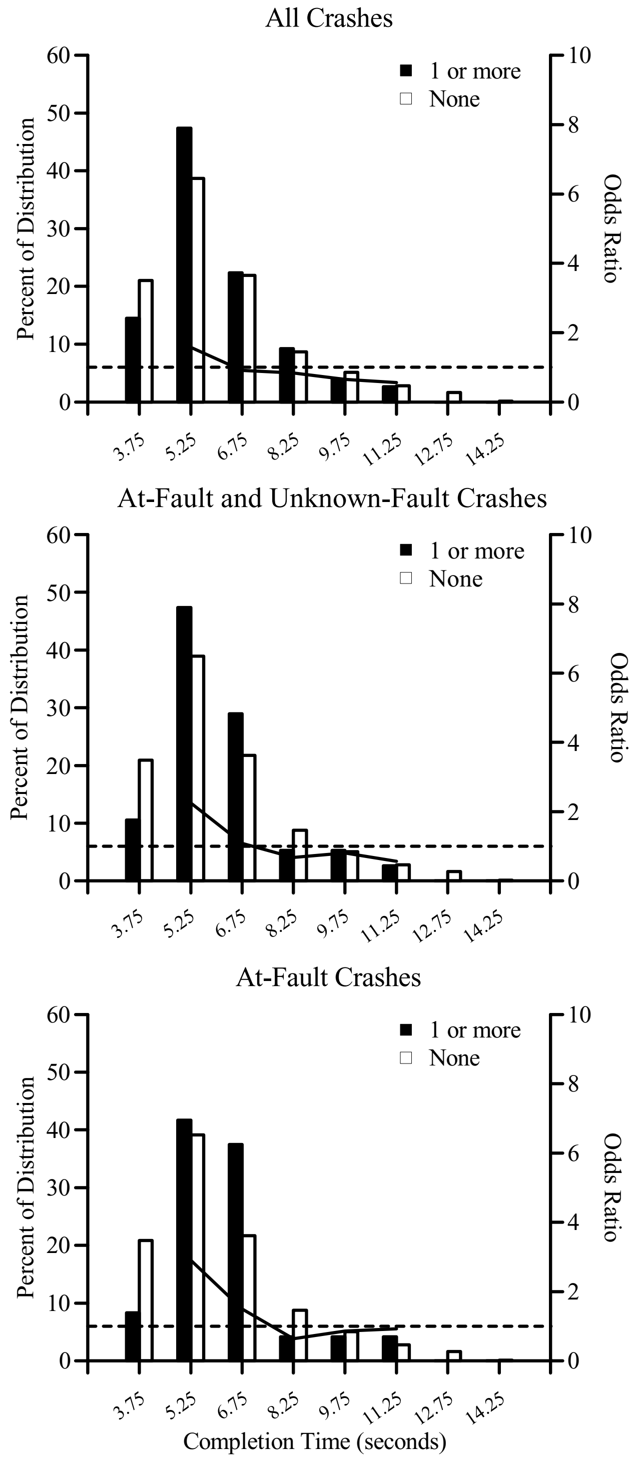

Figure 37. Foot Tap performance distributions and odds ratios for analyses including all crashes, at-fault and unknown-fault crashes, and at-fault crashes only.

Head/Neck Rotation. As another binary (pass/fail) measure, no OR plots were generated for Head/Neck Rotation. Sufficient differences were found to support reliable analyses, however: 36.4 percent of drivers with 1 or more (at-fault) crashes failed this test versus only 18.2 percent of drivers in the non-crash group. The peak OR value of 2.56 for this analysis category was statistically significant ($\chi^2 = 4.69$, df = 1, $p<.03$).

The chi-square test results and cell counts for this measure can be found in table 55 of appendix G.

Arm Reach. As with the Scan Test measure, virtually all (99.3 percent) of the drivers in the sample passed the Arm Reach test. Of those who failed, only one driver was involved in an at-fault crash. The lack of drivers failing this measure precluded reliable statistical tests, and renders this procedure of little value as a screening tool.

Relationships of Screening Measures With Conviction Data

This section quantifies and tests the significance of the statistical relationships between the functional screening measures and the conviction data extracted from the Maryland Motor Vehicle Administration files. These associations were calculated according to the conventions for measuring, sorting, and summarizing functional status and safety outcome data described previously in this report. A brief overview of the analysis technique follows.

Analysis Techniques

The strength of relationship between functional status and conviction experience was again assessed through the use of the "odds ratio" (OR) calculation. Greater detail about the nature of this calculation and the assumptions that must be met for its valid application were provided at the beginning of the preceding (crash analysis) section.

Results of the OR calculations are indicated in data plots for each functional screening measure used in the Pilot Study. Each plot shows the percentage of the distribution of drivers in the License Renewal sample who would fail a test, at each possible cutpoint, that were convicted of moving violations versus violation-free; and, it shows the calculated OR value at each possible cutpoint.

In accordance with assumptions and limitations of the OR technique explained earlier, a line representing the calculated OR value begins at the second-best level of performance, or first possible cutpoint, marked along the *x*-axis in each plot presented in this section. Also, in every plot a dashed line, connoting an OR of 1.0, is included for reference. At this level, a driver is as likely to be crash-involved when passing a test as he/she is when failing the test; and the OR effectively has no predictive value. Exact OR values for the data represented in the plots, including each potential cutpoint marked on the *x*-axis, are presented in appendix I.

Three categories of conviction data are represented in the plots presented in this section: all moving violations; all moving violations *except* speeding; and, all moving violations except speeding *and* occupant restraint citations. A variety of specific incident types are subsumed under the heading "moving violations;" these were identified earlier in the section describing the extraction of motor vehicle administration safety data.

Levels of significance of calculated OR values were assessed using chi-square (G2) tests. Test statistics were calculated by SPSS/SYSTAT for each functional performance measure where the strongest relationship with a safety outcome—indicated by the peak valid OR—was demonstrated; in all cases but one, this outcome was moving violations *except* speeding and restraint citations. As a general finding, it was observed that an OR value of approximately 2, or greater, was associated with a statistically significant (p<.05) chi-square test result.

Results of Conviction Analyses

<u>Motor Free Visual Perception Visual Closure Subtest (MVPT/VC)</u>. Figure 38 contains the results for the MVPT/VC. The top plot relates functional performance to conviction experience using "all moving violations" as the safety outcome measure. The middle plot relates functional status to the more restrictive outcome measure of "moving violations without speeding," and the bottom plot shows the distributions of License Renewal sample drivers with and without moving violations excluding speeding *and* occupant restraint citations at each level of functional ability measured by this test. In all cases, declining functional ability is indicated by an increasing number of <u>incorrect</u> responses, moving to the right along the *x*-axis.

Inspection of this figure reveals stronger relationships moving from the top plot, where the OR curve is virtually flat

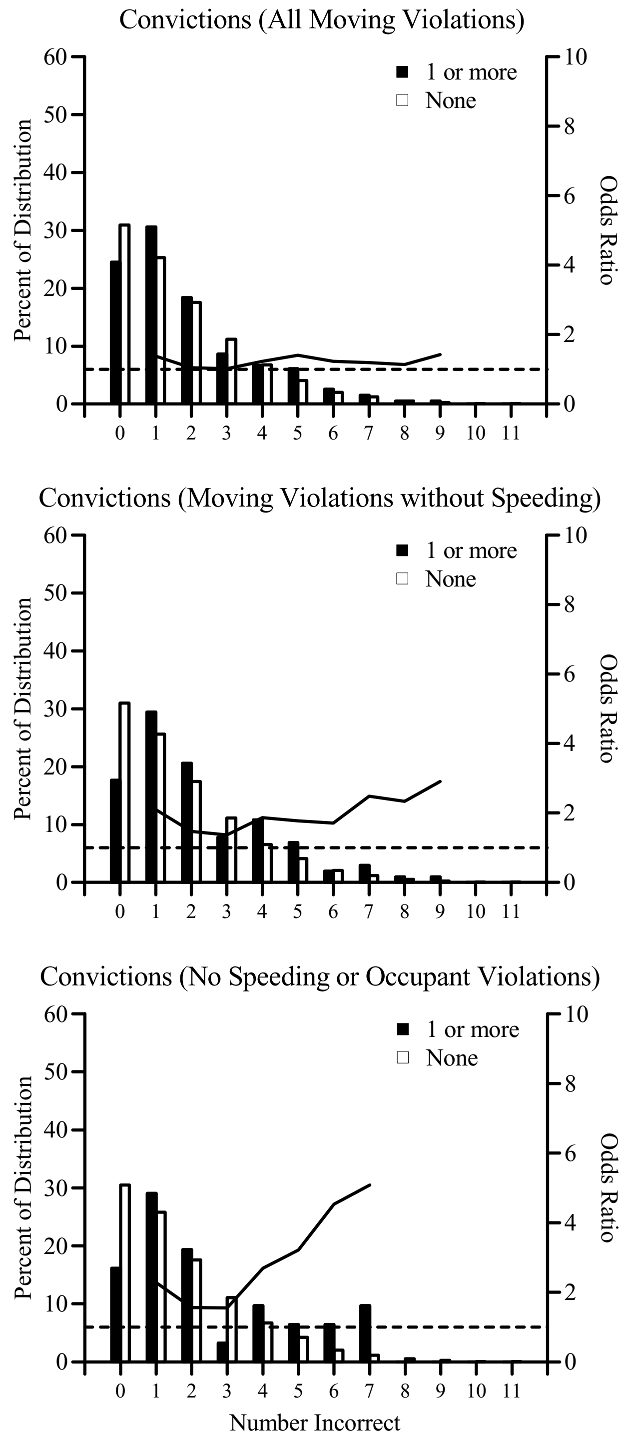

Figure 38. MVPT/Visual Closure Subtest distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

with calculated values all near 1.0, to the bottom data plot where a statistically significant ($G2$ = 10.83, df=1, $p<.001$) odds ratio of 4.53 was found. The cutpoint where this result was obtained was at a performance level of six incorrect responses. As shown in figure 38, a higher OR value was calculated for seven incorrect responses, but cell counts were too small for this calculation to be valid.

A consistent result that also is shown by this figure is the pattern in the relative percentages of drivers in the distribution with violations versus the percentage who were violation-free. In all three plots, there is a reversal at the performance level of three incorrect responses; otherwise, at every level of this measure except perfect performance (zero errors) more drivers who "failed" the test at a given cutpoint had moving violations than the number who remained violation-free.

The data plotted in figure 38 are presented in tables 56, 57, and 58 of appendix H. The chi-square test results noted above and cell counts can be found in table 77 of appendix I.

Delayed Recall. The relationships between performance on the Delayed Recall procedure and the three categories of moving violations are described by the plots shown in figure 39.

As shown, the association between functional status and moving violations, revealed through calculated OR values at each of the four possible levels for this measure, is generally weak. The peak valid OR, calculated for data described by the bottom plot, was 1.72. This result was obtained at the level of two incorrect responses; it approached but did not reach statistical significance ($G2$ = 1.58, n.s.).

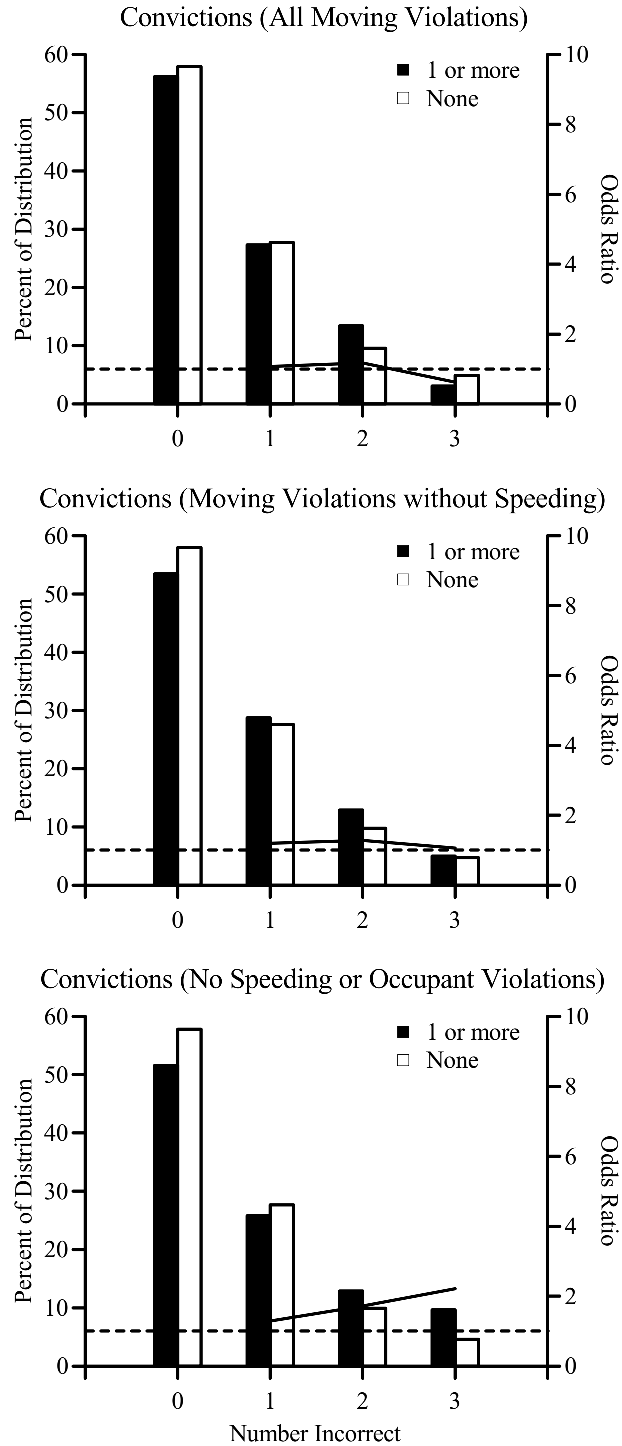

Figure 39. Delayed Recall distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

The data plotted in figure 39 are presented in tables 59, 60, and 61 of appendix H. The chi-square test results noted above, with corresponding cell counts, can be found in table 78 of appendix I.

Useful Field of View, Subtest 2. Figure 40 contains the results for the Useful Field of View, Subtest 2. The plots in this figure allow comparison of the distributions of drivers with and without moving violations at each target duration characterizing different performance levels for this measure. As noted earlier in the crash analysis section, all responses at target durations longer than 500 msec were grouped together at that performance level.

As shown in this figure, OR values hover near 1.0 at all performance levels, for all analysis categories, with almost exactly matching distributions of drivers with and without moving violations at each cutpoint. The peak valid OR calculated for Useful Field of View, Subtest 2 was 1.67; this result obtained at the target duration designated 100 msec in the analysis of "moving violations except speeding and occupant restraint citations." This result was not statistically significant ($G2 = 1.53$, n.s.).

The data plotted in figure 40 are presented in tables 62, 63, and 64 of appendix H. The chi-square test results noted above, with corresponding cell counts, can be found in table 79 of appendix I.

Trail-making, Part B. The results for this paper-and-pencil test of perceptual-cognitive ability are displayed in figure 41. After MVPT/VC, this

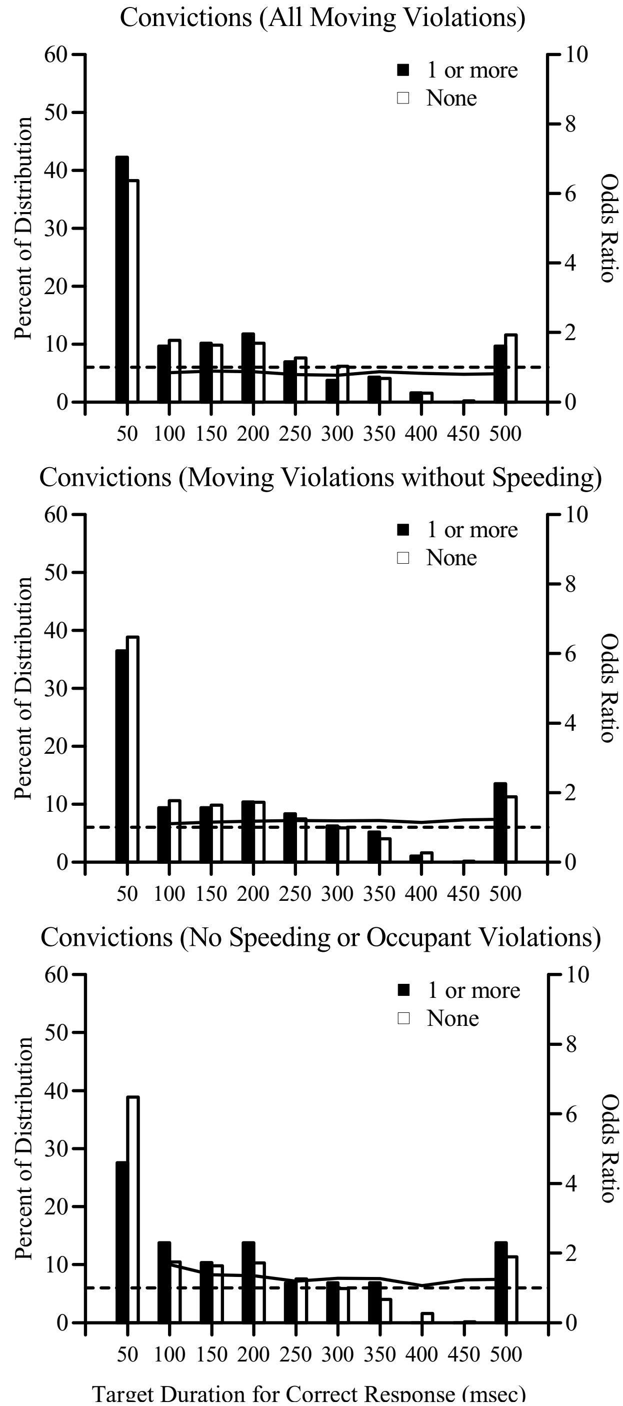

Figure 40. Useful Field of View, Subtest 2 distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

measure evidenced the strongest relationship of functional ability with moving violations found in these analyses.

Inspection of the OR curves in figure 41 shows the highest values in the middle and bottom plots. The highest valid OR calculated for this measure, 1.72, was found at the performance level designated 140 seconds for the analysis of moving violations except speeding. This result was statistically significant at *p*<.01 (G2 = 6.70, df=1).

The 140 msec performance level was also the cutpoint at which the percentage of drivers with moving violations exceeded the percentage of violation-free drivers by the widest margins, for all three of the analysis categories.

The data plotted in figure 41 are presented in tables 65, 66, and 67 of appendix H. The chi-square test results noted above, with corresponding cell counts, can be found in table 80 of appendix I.

Dynamic Trails. Figure 42 plots the results for Dynamic Trails. This automated test was related to the paper-and-pencil Trail-making (Part B) measure but was shorter, with fewer test items, and also potentially more distracting, with moving traffic in the background instead of a blank page.

With the exception of a spike at the 50-second performance level for the data in the bottom plot, which represented too few drivers for a valid analysis, the calculated OR value for this measure hovers near 1.0 across the board. The peak valid OR, 1.27, was found at the 25-second cutpoint in the bottom plot; this result was not statistically significant (G2 = .24, n.s.).

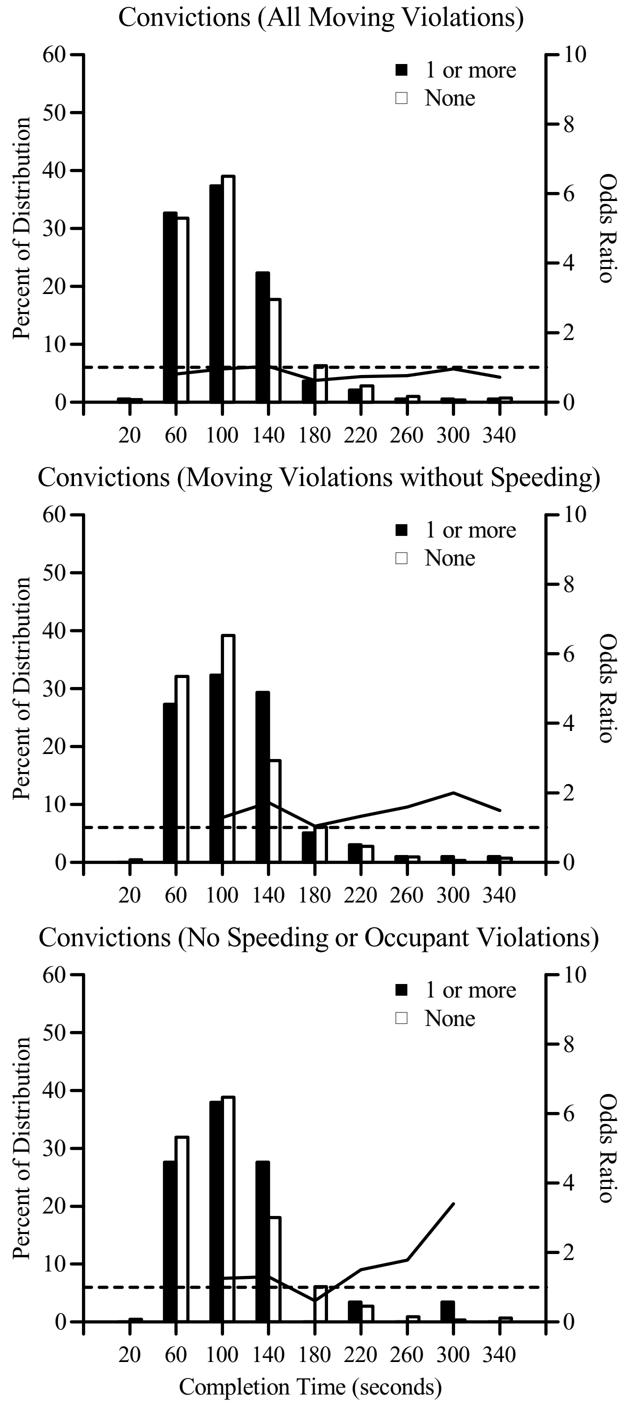

Figure 41. Trail-Making, Part B distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

However, there is convergence in these findings with the (at-fault) crash analysis, which also demonstrated a peak valid odds ratio at the same cutpoint.

It may again be noted that the sample size (n = 759) for this particular measure was only about half of that attained for other procedures in the screening battery.

The data plotted in figure 42 are presented in tables 68, 69, and 70 of appendix H. The chi-square test results noted above, with corresponding cell counts, can be found in table 81 of appendix I.

Scan Test. The remaining measure of perceptual ability, the Scan Test, was a binary measured scored simply on a pass/fail basis. With only one criterion possible, OR calculation is irrelevant to cutpoint determination, and no data plot was prepared.

For this measure, 95.6 percent of all drivers in the study sample—whether violation-involved or not—passed. Whether this was due to the insensitivity of the measurement procedure or whether these results reflect a true measurement of generally "intact" functional ability is unclear. Either way, the very small percentage of drivers failing the measure indicates a very limited utility for the Scan Test as a screening tool.

Of the 81 drivers who failed the Scan Test, only *one* was convicted of a non-speeding, non-occupant-restraint violation. This result precluded a valid OR calculation, and no chi-square test was performed for these data.

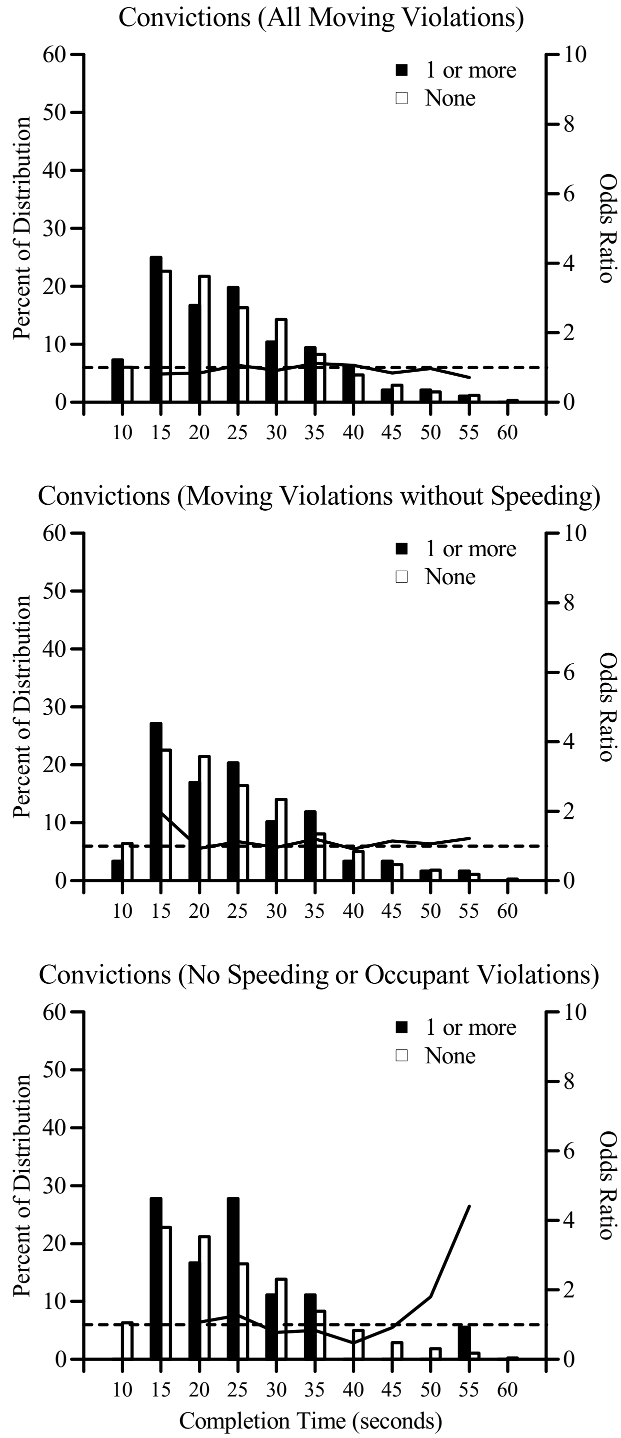

Figure 42. Dynamic Trails distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

Rapid Pace Walk. Figure 43 presents the plots for the Rapid Pace Walk measure, the first of the physical screening tests for which results are reported. As shown, the calculated OR value is at or below 1.0 except for the highest test completion times in all three plots for this measure.

The peak valid OR, 1.48, was calculated at the performance level designated 5.25 seconds in the analysis of moving violations except speeding. This result was not statistically significant (G2 = 0.96, n.s.). This same performance level was also where the percentage of drivers with moving violations exceeded the percentage without violations by the largest amount, in each analysis category.

The data plotted in figure 43 are presented in tables 71, 72, and 73 of appendix H. The chi-square test results and cell counts can be found in table 82 of appendix I.

Foot Tap. Data plots of the results of the Foot Tap measure are presented in figure 44. As shown, the odds ratio curves for the top two analysis categories are very close to the dashed horizontal line (OR = 1.0), indicating no relationship, until the poorest performance levels are reached. In fact, the peak valid OR of 2.14 is found in the top plot, at the 12.75-s level; this result approached but failed to reach statistical significance (G2 = 2.34, n.s.).

In the bottom plot, higher OR values were found, but cell counts were too few for a valid analysis. Also, the OR values in this plot range from higher to lower as performance shifts from "intact" to greater and greater degrees of functional loss. This counterintuitive finding is consistent with the results observed for this

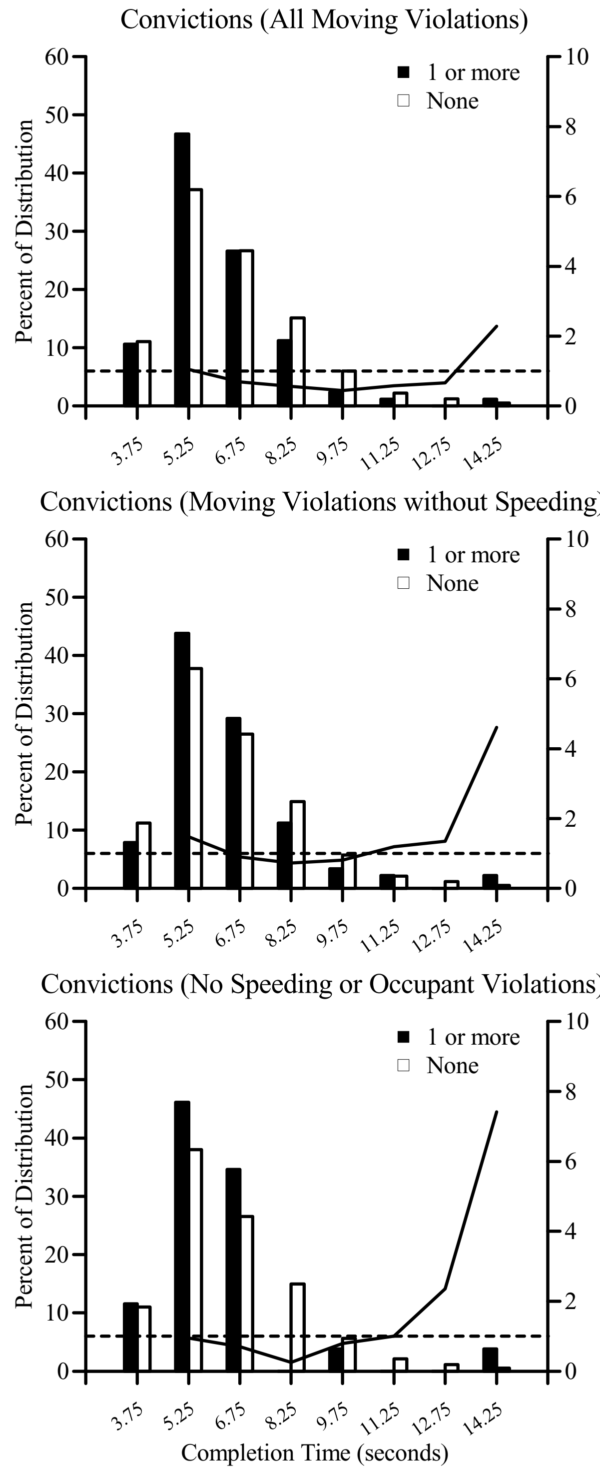

Figure 43. Rapid Pace Walk distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

measure in the earlier analysis of (at-fault) crashes.

The data plotted in figure 44 are presented in tables 74, 75, and 76 of appendix H. The chi-square test results and corresponding cell counts can be found in table 83 of appendix I.

Head/Neck Rotation. Because only pass/fail outcomes are possible for this (binary) measure, no odds ratio plot was prepared for the Head/Neck Rotation data. As noted earlier, 81.4 percent of drivers passed this test. When analyzed to examine the relationship between performance on this measure and moving violation experience, these data included only three drivers who failed the test *and* had at least one non-speeding, non-occupant restraint violation. This result also precluded a valid calculation of OR, and no statistical tests were performed on these data.

Arm Reach. Results for this remaining measure of physical ability, another binary (pass/fail) measure, were the most skewed among all screening activities as 99.3 percent passed, and only14 failed this test. Among those who failed, there were *no drivers* who received convictions for non-speeding, non-occupant-restraint violations. Accordingly, no valid OR calculations were permitted, and there are no chi-square test results to report.

RESOURCE REQUIREMENTS FOR FUNCTIONAL SCREENING

This section documents costs associated with the functional screening and evaluation activities undertaken in the Maryland Pilot Older Driver Study. It encompasses administrative and support

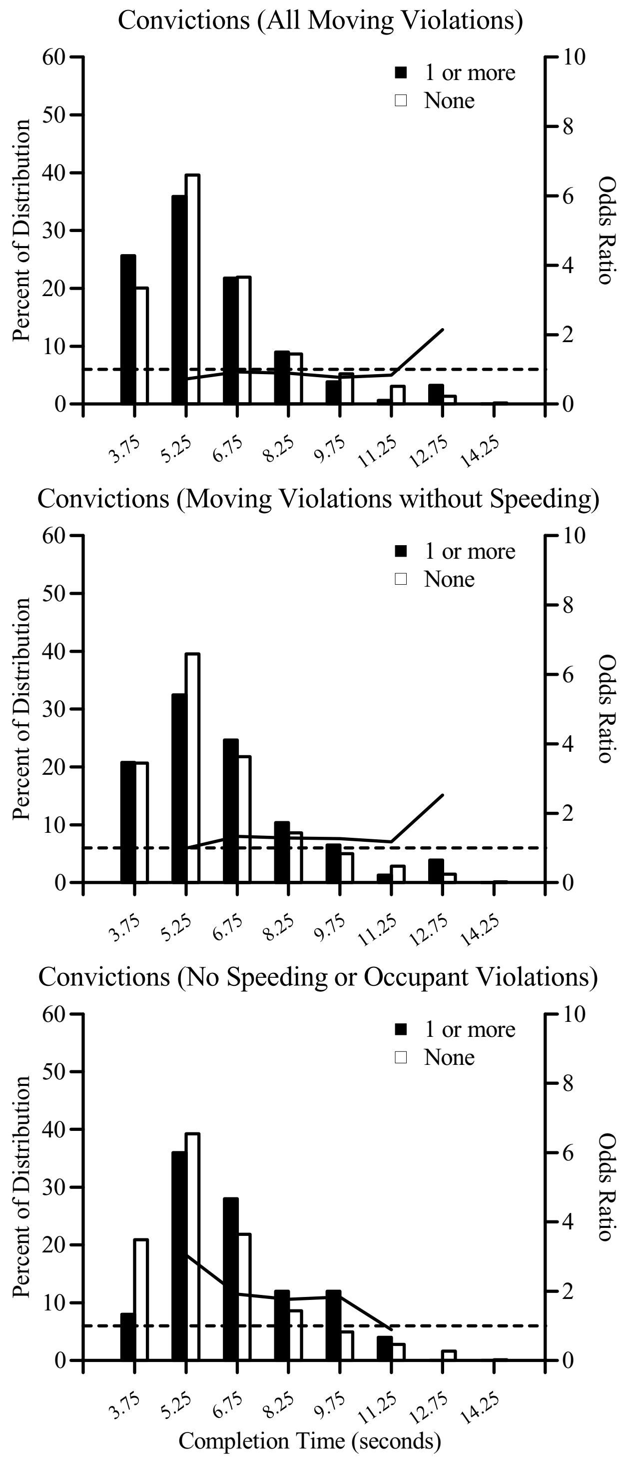

Figure 44. Foot Tap distributions and odds ratios for analyses including all moving violations, moving violations without speeding, and moving violations without speeding and occupant restraint citations.

activities, as well as the time actually spent by State employees performing the various testing procedures. The included cost data, as compiled by the MVA, represent the incremental costs of carrying out the Pilot Study, specifically; the costs associated with medical review of referred drivers when an activity or procedure was already a part of existing processes at the licensing agency are accounted for separately. Also, costs associated with the development of materials and procedures used during driver screening and evaluation by MVA staff are omitted from this accounting, to the extent that research team members' labor or equipment were covered under this NHTSA contract or other sources of extramural funding.

After documenting the costs experienced in a research setting to acquire the functional screening data in the Pilot Study, a projection of the *cost per licensed driver* interacted with by the MVA to accomplish functional screening in a production setting is presented, consistent with program parameters provided by the MVA. Supplemental costs associated with post-screening (education and counseling) activities are similarly estimated.

The cost accounting below is keyed to four categories: labor; equipment; training and quality control; and overhead. Labor costs include salary, and benefits where applicable, for the staff who conduct functional testing and who perform program administrative functions such as scheduling, customer contact, and data management. Equipment costs pertain to hardware and software resources needed to administer the functional tests. Training and quality control costs cover the time spent by MVA staff preparing to perform testing activities, and participating in periodic "refresher" sessions to maintain consistency in the administration of screening procedures. Overhead costs are limited to the space required to carry out the screening activities, apportioned according to the amount of time multi-purpose facilities at the MVA were dedicated to these activities.

Because different activities were performed in different venues, cost-per-driver-screened figures are calculated initially for screening activities performed with license renewal populations, then modified to account for differential costs in screening medical referral and residential community populations.

Beginning with functional screening for the *license renewal* sample in the Pilot Study. the total number of drivers who participated in screening activities was 2,381. Though only data for 1,876 were complete and valid, the costs described in this section will be based on the total number of drivers tested during the 11-month interval from the end of November to late in the following October.

To collect these data, the MVA utilized 7 line personnel who worked three days per week on this project. This translates to 4.2 full-time employees (FTE). The average hourly wage including benefits for a line employee is $15.00. Based on a work year of 2,080 hours, the cost for one FTE was $31,200; thus, the total annual cost for the 4.2 full-time employees who conducted screening may be estimated at $131,040. Adjusted for an 11-month study period, the resulting labor cost to acquire screening data for the license renewal sample was $120,120.

Administrative and logistics support for this data collection activity was provided by two research associates in the MVA Driver Safety Research Office, who devoted approximately one-third of their time each. At an hourly rate of $33.00, this resulted in an additional 0.66 FTE at an annual cost of $45,760. The adjusted figure for the 11-month duration of the Pilot Study is $41,947. Thus, total labor costs to perform functional screening for the license renewal sample in the Pilot Study may be estimated at $162,067.

The costs of equipment dedicated to screening activities in the Pilot Study were confined to additional computers (PC's) and peripheral devices (light pens and scanners), plus materials used for “manual” data collection (e.g., test stimuli and scoring forms). Specifically, three (3) PC's were purchased at $843 each, and subsequently were connected to a wide area network for data acquisition and data entry. Three (3) light pens were purchased at a cost of $258 each, to acquire data for measures where examinees actually needed to touch the screen to indicate their responses. And, two (2) CCD scanners used to read the bar codes on driver's licenses containing their driver identification (Soundex) numbers were purchased, at a cost of $198 each. Seven (7) test kits containing all materials and supplies used to perform the "Gross Impairment Screening" (GRIMPS) measures were also purchased, at a cost of $100 each. Total costs for equipment and supplies therefore may be estimated at $4,399.

Estimated costs associated with training and quality control may be derived based on the time that MVA staff who collected screening data and performed administrative and support functions were engaged in these activities. An initial training exercise spanning two, half-day (4–hour) sessions included ten (10) MVA line personnel and two (2) MVA research associates. For two days following initial training, ten (10) additional line personnel provided on-site supervision and observation of the individuals collecting screening data, for 6 hours each day. Through the duration of the Pilot Study, periodic visits for observation and “refresher” training to promote consistency and reduce errors in data collection and data entry procedures required a total of 12 full days of staff time at the research associate level. Together, these activities required the equivalent of 200 hours of time for line personnel, at $15/hr, plus 112 hours of research associate time at $33/hr, for a total of $6,696.

Finally, the real estate required to collect screening data for license renewal drivers in the Pilot Study consisted of a room in each of three MVA field offices. The rooms, which were used for other MVA functions when screening activities were not being performed, provided a footprint of approximately 100 square feet. At a fair market value of $12/ft^{2}/year, the cost of this space utilized full-time, would be $3,600. Utilized three days per week, the apportioned cost of MVA office space to conduct screening was 60 percent of this amount, or $2,160.

Summing the component costs identified above associated with Pilot Study efforts to acquire the functional abilities screening data, enter and store the data, and generate raw data tables to support the project analyses, for a sample of license renewal drivers tested at MVA field offices yields an estimated total cost of $175,322.

A preliminary estimate of the *cost-per-driver-screened* in the <u>research</u> settings of the Maryland Pilot Older Driver Study is reached by dividing this amount by the number of licensed drivers tested by the MVA under this programЬ2,381. The result is $73.63. This estimate is termed "preliminary" because, according to an MVA research associate,[1] the amount of time devoted to data collection, *per se*, averaged no more than 30 minutes per driver. The apparently much larger time requirement suggested by the 4.2 FTE figure cited above reflects a number of factors, most prominently challenges in recruiting the study sample: only older individuals were approached to be asked to volunteer for the license renewal study, and only about half of those approached agreed to participate.

A first step toward developing an estimate of the *cost-per-driver-screened* in a production setting versus the research setting is reached by limiting the time allowed per driver to only the 30 minutes (or less) that is necessary to acquire functional screening data. Because this activity would no longer be voluntary, many of the extra duties experienced by the MVA staff in the research setting would disappear. With this one adjustment, the cost element represented by the line personnel serving as data collectors in the Pilot Study is reduced to 1,191 hours (i.e., the number needed to screen the license renewal sample at one half-hour per driver) times the hourly wage of $15.00, or $17,865. Including equipment, training and quality control, and overhead costs as previously documented, the adjusted total cost is $31,120, or $13.07 per driver screened.

Next, certain cost elements were modified and others were added as data collection moved into other venues during the Pilot Study. Principal differences were the use of Driver License Examiners (DLE's) instead of line personnel to conduct screening for the *medical referral* sample; and, the addition of occupational therapists to provide feedback and counseling to drivers on the meaning of their screening results and changes in driving habits they should consider, with the *residential community* sample.

The DLE staff who performed functional screening of the medical referral sample earned a wage (salary plus benefits) of $20 per hour. The introduction of staff at this level followed observation of inconsistencies in test administration during Pilot Study data collection with the license renewal sample. The DLE staff, who were accustomed to performing a wide range of examination activities, did achieve a higher degree of consistency in administering the functional tests. In addition, because the medically-referred drivers were screened only during scheduled appointments, the test administration time was effectively limited to and consistently fell within the range of 20 to 30 minutes per driver, as stipulated above.

If all functions performed by line personnel in the cost estimate developed above—including training and quality control as well as data collection—are instead performed by DLE-level staff, the adjusted total cost for functional screening including equipment, training and quality control, and overhead increases to $38,075, or an estimate of $15.99 per driver screened.

Finally, when older drivers in the *residential community* sample were screened in the Pilot Study, an occupational therapist (OT) was available to provide feedback and counseling services. By design, these interactions were to be tailored as follows: functionally intact drivers would receive educational information about the relationship between functional ability and driving risk, advice on self-testing and what to do when abilities begin to decline in the future; while persons "failing" one or more screening measures, in addition to receiving educational

[1] *pers. comm.*, Mr. Jack Joyce, Senior Research Associate, Maryland Motor Vehicle Administration Office of Driver Safety Research, 8/9/02.

information, would be counseled on specific risks posed by their functional impairments and/or what actions were needed *vis-à-vis* changes in driving habits, where they should go for more in-depth assessment, and what options might be explored to remediate their functional loss. As a practical matter, however, the OT's time was limited to interactions with drivers for whom the screening activities indicated the most pronounced functional deficits. The occupational therapists participating in the Pilot Study were outside consultants, i.e., not MVA staff personnel, who were paid $45 per hour.

If OT's, nurses, or similarly-qualified professionals were engaged to provide counseling services on a broader scale, the incremental cost associated with this service would be driven by the percentage of drivers screened who would "fail" the functional ability screening, *and* the fraction of this group who would require one-on-one attention from a medical professional to have their questions answered or to receive the necessary referrals for further evaluation and/or to identify remediation options.

It is the perspective of MVA officials[2] that not more than 25 percent of the population of renewing drivers in the 55+ cohort would "fail" functional screening using a to-be-selected subset of the measures examined in the Pilot Study, and applying the cutpoints that are best supported by available data relating functional status to safety outcomes as *per* the analyses reported herein; and further, that a majority of even the "failing" drivers could have their needs for feedback and counseling effectively met by properly trained DLE-level staff. Only those individuals whose questions could not be answered adequately or whose need for an immediate referral required the attention or action of a medical professional would interact with an OT or nurse after completing screening. Accordingly, incremental cost estimates for the provision of post-screening services to the license renewal sample, in a production setting, are based on the following assumptions:

(1) Post-screening feedback for all of the "functionally intact" drivers (75 percent of the total number screened) would be accommodated through interactions with the DLE that focus on education and promote awareness of the functional abilities needed for safe driving, at 5 minutes per interaction;

(2) Eighty percent of drivers with significant functional loss (20 percent of the total number screened) would be accommodated through more extensive interactions with the DLE, at 10 minutes per interaction; and

(3) Twenty percent of drivers with significant functional loss (5 percent of the total number screened) would receive initial feedback from the DLE, lasting up to 10 minutes, then would require additional consultation with a medical professional, at 20 minutes per interaction.

Based on the $20/hr and $45/hr costs experienced in the Pilot Study for DLE and OT labor, respectively, these assumptions yield an incremental cost of $6,745, raising the total cost for screening and evaluation activities in a license renewal context to $44,819 and the *cost-per-driver* interacted with by the MVA to $18.82.

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[2] *pers. comm..,* Dr. Robert Raleigh, Chief, Maryland Medical Advisory Board, telephone conversation on 8/08/02.

It deserves mention that no costs have been included in these estimates for Pilot Study involvement by the Chief or the Daily Duty Doctors serving on the Medical Advisory Board at the MVA. While these individuals played key roles in the early planning and later evaluation of screening activities, an ongoing screening program is viewed as but one additional source of information complementing other data currently considered in medical reviews for fitness-to-drive determinations. Since fitness-to-drive determinations are a defining characteristic of the MAB, the only incremental cost in this process is represented by the *acquisition* of screening data plus whatever post-screening educational and counseling services, if any, are provided to drivers. The consideration of screening outcomes within the context of responsibilities normally discharged by the MAB, by comparison, does *not* represent an incremental cost.

Perhaps more importantly, it must be emphasized that the cost analysis in this section reflects screening activities (including data entry) that were performed mostly on a manual and labor-intensive basis—only two of the measures were automated—and by MVA staff for whom this was a completely novel assignment. As with any procedure, staff became more efficient and skilled in administering the functional tests with experience, especially the Driver License Examiners.

Most important from a cost standpoint is the potential to automate the majority of the most-promising measures emerging from the Pilot Study. Automation of data entry as well as data collection functions could enable one staff member to direct and monitor the screening of two or perhaps three drivers, and still provide feedback within the parameters outlined above. Under this scenario, the cost-per-driver-screened could be reduced to the range of $5 to $10.

Further discussion relating the cost estimates developed above to the anticipated benefits of a functional capacity screening program to identify persons at high risk of driving impairment is presented in Volume 1 of this report.

CHAPTER 5: SUMMARY AND CONCLUSIONS

The Maryland Pilot Older Driver Study collected and analyzed data describing the functional status of a total of 2,508 drivers age 55 and older between November 1998 and October 2001, sampled in three different venues: 1,876 License Renewal applicants, tested in Motor Vehicle Administration (MVA) field offices; 366 Medically Referred drivers, also tested in MVA field offices statewide; and 266 older drivers in a Residential Community, tested at Leisure World in Montgomery County, MD. The larger, License Renewal sample was deemed sufficiently representative of its age cohort to permit generalization to the broad population of older drivers, with respect to crash and violation experience; it served as the test bed for project data analyses examining the relationship between functional ability and a number of traffic safety outcome measures. Self-reported mobility restrictions and estimates of exposure also were collected and analyzed among all three study samples.

Ten measures of functional capacity were included in the research design. These were selected based upon prior, independent studies relating specific procedures and/or more general measurement constructs to safe driving ability and driving impairment, and upon a pre-pilot study suggesting that they could meet additional project criteria concerned with feasibility of test administration. All ten measures could be completed in approximately 20 minutes, on average.

Six screening procedures addressed perceptual-cognitive abilities—the *Motor-free Visual Perception Test/Visual Closure Subtest* assessed visuospatial skills, including the ability to visualize missing information as needed when only part of a threat object or other critical target is visible to a driver; *Trail-making (Part B)* used a paper-and-pencil exercise to measure directed visual search and divided attention capabilities, both essential to way-finding as well as rapid recognition of safety threats; *Dynamic Trails* also measured directed visual search and divided attention abilities, as above, but used a PC-based methodology with an added element of distraction provided by a moving traffic scene in the background; *Useful Field of View Subtest 2* used a PC to measure divided attention and information processing speed, specifically the peripheral target duration at which a person can correctly localize the target while maintaining attention with central vision, a key to safe intersection negotiation; *Delayed Recall* assessed "working memory" ability, needed for proper response to all manner of driving situations and traffic control devices, and for basic navigation; and the *Scan Test* sought evidence of visual field neglect and erratic scanning patterns.

Four screening procedures addressed physical abilities—the *Rapid Pace Walk* and *Foot Tap* tests measured lower limb strength and mobility as needed to sustain steady control over brake and accelerator operation, and to quickly shift from one pedal to the other as circumstances may require; *Head/Neck Rotation* measured whether or not an individual could look directly over his/her shoulder as needed to safely change lanes or merge, with the lower torso fixed in place with a seatbelt as when driving; and the *Arm Reach* test measured upper limb strength and flexibility as needed for effective steering control.

Safety outcome measures analyzed in this research included three levels of crash data and three levels of convictions for moving violations, applying progressively more stringent criteria to evaluate the relationship between functional loss and the risk of injury due to a motor vehicle crash. In the crash analyses, at-fault crashes were segregated from the larger set including crashes where fault was unknown, and from all police-reported crashes (i.e., without regard to fault). Assignment of fault was based on the report of the investigating police officer; to be reported, a crash must have been serious enough to require a vehicle to be towed from the scene.

In the conviction analyses, “all moving violations” were further sorted to exclude those for speeding—a behavior not typically associated with older drivers—and also to exclude violations of passenger restraint system laws that pertain to behaviors which, while critically important in determining the severity of injuries experienced in a crash, are arguably of less concern as precursors of a crash than infractions such as running a stop sign or traffic signal, failure to yield, one-way and wrong-way violations, etc.

Among the crash analyses, the strongest relationships with functional status were uniformly found when examining at-fault crashes only. Among the analyses of moving violations, the strongest relationships were most often found for that category of events described by “all moving violations without speeding and occupant restraint citations.” This is important from the standpoint of “construct validation”—the behaviors signified by these particular subcategories of events are those bearing the strongest *a priori* relationships to crash risk. And while the relationships based on conviction data were weighted less heavily than those based on crash analysis outcomes, they nevertheless provided key convergent evidence in identifying the best predictors among the screening measures included in the Pilot Study.

It was recognized that the analyses of safety outcomes, as related to drivers' functional status, were subject to several potential sources of bias. First, because test dates varied while a common cutoff date for driving history observations was applied to the analysis sample, there was a varying period during which drivers could have accumulated adverse safety outcomes. However, a comparison of the amount of time (in months) comprising the analysis intervals for crash-involved versus crash-free drivers showed no significant differences. Next, the question of whether exposure differences (i.e., apart from differences in functional status) might account for differences in crash experience among the study sample was raised; but, the only source of such information was self-reports. Internal checks between weekly versus annual estimates of miles driven, by the same individuals, underscored concerns about the reliability of these subjective data, as almost 50 percent of the responses demonstrated a 50 percent error rate in estimated miles driven. Though appealing in concept, without an objective index of how much driving occurs, and under what conditions, no “corrections” for individual differences in exposure in these analyses could be justified.

Descriptive statistics revealed broad differences between the three study samples. The License Renewal sample was approximately 10 years younger (mean age = 68.3) than the Medical Referral (mean age = 76.8) and Residential Community (mean age = 77.1) samples. However, the Residential Community sample mirrored the population-based License Renewal sample much more closely in terms of functional ability, especially with respect to perceptual-cognitive tests. This result reinforces the notion that functional status, not age *per se*, is of primary importance. In terms of self-reported mobility restrictions, the Residential Community and Medical Referral samples were more alike, particularly with respect to how often they “never” and “always” avoided problem situations (nighttime, bad weather, heavy traffic, etc.). Thus, drivers of similar age but differing in functional ability may nevertheless make similar behavioral adaptations in their driving habits, to compensate for a perceived increase in driving risk. This finding is useful in designing educational and counseling components of a screening and evaluation program.

The analysis results obtained in the Maryland Pilot Older Driver Study have provided perhaps the best evidence to date that functional capacity screening, conducted quickly and efficiently, in diverse settings, can yield scientifically valid predictions about the risk of driving impairment experienced by older individuals. The evidence that a person's ability to drive safely has been impaired, at a given level of functional decline, is based on "odds ratio" calculations. These calculated values express how much greater the odds are of being involved in a crash (and of committing moving violations) if a driver fails a test than if he or she passes it.

The results of the analyses relating functional status to crash involvement in this research are summarized in table 7 below, in terms of the peak (valid) odds ratio value calculated for each included screening measure. These odds ratio (OR) values highlight the *most predictive levels* attained by the various functional screens examined in the Pilot Study. At a value of 1.0, a driver has the same odds of being crash-involved if he/she passes a test as if he/she fails it; higher OR values connote greater predictive value. For comparison purposes, peak valid OR values for the same measures are also shown based on calculations using *prospective data only*. The inclusion of one year of retrospective driving experience data (keyed to each individual's test date) in the primary analyses was justified earlier, on medical grounds; however, it is reasonable to question how the results might have varied if restricted to the smaller data set described by a purely prospective analysis. Across both data sets (i.e., with and without the added year of retrospective driving experience), the strongest relationships were consistently demonstrated between functional status and at-fault crashes.

Table 7. Peak valid odds ratios for prediction of crashes.

Functional Capacity Screening Measure	**Peak Valid Odds Ratio** Prospective + 1 Year Retro	Prospective Only
Perceptual-cognitive measures		
Motor-free Visual Perception Test, Visual Closure Subtest	4.96	6.22
Trail-making, Part B	3.50	2.21
Delayed Recall	2.92	1.05
Useful Field of View, Subtest 2	2.48	3.11
Dynamic Trails	1.45	‡
Scan Test	‡	‡
Physical measures		
Rapid Pace Walk	2.64	1.70
Head/Neck Rotation	2.56	4.46
Foot Tap	1.50	1.06
Arm Reach	‡	‡

‡ One or more cell counts were too small to permit a valid odds ratio calculation.

As indicated, the Motor-Free Visual Perception Test/Visual Closure subtest was most predictive of (at-fault) crash involvement by drivers in the License Renewal sample, by a wide margin. Three additional perceptual-cognitive measures—Trail-making, Part B; Delayed Recall; and Useful Field of View, subtest 2—also were shown to be potentially useful predictors for identifying at-risk drivers. Among the physical measures, the Rapid Pace Walk and Head/Neck Rotation appear to have the greatest potential value as predictors of driving impairment.

The results of analyses relating functional status to convictions for three categories of moving violations are summarized in table 8 below, in terms of the peak valid odds ratio (OR) value calculated for each included screening measure. As before, the OR values express how much more likely drivers who fail a test are to experience a particular (negative) safety outcome—in this case a conviction for a moving violation—versus drivers who pass the test. While the behaviors associated with moving violations do not necessarily lead to crashes, they are clearly of concern to traffic safety professionals. Accordingly, these indications of driving negligence serve as secondary outcome measures for gauging the relative utility of different screening procedures.

Table 8. Peak valid odds ratios for prediction of moving violations.

Functional Capacity Screening Measure	**Peak Valid Odds Ratio**
Perceptual-cognitive measures	
Motor-free Visual Perception Test, Visual Closure Subtest	4.53[a]
Trail-making, Part B	1.72[b]
Delayed Recall	1.72[a]
Useful Field of View, Subtest 2	1.67[a]
Dynamic Trails	1.27[a]
Scan Test	‡
Physical measures	
Rapid Pace Walk	1.48[b]
Head/Neck Rotation	‡
Foot Tap	2.14[c]
Arm Reach	‡

‡ One or more cell counts were too small to permit a valid odds ratio calculation.
[a]Peak valid OR was calculated for analysis of moving violations without speeding and occupant restraint citations.
[b]Peak valid OR was calculated for analysis of moving violations without speeding.
[c]Peak valid OR was calculated for analysis of all moving violations.

As shown, the peak valid OR value was demonstrated for analyses of moving violations without speeding and occupant restraint citations, in a majority of cases. This was expected because this, the most restrictive analysis category, focused upon behaviors believed to be—but for random good fortune—the logical precursors of crashes, e.g., reckless, careless, and negligent operation; stop and yield violations; improper turning, passing, following, lane changing, and backing maneuvers; lane exceedance; and wrong-way and one-way movements.

In fewer cases the peak OR was found when occupant restraint violations remained in the analysis, and speeding violations only were removed from the analysis; and, in one case peak valid OR was found for the analysis of "all moving violations." No special importance is attached to these findings. With weaker relationships overall compared to those revealed in the crash analyses, there is more random fluctuation or "noise" in the violation data that can result in an anomalous high OR value at a particular performance level, for any given measure. The calculated odds ratio values presented in appendix H indicate that, across all performance levels, the strongest relationships (even if not statistically significant) obtain for the analyses focusing upon moving violations excluding speeding and occupant restraint citations.

Again, the Motor-Free Visual Perception Test/Visual Closure subtest was most predictive of negative safety outcomes—convictions for moving violations, in this case. The ordering of the remaining perceptual-cognitive measures in terms of peak valid OR values was the same as for the full crash analysis (including 1 year of retrospective experience), but weaker relationships were demonstrated across the board. The only other statistically reliable result was found for Trail-making, Part B, for the relationship between this measure and moving violations except speeding. For the physical measures, no statistically reliable relationships with the conviction measures were demonstrated, even at the performance levels where the peak OR was calculated.

The crash and conviction analysis results lead to the consideration of candidate "cutpoints," or pass/fail criteria, for measures that appear to be of potential value in identifying at-risk drivers.

It may be argued that judgments about the best cutpoints for pass/fail decisions should be pegged to the functional ability (test performance) level where a clear spike in OR is observed. If performance levels for the predictor variable are examined at very fine gradations, however, what may appear as a "spike" in calculated OR could actually be a spurious result that gives a misleading interpretation of the larger predictor-criterion relationship. Other problems include reversals in the OR curves, and/or the curve describing calculated OR for a specific measure may change so gradually that it is difficult to single out a candidate cutpoint on this basis. This is not surprising, given the sensitivity of OR calculations to the shift of a very small number of observations from one cell to another in the 4-way classification table defined by "pass" or "fail," versus "crash" or "no crash."

Thus, one conclusion of this work is that broader trends in the distributions of crash-involved versus non-crash-involved drivers also deserve consideration when identifying candidate cutpoints. Specifically, analysis outcomes must be scrutinized to determine where there is a clear performance-versus-safety transition in the distributions of crash-involved versus non-crash-involved drivers, i.e., to pinpoint a level of functional loss where the percentage of drivers in the former group begins to consistently exceed the latter.

A good example is provided by the at-fault crash analysis for the best-performing screening measure in the Pilot Study, MVPT/VC. Elements from an earlier plot of these analysis results that are most germane to this discussion are reproduced in figure 45. The ratio of crash-involved to non-crash-involved drivers, illustrated by the relative height of the black bars to the white bars, peaks at two different performance levels: 5 incorrect and 7 incorrect responses. Based on cell counts in the OR calculation matrix, however, only the analysis result for 5 incorrect is valid. Meanwhile, the transition point where the proportion of crash-involved drivers begins to "consistently exceed" the proportion of non-crash-involved drivers occurs between 3 and 4 incorrect responses.

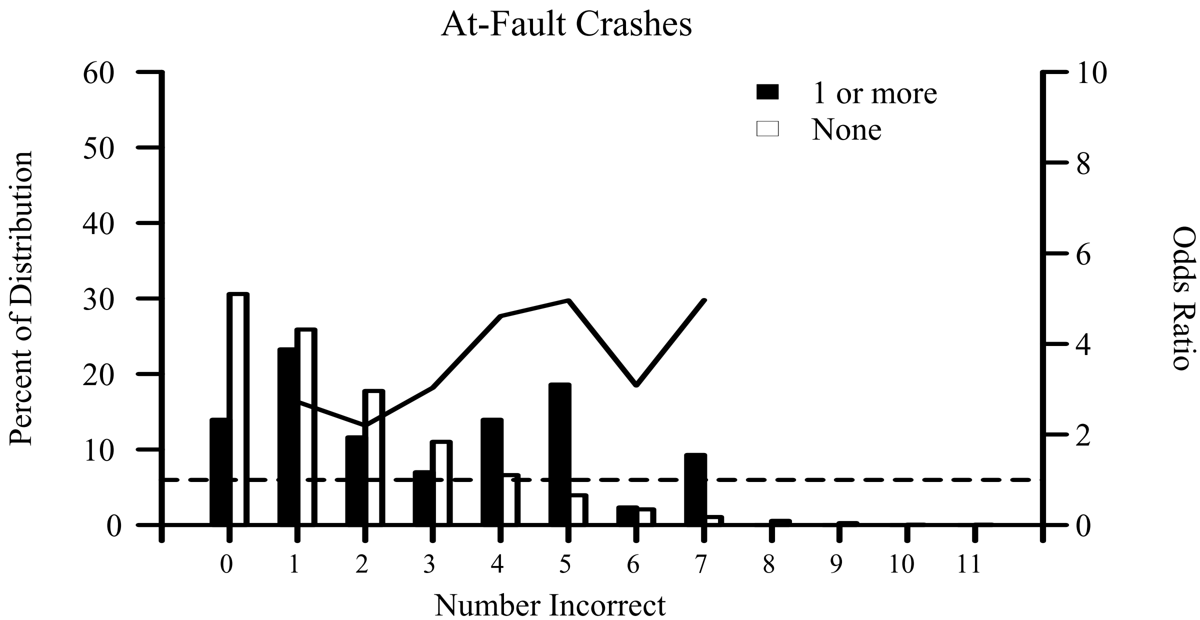

Figure 45. Motor-Free Visual Perception/Visual Closure subtest results illustrating the disparity between using isolated, peak OR values and shifts in the distribution of crash-involved, versus non-crash-involved, drivers as a basis for selecting pass/fail cutpoints.

But it is the overall shape of the two distributions that may be most revealing. While the distribution of non-crash-involved drivers shows a monotonic decline from zero incorrect (perfect performance) to 7 incorrect responses, the distribution of crash-involved drivers is distinctly bimodal—as if two separate distributions of crash-involved drivers are represented in the same plot.

An explanation for this analysis outcome with clear implications for cutpoint identification may be suggested. Among the non-crash-involved drivers, which constitute the vast majority—97.7 percent—of the total number screened, a normal distribution of functional ability should be detected by a valid test. For the MVPT, on a population basis, higher frequencies are observed with fewer errors, and a steady decline in frequency is observed as number of errors increases. This is precisely the monotonic curve demonstrated for the non-crash-involved drivers in the Pilot Study, bolstering the assertion that a representative sample was obtained for this study.

With regard to crash-involved drivers, only *some* would be expected to experience a crash because of this *particular* functional loss. The frequency distribution of their scores might be expected to differ from the rest who, logically, would have experienced their crashes because of a different kind of impairment, or simply by chance.

If this premise is valid, two separate distributions could indeed be represented among the crash-involved drivers. For the group whose driving has been impaired *because of this specific functional deficit*, a frequency distribution centered around a mean performance level representing significant functional decline can be postulated. For the other group—i.e., the drivers involved in crashes because of another type of deficit, or for reasons that have nothing to do with functional ability—there is no reason why the frequency distribution of scores on *this* measure should not follow the same pattern as for the general population.

The idealized set of curves presented in figure 46 may help to illustrate this suggested explanation for the observed analysis outcome.

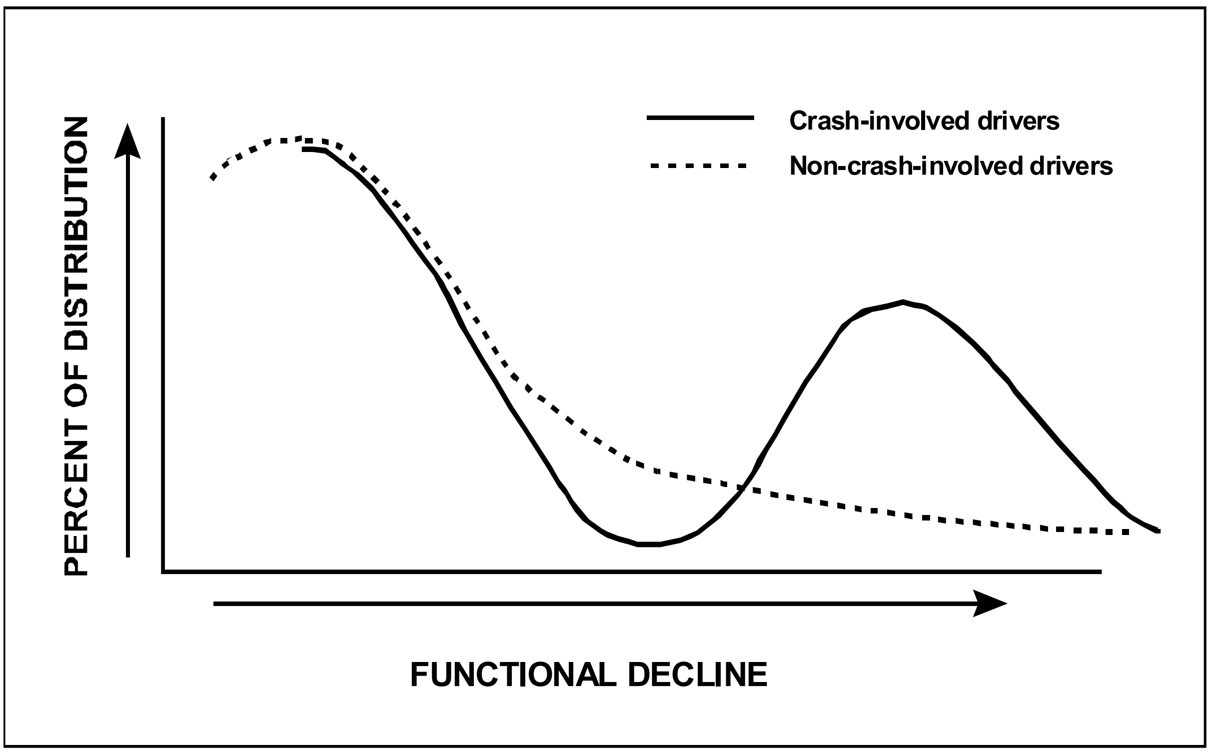

Figure 46. Idealized frequency distribution plot segregating crash-involved drivers into one group that is at risk because of the specific functional ability under consideration, versus another group that crashes because of other sources of impairment or random events.

This interpretation lends support to the identification of not one cutpoint per screening measure, but two. A cutpoint connoting an “early warning” that an individual's level of functional decline is just beginning to place him/her at higher risk of driving impairment may be distinguished from an "immediate danger" cutpoint, where functional decline has reached a level associated with the highest relative risk[1] of crash involvement compared to functionally intact drivers. The former may trigger *prevention* efforts; the latter signals a need for *intervention*.

For a majority of screening measures included in the Pilot Study, the analysis outcomes may be applied within this framework to identify candidate cutpoints as shown in table 9 below.

Table 9. Candidate cutpoints for screening measures in the Pilot Study that are supported by present crash analysis results.

Functional Capacity Screening Measure	**Candidate Cutpoint** Prevention	Intervention
Perceptual-cognitive measures		
Motor-free Visual Perception Test, Visual Closure Subtest	3 incorrect	5 incorrect
Trail-making, Part B	80 seconds	180 seconds
Delayed Recall	1 incorrect	2 incorrect
Useful Field of View, Subtest 2	200 msec	300 msec
Dynamic Trails	‡	‡
Scan Test	†	†
Physical measures		
Rapid Pace Walk	7.5 seconds	9.0 seconds
Head/Neck Rotation	†	†
Foot Tap	‡	‡
Arm Reach	†	†

‡ Analysis outcomes were not statistically reliable and/or too few observations to support cutpoint identification.
† N/A (binary measure)

In conclusion, the results of the Maryland Pilot Older Driver Study reinforce the proposition that loss of key functional abilities predicts an increase in driving impairment and higher risk of crash involvement. There is also evidence that it would be feasible to conduct functional capacity screening in a "production" (driver licensing) setting, at a cost in the range of $5 to $10 per driver screened. If only a subset of the battery of measures included in the Pilot Study were to be implemented, it would drive the cost-per-driver-screened even lower. Caution still must be exercised in using the study's findings to select "best" measures, however. It is the *domains of functional ability*, <u>not</u> particular measurement techniques, that should be the focus of

[1] For reference, calculations using the Relative Risk analytical technique yield results identical to the Odds Ratio calculation when critical outcome event (crash) counts are small.

attention given our present understanding of how well functional screening can detect high-risk drivers. While certain procedures yielded stronger relationships with crashes and moving violations than others in the Pilot Study, a need for methodological refinements and increased sample sizes to bolster confidence in the reliability of these findings, and to solidify cutpoint determination, is paramount. And it may confidently be assumed that better technology as well as better understanding of the sought-after relationships between functional status and safety will undoubtedly lead to superior screening and assessment tools in the future.

Finally, there are broader implications for developing and implementing a driver screening program that can be drawn from this experience in Maryland. Most importantly, to "fail" a screen does not necessarily mean that an individual should stop driving. It means that the individual's functional status places him or her at greater risk of a motor vehicle crash, and may establish a need for follow-up to more accurately diagnose underlying medical problems; to undergo, in some cases, a formal (on-road) driving evaluation; to consider changes in driving habits that reduce exposure to the most risky conditions; and to explore the potential for remediation to counter the indicated functional loss. Thus, the application of findings in the Maryland Pilot Older Driver Study, described herein, must be gauged in relation to a larger, integrated set of activities devoted to enhancing public safety while allowing older persons to continue driving as long as they can safely do so. This expanded discussion is a part of Volume 1 of the Final Technical Report submitted in this project.

REFERENCES

Centres for Health Evidence. "How to use an Overview." Based on the *User's Guides to Evidence-Based Medicine* and reproduced with permission from JAMA. (1994 Nov 2; 272(17);1367-71). www.cche.net/usersguides/overview.asp. (web site accessible as of 6/28/02).

Colarusso, R.P. and Hammil, D.D. (1972). *Motor-Free Visual Perception Test*. Western Psychological Services: Los Angeles, CA.

Diller, E., Cook, L., Leonard, D., Reading, J., Dean, J.M., and Vernon, D. (1999). *Evaluating Drivers Licensed with Medical Conditions in Utah, 1992-1996*. U.S.DOT/NHTSA Publication No. DOT HS 809 023. Washington, D.C.

Folstein, M.F., Folstein, S., and McHugh, P.R. (1975). "The Mini-Mental State. A Practical Method for Grading the Cognitive States of Patients for the Clinician." *Journal of Psychiatric Research*, 12, 189-198.

Koepsell, T.D., Wolf, M.E., McCloskey, L., Buchner, D.M., and Louie, D. (1994). "Medical Conditions and Motor Vehicle Collision Injuries in Older Adults." *Journal of the American Geriatrics Society*, 42(7), 695-700.

Marottoli, R.A., Cooney, L.M., Wagner, D.R., Doucette, J., and Tinetti, M.E. (1994). "Predictors of Automobile Crashes and Moving Violations Among Elderly Drivers." *Annals of Internal Medicine*, *121*, 842-846.

Owsley, C., Ball, K., McGwin, G., Sloane, M., Roenker, DLL., White, M.F., & Overley,T. (1998). "Predicting Future Crash Involvement in Older Drivers: Who is at Risk?" *Journal of the American Medical Association*, 279, 1083-1088.

Owsley, C., Ball, K., Sloane, M., Roenker, D., and Bruni., J. (1991). "Visual/Cognitive Correlates of Vehicle Accidents in Older Drivers." *Psychology and Aging*, *6(3)*, 403-415.

Owsley, C. and McGwin, G. (1999). "Vision Impairment and Driving." *Survey of Ophthalmolog*y, 43(6), pp. 535-550.

Reitan, R.M. (1958). "Validity of the Trail Making Test as an Indication of Organic Brain Damage." *Perceptual and Motor Skills*, 8, 271-276.

Sims, R.V., Owsley, C., Allman, R.M., Ball, K., Smoot, T.M. (1998). "Medical and Functional Factors Associated with Vehicle Crashes in Older Adults." *Journal of the American Geriatric Society*, 46: pp. 556-561.

Szlyk, J. P., Brigell, M., & Seiple, W. (1993) "Effects of Age and Hemianopic Visual Field Loss on Driving." *Optometry and Vision Science*, 70, 1031-1037.

University of Oxford, Center for Evidence-Based Medicine. "Odds Ratios." *How to Practice and Teach Evidence-Based Medicine*. www.jr2.ox.ac.uk/cebm/docs/oddsrats.html. (web site accessible as of 6/27/2002).

Vernon, D.D., Diller, E., Cook, L., Reading, J., and Dean, J.M. (2001). *Further Analysis of Drivers Licensed with Medical Conditions in Utah*. U.S.DOT/NHTSA Publication No. DOT HS 809 211. Washington, D.C.

Warren, M. (1990). "Identification of Visual Scanning Deficits in Adults After Cerebrovascular Accident." *The American Journal of Occupational Therapy*, 44(5), pp. 391-399.

APPENDIX A: MARYLAND RESEARCH CONSORTIUM GOALS, OBJECTIVES, AND ACTION STEPS

Table 10. Maryland research consortium goals, objectives, and action steps for working group 1: identification & assessment of high-risk older drivers.

Goal	***Objective***	***Action Steps***
A. Identify at-risk older drivers.	A1. Develop materials to permit those who come in contact with potentially at-risk older drivers to determine the need to have their driving abilities assessed.	A1a. Determine who can identify at-risk older drivers and the resources they need.
		A1b. Review/develop materials (e.g., checklists) appropriate for use by non-professionals to monitor driving and detect potential problems; users include older drivers themselves, their friends and families, and a wide range of lay caregivers and service providers in the community.
		A1c. Review/develop materials appropriate for use by professionals to detect potential driving problems; users include health care professionals, law enforcement professionals, and rehabilitation professionals.
	A2. Develop a quick, easy-to-administer screen to enable practitioners, including MDs, OTs, PTs, ADED, and others, to reliably assess the most at-risk older drivers.	A2a. Comprehensively list and describe tests now used by MDs, OTs, PTs, ADED, and other health professionals and practitioners to evaluate drivers= functional abilities.
		A2b. Relate performance on prior and current administrations of candidate measures to crash data; to over-involvement in moving violations; and to medical/ functional disability referrals to the MVA.
		A2c. Establish preliminary cutoffs for performance on 1st tier/screening measures to trigger 2nd tier tests.
		A2d. *See A1a above.*

Table 10 (Continued). Maryland research consortium goals, objectives, and action steps for working group 1: identification & assessment of high-risk older drivers.

A. Identify at-risk older drivers (cont=d).	A3. Develop a standard set of screening procedures to enable lay caregivers, DMV line personnel, Area Agency on Aging personnel, and other volunteers/non-professionals, to identify driving limitations; and provide accompanying materials so these personnel can identify who needs more detailed assessment or treatment, and where to obtain it.	A3a. Develop a Atest kit@ of inexpensive materials that can be used in diverse (field) settings. A3b. *See A1a above.* A3c. *See A2b above.* A3d. *See A2c above.*
B. Identify which at-risk older drivers are the best candidates for rehabilitation.	B1. Define a standard set of screening/diagnostic procedures to determine whether at-risk older drivers can be rehabilitated.	B1a. Review research studies/rehabilitation literature to determine what diagnoses have the potential to be successfully remediated. B1b. Review content and protocols of diagnostic tests to determine how functional limitations of at-risk older drivers can be assessed. B1c. Develop recommendations for specific test procedures and protocols (hardware & software) and who can/should perform them.

Table 10 (Continued). Maryland research consortium goals, objectives, and action steps for working group 1: identification & assessment of high-risk older drivers.

C. Identify which at-risk older drivers can drive in a restricted manner.	C1. Define a standard set of screening/diagnostic procedures to determine whether at-risk older drivers need to change their driving patterns/exposure.	C1a. Determine from literature what conditions require what kind of driving restrictions.
		C1b. Review research conducted in other states (e.g., Utah) to determine effectiveness of restrictions for specific medical conditions in reducing crash risk.
		C1c. Evaluate the current restriction policy in Maryland to determine whether/what restrictions reduce crash risk, for which drivers.
		C1d. Identify road test components required to determine whether drivers can compensate for their disabilities.
		C1e. *See B1c above.*
		C1f. Identify research required to develop more objective criteria for driving restrictions.

Table 10 (Continued). Maryland research consortium goals, objectives, and action steps for working group 1: identification & assessment of high-risk older drivers.

D. Identify which at-risk older drivers need to stop driving.	D1. Define a standard set of screening/diagnostic procedures to identify those who should stop driving.	D1a. Determine from literature what driving cessation/license surrender policies and review practices are in place for medical conditions/functional impairment levels.
		D1b. List minimum levels of performance for MVA licensing (e.g., scores on knowledge and vision tests, and on-road driving evaluations).
		D1c. Describe levels of functional impairment or progression of medical conditions at which MAB/other health care providers determine that driving is no longer safe.
		D1d. Identify road test components that clearly indicate individuals who should not drive.
		D1e. *See B1c above.*
E. Identify and describe functional limitations that would interfere with or preclude use of specific forms of alternative transportation.	E1. Develop a matrix relating levels of cognitive and physical capability to alternative transportation and services.	E1a. Determine levels of cognitive and physical capability required to use transportation alternatives.
		E1b. Determine who has the ability to use alternative transportation, and the information needed.
		E1c. Determine (with WG III) who provides what alternative transportation options for which populations, particularly the disabled.

Table 11. Maryland research consortium goals, objectives, and action steps for working group 2: remediation and counseling contributions to safe mobility.

Goal	***Objective***	***Action Steps***
A. A mechanism to refer and place at-risk individuals in appropriate remedial treatments, and track treatment outcomes.	A1. Produce a matrix of treatments and providers for the population served by each service organization, for each deficit revealed through referral, screening, or diagnostic testing, and description of interrelationships and roles of providers.	A1a. Create a list of functional impairments (drawing from the efforts of WG I).
		A1b. Perform a critical review of what conditions are remediable through restoration of functional ability, or adaptation/compensation for functional loss.
		A1c. Develop a list of appropriate agencies, centers, or personnel that address, treat, or train for improvement or compensation for noted deficits/impairments and their interrelationships.
		A1d. Set guidelines for the agency which is to coordinate and orchestrate the evaluation, treatment, remediation, and counseling.
	A2. Develop a database, plus administrative protocols, to monitor client status and share information among service providers and the licensing agency.	A2a. Identify appropriate software tools to use the Internet for sharing information among all consortium entities, including limited development of input screens as required; perform usability tests.

Table 11 (Continued). Maryland research consortium goals, objectives, and action steps for working group 2: remediation and counseling contributions to safe mobility.

B. Remediate older drivers whose functional disabilities are correctable.	B1. Develop guidelines for practitioners, including PTs, OTs, rehab specialists, vision specialists, and other health professionals; and for non-health professionals, including social service personnel, driving instructors, and others who support driver improvement through remediation, education, or skills training.	B1a. Review research where available and/or collect case data to determine validity or effectiveness of remediation techniques.
		B1b. List and describe existing or new remediation techniques or procedures, their target populations and application.
		B1c. Survey practitioners to see who can perform what rehabilitation activities.
		B1d. Develop or sponsor a training course for people who remediate older drivers.
	B2. Develop curriculums necessary to train appropriate personnel to address remediation and driver training.	B2a. Survey and select existing curriculums/ components for training staff to perform driving rehabilitation activities
		B2b. Determine procedures and costs of training the trainers.
	B3. Evaluate the feasibility of providing remedial treatments for functional disabilities.	B3a. Determine staff qualifications, level of training, equipment & facility needs, course/duration, resulting cost, and reimbursement eligibility for remedial treatments.

Table 11 (Continued). Maryland research consortium goals, objectives, and action steps for working group 2: remediation and counseling contributions to safe mobility.

C. Counsel older drivers faced with restriction or cessation of driving.	C1. Develop guidelines for counselors specific to the population served, and to the (older) drivers= deficit(s) as revealed through referral, screening, or diagnostic testing.	C1a. Review and evaluate counseling programs for older drivers and their families, and select best examples for present use.
		C1b. Identify what types of information and communications are most appropriate and effective for whom.
		C1c. Establish skill/training requirements for different counseling needs (e.g., practical A*how to-s*@ versus clinical depression and related symptoms).
	C2. Develop guidelines for recommending driving restrictions.	C2a. List and describe recommended changes in driving that follow from identified, non-remediable functional limitations.
		C2b. Identify when drivers who do not comply with a recommendation should be reported to the MVA.
		C2c. *See C1b above*.
	C3. Develop guidelines for recommending driving cessation.	C3a. List and describe recommended uses of alternative transportation options that follow from identified, non-remediable functional limitations.
		C3b. *See C2b above.*
		C3c. *See C1b above*.

Table 11 (Continued). Maryland research consortium goals, objectives, and action steps for working group 2: remediation and counseling contributions to safe mobility.

D. Identify mechanism(s) to fund evaluation, training, rehabilitation, equipment purchase, and counseling services re: maintaining safe mobility.	D1. Develop a matrix of funding resources, including health care/medical insurance industry participation.	D1a Determine costs.
		D1b. Determine resources.
		D1c. Identify cost savings derived from improved assessment, rehab, and counseling activities.
		D1d. Conduct a cost-benefit analysis.
		D1e. Recommend appropriate cost-reduction strategies.

Table 12. Maryland research consortium goals, objectives, and action steps for working group 3: mobility options for individuals facing driving restriction or cessation.

Goal	***Objective***	***Action Steps***
A. Determine the mobility needs of those who must reduce or stop driving.	A1. Identify which mobility needs are being met, and how.	A1a. Review existing information, and if necessary, conduct survey through Area Agencies on Aging to document mobility needs and desires of older clients.
		A1b. Analyze the attributes that contribute to adequacy/desirability of mobility options for Asatisfied@ clients.
	A2. Identify which mobility needs are not being adequately met, and why.	A2a. *See A1a above*.
		A2b. Develop a list of needs that are not being met (e.g., seniors in Montgomery County who cannot find ways to travel to Johns Hopkins in Baltimore for medical treatments).
	2. Compile the information in formats which will be of most use to providers, seniors, and family members.	

Table 12 (Continued). Maryland research consortium goals, objectives, and action steps for working group 3: mobility options for individuals facing driving restriction or cessation.

B. Identify mobility options at the local level.	B1. Develop an inventory of all mobility resource options in communities across the country and in Maryland counties where pilot studies will be initiated.	B1a. Compile an inventory of resources, usage, and contacts by community (as providers, brokers, clearinghouses).
		B1b. Contact relevant agencies that deal with senior transportation (both formal and informal) and alternative services (e.g., in-home delivery services).
		B1c. Inventory senior community living facilities that provide transportation for residents (for individuals who would benefit most by relocation to improve mobility).
		B1d. Contact foundations (e.g., Robert Wood Johnson) to identify mobility programs they support.
	B2. Evaluate best practices among currently available options.	B2a. Survey seniors and family members to determine how currently-used options are accessed.
		B2b. Survey seniors and family members to determine why currently-used options are selected.

Table 12 (Continued). Maryland research consortium goals, objectives, and action steps for working group 3: mobility options for individuals facing driving restriction or cessation.

C. Develop mobility options information and guidelines, and disseminate to groups/agencies in need of such information.	C1. Determine which information (re: mobility options) will be of most use to providers, seniors, and family members in pilot study counties, and present in the form of guidelines to foster best practices in local areas.	C1a. Investigate structure of service provision in the selected communities. C1b. Determine if structure for this project must be the same in each community or if it is more practical to utilize existing resources. C1c. Determine which structures have the maximum potential for success (such as AAA, MVA, central clearinghouse such as Connect-A-Ride, county I&R services) based on past performance where possible. C1d. For all structures, determine capabilities of service providers to perform mobility counseling - type of personnel, time requirements, office space, etc. C1e. For all structures, identify methods by which clients can access mobility providers, particularly informal providers. C1f. Develop needed job specifications, training reqs., materials, etc.

Table 12 (Continued). Maryland research consortium goals, objectives, and action steps for working group 3: mobility options for individuals facing driving restriction or cessation.

C. Develop mobility options information and guidelines, and disseminate to groups/agencies in need of such information (cont=d).	C2. Prepare information for dissemination.	C2a. Identify the specific groups to whom the information will be targeted.
		C2b. Identify the specific provider contacts who will disseminate the information.
		C2c. Insure content is consistent with requirements of providers.
		C2d. Format information in such a way to be helpful to providers and seniors.
D. Update database on mobility options and guidelines.	D1. Develop central database containing all information re: mobility options, that is flexible enough to compile reports in a variety of formats, building on closely related efforts (e.g., Maryland FTA project) to the greatest extent possible.	D1a. Develop database.
		D1b. Develop methods and formats to disseminate database information to appropriate sources.
		D1c. Develop effective means of updating information on a frequent basis.
		D1d. Develop ways to relay this updated, local information back to the central database.
	D2. Develop quality control methods.	D2a. Develop standard intake form for all "clients" receiving data, regardless of location.
		D2b. Develop quality-of-service survey for providers.
		D2c. Develop quality-of-service survey for the recipients.

Table 12 (Continued). Maryland research consortium goals, objectives, and action steps for working group 3: mobility options for individuals facing driving restriction or cessation.

E. Secure best resources to ensure safe mobility.	E1. Identify what new funding and/or human resources are needed to maintain and enhance safe mobility options.	E1a. Assess unmet needs in each community.
		E1b. Determine if current structures can be enhanced to meet these needs or if new options are needed.
		E1c. Develop detailed description of new service to meet needs that cannot be addressed though enhancement of existing options.
		E1d. Identify stakeholders in community and determine extent to which they will support new options.
		E1e. Develop ways to relay updated local information back to the central database.
	E2. Determine sources of funding.	E2a. Investigate various payment and funding options: users, families, insurance, business, HMO=s, etc.
		E2b. Investigate use of volunteers, including coordinating agencies and foundations.

Table 13. Maryland research consortium goals, objectives, and action steps for working group 4: public information & education campaign.

Goal	***Objective***	***Action Steps***
A. Provide a broad social awareness that loss of mobility is a serious health and quality of life issue for older people.	A1. Market the goal to citizens and professionals alike.	A1a. Develop PR materials which illustrate how maintaining safe mobility is central to maintaining physical and mental health in old age.
		A1b. Identify a spokesperson(s) to deliver our message.
	A2. Develop an educational campaign on the varied impacts of loss of mobility for seniors.	A2a. Identify and estimate the changes in physical and mental status that are associated with declining mobility and social isolation.
		A2b. Identify available PI&E resources and determine additional needs to attain the goal.
		A2c. Create campaign content, implementation strategy, and evaluation plan.
B. Provide a broad social awareness that a scope of driving that is inappropriate to an individual=s functional abilities is a serious public health issue.	B1. Market the goal to citizens and professionals alike.	B1a. Develop PR materials which illustrate how safe mobility lowers costs to society while improving quality of life for seniors.
		B1b. Identify a spokesperson(s) to deliver our message.
	B2. Develop an educational campaign on the impact of age-related diminished functional capabilities on driving.	B2a. Identify and estimate the magnitude of driving risks that result from functional impairments.
		B2b. Identify available PI&E resources and determine additional needs to attain the goal.
		B2c. Create campaign content, implementation strategy, and evaluation plan.

Table 13 (Continued). Maryland research consortium goals, objectives, and action steps for working group 4: public information & education campaign.

C. Dissemination of tools supporting widespread, effective identification & evaluation of declining abilities to drive by older persons themselves; by their health care providers; by their families and friends; and by other senior support professionals or volunteer organizations.	C1. Develop materials describing functional limitations & assessment techniques suitable for dissemination to each group targeted in goal statement.	C1a. Incorporate information needs identified by other MRC Working Groups into requirements for PI&E materials. C1b. Identify education and evaluation materials developed by other agencies or traffic safety organizations. C1c. Select/combine most appropriate content and best formats and media. C1d. Identify commercial sites (e.g., pharmacies, grocery stores, etc.) most frequently-visited by target population, for distribution of materials. C1e. Identify service providers (e.g., physicians and other health care facilities, senior citizen centers, driver license centers) most frequently-visited by target population, for distribution of materials.
C. Dissemination of tools supporting widespread, effective identification & evaluation of declining abilities to drive by older persons themselves; by their health care providers; by their families and friends; and by other senior support professionals or volunteer organizations (cont=d).	C2. Develop support materials meeting the needs of those who counsel older drivers.	C2a. Review/select current best practices to identify functional limitations and their influence on safe driving and/or use of transportation alternatives. C2b. Review/select best practices to direct those who come in contact with older drivers on how to get help for further (diagnostic) assessment.

APPENDIX B: MATERIALS USED TO RECRUIT SUBJECTS FOR THE LICENSE RENEWAL SAMPLE, THE RESIDENTIAL COMMUNITY SAMPLE, AND THE MEDICAL REFERRAL SAMPLE

MVA
Motor Vehicle Administration

Can you help?

You are vital!

MVA is studying a new program that is designed to help keep you driving safely.

Your participation is completely confidential and will <u>not affect your driving status</u> in any way.

Please say *YES* when a study representative asks for your help with a few interesting exercises before you leave today. These are summarized on the back of this card.

Thank you for your cooperation.

You *can* and *do* make a difference!

Safe Driving Abilities We Are Studying

Our study representative will take you through a few simple exercises in another room in this building. These are aimed at the safe driving skills listed below.

1. <u>Lower Limb Strength and Flexibility</u>
   Driving Skills: Moving your leg to shift back and forth quickly from the gas to the brake.
2. <u>Upper Body Flexibility</u>
   Driving Skills: The strength to turn the steering wheel quickly in an emergency, and the ability to look behind you to check for traffic.
3. <u>Pattern Recognition</u>
   Driving Skills: Advance understanding of a sign's meaning from information about its shape only.
4. <u>Recall</u>
   Driving Skills: Remembering to use safe driving practices and following simple directions.
5. <u>Visual Attention and Scanning Exercises</u>
   Driving Skills: Searching for important features when scanning the roadway ahead.

Figure 47. Card used to recruit subjects in the MVA renewal sample.

Maryland Research Consortium

The Motor Vehicle Administration (MVA) is pleased to extend the services of its mobile office, MVA ON WHEELS, to the residents of Leisure World. We will be offering a broad range of transactions including Driver License and Vehicle Registration renewals, Photo ID cards, Certified Copies of your Driving Record, Disabled Tags and Placards, Change of Name and Address, Voter Registration, Organ Donor registration, Tag Return, Duplicates, and Corrections. We will accept payment in cash, money orders, Visa/MasterCard, or personal check (with two current IDs).

At the April 1999 Community Council meeting, Dr. Raleigh spoke of his appreciation that the residents of Leisure World would be involved in the Maryland Driver Safety Research Program. These research activities now underway in Maryland will be part of your visit to MVA ON WHEELS. This driver safety research activity will help us understand how vision, physical abilities, and other skills used in driving change as we age. All of us age differently, and at one point we may place others and ourselves at risk for death or injury from motor vehicle crashes. Impaired driving from functional change is a public health issue and we must learn to accurately screen for driving skill loss as we screen for cancer and heart disease.

Please rest assured that participation will have no effect on your individual driver license. However, your involvement will help set guidelines for the future in keeping drivers behind the wheel longer and with greater safety. No individual's results will ever be identified as this information is collected during this 15-20 minute screening. We will only use group data to statistically validate the screening procedures. In the years ahead, we may employ the results of this study to propose changes to Motor Vehicle policy. This research will become very important as we approach the year 2011, when the first "baby-boomers" will turn 65 years of age.

The MVA ON WHEELS, in the Clubhouse II parking lot, schedule for the remainder of 1999: July 6; August 3; September 7; October 5; November 2; November 30. Hours of operation are 10 a.m. - 3p.m. For information call: 410-424-3128. The monthly schedule for the year 2000 will be available December 1999.

We feel certain that on-site availability of these services will prove to be a major convenience to the residents of Leisure World. At the same time, your participation in the research activities of the Maryland Research consortium will be a valuable input to the development of guidelines and policies for continued safe mobility for us all.

Figure 48. Advertisement for MVA ON WHEELS in the July 1, 1999 issue of Leisure World News.

Motor Vehicle Administration Mobile Office

On Tuesday, November 2, the MVA Mobile Van will be in Leisure World at Clubhouse II. Residents will be able to conduct all MVA business at this site from 10:00 a.m. to 3:00 p.m.

Leisure World is also participating in a voluntary senior driver research program with the MVA. Residents are encouraged to participate in a number of tests that will identify driving skill loss and assist in keeping seniors driving safely longer.

Figure 49. Monthly advertisement in the *Leisure World News*.

MOTOR VEHICLE ADMINISTRATION Department of Transportation 6601 Ritchie Highway, N.E. Glen Burnie, MD 21062	HEALTH INQUIRY COVER PAGE Driver Control Division	Health Inquiry Package Questions? Please Call: 1-410-768-7361 *TTY For the Deaf 1-800-492-4575*

____
NOTICE DATE

____
DUE DATE FOR ALL FORMS

The Motor Vehicle Administration has received information that indicates you may have a medical condition that could affect your ability to drive safely. Three forms are enclosed. When properly completed, these forms often allow our Medical Advisory Board (MAB) to make an evaluation about your fitness for driving. These forms are:

1). Medical Advisory Board Health Questionnaire: your medical history and your understanding of your overall situation are most valuable in helping us develop an accurate appreciation of your condition. Your completed questionnaire will be reviewed carefully by at least one MAB doctor. Please be candid: the information you provide will be treated with the professional confidentiality appropriate to any personal medical communication. All MAB doctors and members of the administrative staff which supports them are bound by their own ethical standards and the Maryland Vehicle Law (paragraph 16-118(d)) to ensure the contents of MAB records are used only to determine qualification to drive and are never disclosed to others. We must use this questionnaire in our review of the great variety of clinical problems evaluated by the MAB – medical, surgical, psychiatric, substance abuse, and so forth; it also may be used in driver safety research projects. Some of the questions might seem unrelated to your situation, but these often turn out to be important for us, so we hope you will be willing to answer all of the questions.

2). Consent for Release of Confidential Information: please provide the name, address, and phone number of both your primary care physician and other doctors or treatment providers who've been involved in your care so we'll be able to contact them if that should become necessary.

3.) Physician's Report: we hope your doctor will explain your clinical condition on this form in sufficient detail to enable the MAB to estimate the risk, if there is any, to highway safety. Please fill out Section 1 and then ask your doctor to complete the form and return it to us within two weeks of the date our letter was sent to you. If you and your doctor prefer, you may enclose the completed Physician's Report with the other forms you return to us. If you feel our understanding of your condition will require information from more than one physician, you may reproduce the form enclosed or, you may contact your Case Manager and additional forms will be sent to you.

4.) Driver Safety Screening: as part of the review process, we will conduct several driver safety screening tests. Please contact ______________________ at (410) xxx-xxxx who will schedule the screening at one of our MVA full-service offices. Following the screening and review of all medical documentation, you will be further advised.

Please respond promptly. Our commitment to highway safety requires when a driver fails to provide the information requested by the due date, we must render a conservative decision about suspension of the driving privilege. If a suspension is necessary, the right to appeal the decision and the process for doing so will be explained.

______________	______________	______________
CASE MANAGER	DATE	TELEPHONE

Figure 50. Letter Sent to Subjects in the Medical Referral Sample.

APPENDIX C: ACCESS DATA STRUCTURE AND VARIABLES

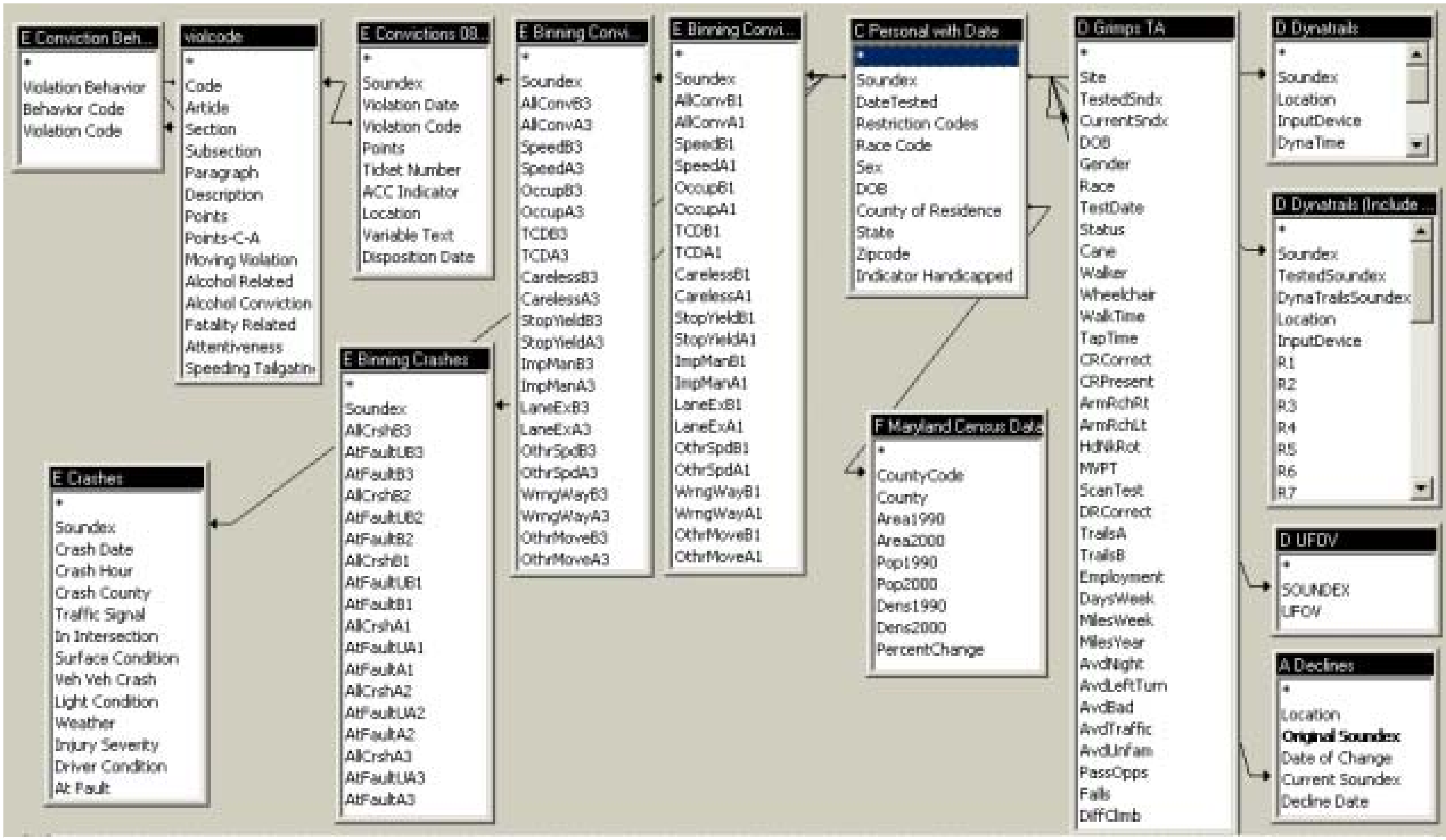

Figure 51. Access query containing all variables in the MARYPODS database.

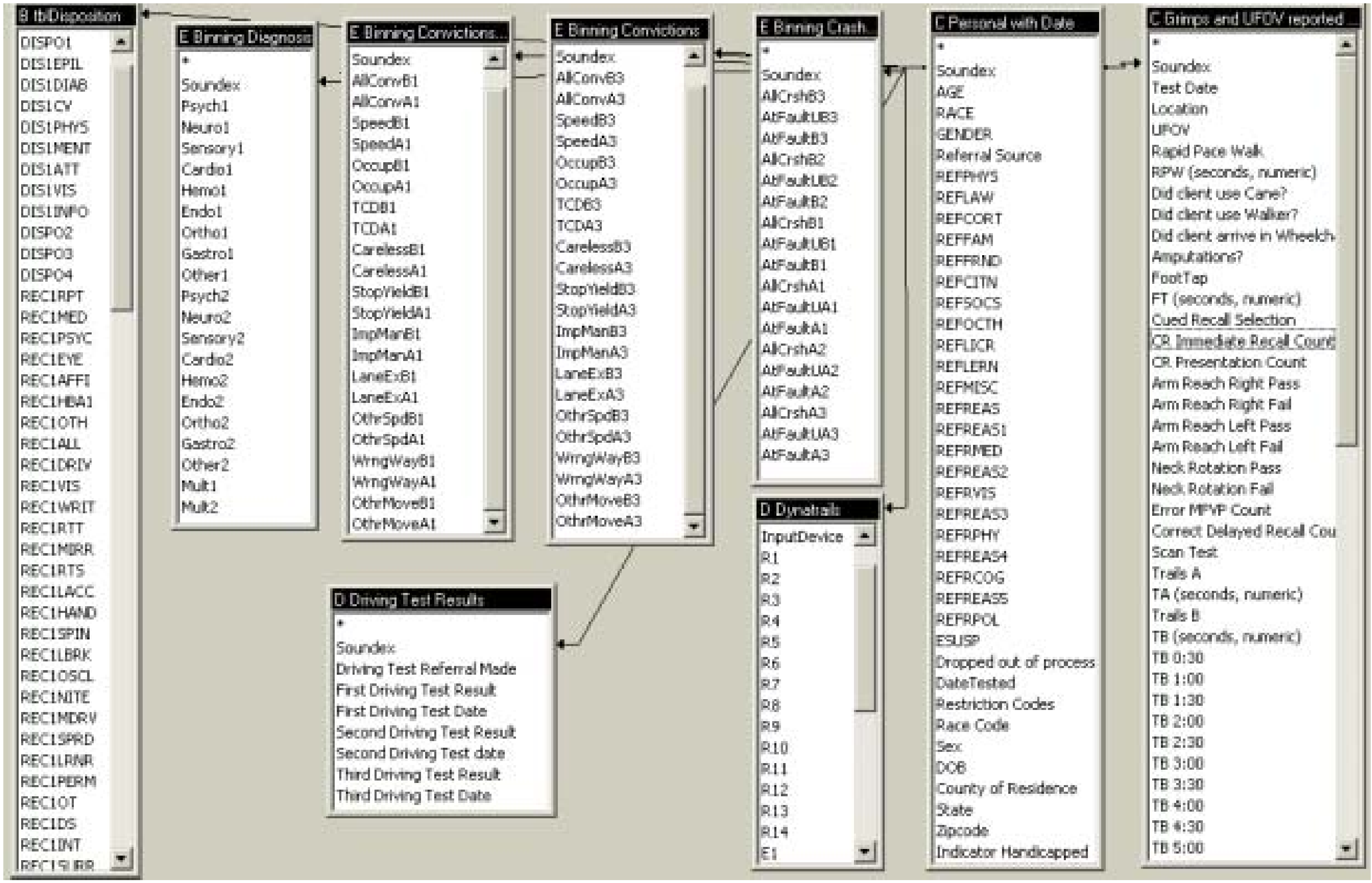

Figure 52. Access query containing all variables in the MAB (v.1.5) database.

APPENDIX D: DESCRIPTIVE STATISTICS FOR PERFORMANCE ON SCREENING MEASURES AS A FUNCTION OF TEST SAMPLE

Key:

REN (variable name) R*en*e*wal* sample
RES (variable name) R*esidential community* sample
REF (variable name) M*edical referral* sample

Table 14. Descriptive statistics comparing performance on the MVPT Visual Closure Subtest measure (number incorrect) as a function of test sample.

	RENMVPT	RESMVPT	REFMVPT
N of cases	1872	266	313
Minimum incorrect	0.00	0.00	0.00
Maximum incorrect	11.00	8.00	10.00
Median	1.00	1.00	2.00
Mean	1.72	1.55	2.68
95% CI Upper	1.80	1.75	2.94
95% CI Lower	1.64	1.35	2.42
Std. Error	0.04	0.10	0.13
Standard Dev	1.79	1.67	2.34

Table 15. Descriptive statistics comparing performance on the Delayed Recall measure (number incorrect), as a function of test sample.

	RENDRINC	RESDRINC	REFDRINC
N of cases	1849	264	306
Minimum	0.00	0.00	0.00
Maximum	3.00	3.00	3.00
Median	0.00	0.00	1.00
Mean	0.62	0.58	0.93
95% CI Upper	0.66	0.68	1.05
95% CI Lower	0.58	0.49	0.82
Std. Error	0.02	0.05	0.06
Standard Dev	0.85	0.77	1.04

Table 16. Descriptive statistics comparing performance on the Useful Field of View Subtest 2 measure (milliseconds) as a function of test sample.

	RENUFOV	RESUFOV	REFUFOV
N of cases	1740	180	304
Minimum	0.00	0.00	0.00
Maximum	500.00	500.00	500.00
Median	130.00	193.00	344.50
Mean	173.10	219.97	321.78
95% CI Upper	180.39	243.27	342.04
95% CI Lower	165.81	196.68	301.52
Std. Error	3.72	11.81	10.30
Standard Dev	154.99	158.39	179.51

Table 17. Descriptive statistics comparing performance on the Trail-Making Part B measure (seconds), as a function of test sample.

	RENTRAILSB	RESTRAILSB	REFTRAILSB
N of cases	1860	264	271
Minimum	32.72	39.90	49.97
Maximum	360.00	360.00	360.00
Median	95.09	97.67	157.44
Mean	106.62	110.23	170.38
95% CI Upper	108.78	116.31	179.07
95% CI Lower	104.45	104.15	161.68
Std. Error	1.10	3.09	4.42
Standard Dev	47.65	50.16	72.70

Table 18. Descriptive statistics comparing performance on the Dynamic Trails Test measure (seconds) as a function of test sample.

	RENDYNA	RESDYNA	REFDYNA
N of cases	777	203	210
Minimum	7.23	10.45	11.71
Maximum	59.94	59.78	59.99
Median	22.39	24.63	30.55
Mean	24.44	26.06	32.63
95% CI Upper	25.15	27.48	34.24
95% CI Lower	23.74	24.64	31.01
Std. Error	0.36	0.72	0.82
Standard Dev	9.99	10.28	11.89

Table 19. Descriptive statistics comparing performance on the Scan Test measure (pass vs fail), as a function of test sample.

	RENSCAN	RESSCAN	REFSCAN
N of cases	1841	264	306
Minimum	0.00	0.00	0.00
Maximum	1.00	1.00	1.00
Sum (pass)	1760.00	258.00	274.00
Median	1.00	1.00	1.00
Mean	0.96	0.98	0.90
95% CI Upper	0.97	1.00	0.93
95% CI Lower	0.95	0.96	0.86
Std. Error	0.00	0.01	0.02
Standard Dev	0.21	0.15	0.31

Table 20. Descriptive statistics comparing performance on the Rapid Pace Walk measure (seconds), as a function of test sample.

	RENWALKTIME	RESWALKTIME	REFWALKTIME
N of cases	1703	264	287
Minimum	3.14	3.15	1.49
Maximum	15.00	14.94	14.94
Median	6.06	6.46	7.31
Mean	6.47	6.77	7.79
95% CI Upper	6.56	7.00	8.08
95% CI Lower	6.38	6.54	7.51
Std. Error	0.05	0.12	0.14
Standard Dev	1.89	1.90	2.44

Table 21. Descriptive statistics comparing performance on the Foot Tap measure (seconds), as a function of test sample.

	RENTAPTIME	RESTAPTIME	REFTAPTIME
N of cases	1404	258	300
Minimum	3.10	3.34	1.58
Maximum	14.58	13.10	14.07
Median	5.62	5.69	6.89
Mean	6.05	6.12	7.08
95% CI Upper	6.16	6.35	7.34
95% CI Lower	5.95	5.89	6.82
Std. Error	0.05	0.12	0.13
Standard Dev	2.00	1.87	2.25

Table 22. Descriptive statistics comparing performance on the Head/Neck upper body flexibility measure (pass vs fail), as a function of test sample.

	RENHDNK	RESHDNK	REFHDNK
N of cases	1201	265	312
Minimum	0.00	0.00	0.00
Maximum	1.00	1.00	1.00
Sum (pass)	978.00	204.00	196.00
Median	1.00	1.00	1.00
Mean	0.81	0.77	0.63
95% CI Upper	0.84	0.82	0.68
95% CI Lower	0.79	0.72	0.57
Std. Error	0.01	0.03	0.03
Standard Dev	0.39	0.42	0.48

Table 23. Descriptive statistics comparing performance on the Arm Reach measure (pass vs fail), as a function of test sample.

	RENARMRCH	RESARMRCH	REFARMRCH
N of cases	1871	266	311
Minimum	0.00	0.00	0.00
Maximum	1.00	1.00	1.00
Sum (pass)	1857.00	261.00	294.00
Median	1.00	1.00	1.00
Mean	0.99	0.98	0.95
95% CI Upper	1.00	1.00	0.97
95% CI Lower	0.99	0.96	0.92
Std. Error	0.00	0.01	0.01
Standard Dev	0.09	0.14	0.23

APPENDIX E: DESCRIPTIVE STATISTICS FOR MOBILITY QUESTIONNAIRE BY SAMPLE.

<u>Variable names and definitions</u>

AGETEST	Age of subject at the time of test	
DAYSWEEK	Number of days per week subject drives (1-7)	
MILESYEAR	Number of miles per year subject drives:	
	1=Less than 1,000	7=12,501 to 15,000
	2= 1,001 to 2,500	8=15,001 to 17,500
	3=2,501 to 5,000	9=17,501 to 20,000
	4=5,001 to 7,500	10=20,001 to 25,000
	5=7,501 to 10,000	11=25,001 to 30,000
	6=10,001 to 12,500	12=30,001 or more
AVDNIGHT	Avoid night driving? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	
AVDLEFTTURN	Avoid left turns? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	
AVDBAD	Avoid bad weather? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	
AVDTRAFFIC	Avoid heavy traffic? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	
AVDUNFAM	Avoid unfamiliar roads? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	
PASSOPPS	Pass up opportunities to go shopping, visit with friends, etc., because of concerns about driving? 1=never; 2=rarely; 3=sometimes; 4=usually; 5=always	

Table 24. Descriptive statistics for self-reported responses by the *MVA renewal sample* on the Mobility questionnaire, for categorical questions.

	AGETEST	DAYSWEEK	MILESYEAR	AVDNIGHT	AVDLEFTTURN
N of cases	1876	1868	1871	1871	1871
Minimum	55.00	0.00	0.00	0.00	0.00
Maximum	96.00	7.00	12.00	5.00	5.00
Sum	128098.00	10018.00	8407.00	4315.00	3495.00
Median	68.00	6.00	4.00	2.00	1.00
Mean	68.28	5.36	4.49	2.31	1.87
95% CI Upper	68.64	5.45	4.62	2.37	1.93
95% CI Lower	67.92	5.28	4.36	2.24	1.81
Std. Error	0.18	0.04	0.07	0.03	0.03
Standard Dev	7.92	1.89	2.84	1.48	1.36

	AVDBAD	AVDTRAFFIC	AVDUNFAM	PASSOPPS
N of cases	1871	1869	1870	1871
Minimum	0.00	0.00	0.00	0.00
Maximum	5.00	5.00	5.00	5.00
Sum	4391.00	3602.00	3833.00	2225.00
Median	2.00	1.00	1.00	1.00
Mean	2.35	1.93	2.05	1.19
95% CI Upper	2.41	1.99	2.11	1.22
95% CI Lower	2.29	1.87	1.99	1.16
Std. Error	0.03	0.03	0.03	0.01
Standard Dev	1.36	1.34	1.35	0.64

Table 25. Descriptive statistics for self-reported responses by the *residential community* on the Mobility questionnaire, for categorical questions.

	AGETEST	DAYSWEEK	MILESYEAR	AVDNIGHT	AVDLEFTTURN
N of cases	266	261	264	265	264
Minimum	56.00	1.00	1.00	1.00	1.00
Maximum	92.00	7.00	10.00	5.00	5.00
Sum	20505.00	1438.00	941.00	763.00	520.00
Median	78.00	6.00	3.00	3.00	1.00
Mean	77.09	5.51	3.56	2.88	1.97
95% CI Upper	77.91	5.72	3.79	3.06	2.14
95% CI Lower	76.26	5.30	3.34	2.70	1.80
Std. Error	0.42	0.11	0.11	0.09	0.09
Standard Dev	6.81	1.76	1.85	1.46	1.40

	AVDBAD	AVDTRAFFIC	AVDUNFAM	PASSOPPS
N of cases	265	265	265	265
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Sum	726.00	688.00	641.00	399.00
Median	3.00	3.00	2.00	1.00
Mean	2.74	2.60	2.42	1.51
95% CI Upper	2.90	2.77	2.59	1.63
95% CI Lower	2.58	2.42	2.25	1.38
Std. Error	0.08	0.09	0.09	0.06
Standard Dev	1.32	1.47	1.40	1.00

Table 26. Descriptive statistics for self-reported responses by the *medical referral sample* on the Mobility questionnaire, for categorical questions.

	AGETEST	DAYSWEEK	MILESYEAR	AVDNIGHT	AVDLEFTTURN
N of cases	366	307	306	305	306
Minimum	55.00	1.00	1.00	1.00	1.00
Maximum	95.00	7.00	12.00	5.00	5.00
Sum	28127.00	1429.00	1011.00	936.00	662.00
Median	79.00	5.00	3.00	3.00	1.00
Mean	76.85	4.65	3.30	3.07	2.16
95% CI Upper	77.81	4.88	3.56	3.25	2.33
95% CI Lower	75.88	4.43	3.04	2.89	2.00
Std. Error	0.49	0.11	0.13	0.09	0.08
Standard Dev	9.39	1.97	2.32	1.61	1.48

	AVDBAD	AVDTRAFFIC	AVDUNFAM	PASSOPPS
N of cases	306	305	306	306
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Sum	937.00	797.00	880.00	498.00
Median	3.00	2.00	3.00	1.00
Mean	3.06	2.61	2.88	1.63
95% CI Upper	3.23	2.79	3.05	1.75
95% CI Lower	2.90	2.44	2.70	1.50
Std. Error	0.08	0.09	0.09	0.06
Standard Dev	1.46	1.53	1.59	1.09

APPENDIX F: RAW SYSTAT OUTPUT FOR ODDS RATIO CALCULATIONS WITH CRASHES AS THE OUTCOME MEASURE

<u>Example Key</u>:

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	25.23	30.55	28.00	538.00	.
2	1.00	25.23	25.89	56.00	994.00	1.30
3	2.00	16.22	17.72	74.00	1306.00	1.27
4	3.00	7.21	11.19	82.00	1503.00	1.44
5	**4.00**	9.91	6.59	**93.00**	1619.00	2.06
6	**5.00**	11.71	3.80	106.00	1686.00	2.21
7	6.00	0.90	2.16	107.00	1724.00	1.06
8	7.00	3.60	1.14	111.00	1744.00	1.74
9	8.00	0.00	0.57	111.00	1754.00	.
10	9.00	0.00	0.28	111.00	1759.00	.
11	10.00	0.00	0.06	111.00	1760.00	.
12	11.00	0.00	0.06	**111.00**	1761.00	.

MVPT *[Note: This variable name changes for each performance measure.]*: The values are the actual labels for bins in the corresponding plots. [NOTE: For continuous measures, the bins represent the midpoint of the interval containing a range of values. The range can be determined by taking the difference between bin values. Half of the range is then subtracted from the bin label to obtain *minimum* value included in the bin (> minimum value) and half of the range is added to the bin label to obtain *maximum* value included in the bin (<= maximum value.]

PERCENTPOS: This is the percent of total *positive events* (i.e., the event occurred – crash or conviction **-** which is *positive* event….gets very confusing) that occur for an individual with a corresponding score on the performance measure. For example, in the table above 24.49% of drivers (or 48 divided by 196 drivers with convictions) with positive events (outcome event occurs) had a score of 0 on MVPT. For each row, PERCENTPOS is the number of cases in the bin divided by total number of positive events.

PERCENTNEG: Same as above variable calculated separately for drivers without negative event convictions.

PERCENTPOS and PERCENTNEG are used to plot distributions in the OR plots. The conversion to percentages of the distribution allows direct comparison of the shapes of the distributions.

The following variables are used to calculate odds ratios:

SUMPASSPOS: Cumulative number of drivers for whom the outcome event occurred.

SUMPASSNEG: Cumulate number of drivers for whom the outcome event did not occur.

NPOS: Number of drivers for whom event occurred which is the number in the last bin for SUMPASSPOS

NNEG: Number of drivers for whom event did not occur which is the number in the last bin for SUMPASSNEG

ODDSRATIO: Odds ratio calculated using formula (a/b)/(c/d) where values are as follows:

a = NPOS **-** SUMPASSPOS
b = NNEG **-** SUMPASSNEG
c = SUMPASSPOS
d = SUMPASSNEG

⇨ The number of drivers who fail at each performance level for a given measure is found by taking the highest value for the "SUMPASSPOS" column, then subtracting the "SUMPASSPOS" value for the performance level immediately above in these appendix tables. For MVPT level = 5.00, above, the number who fail is found by taking the highest SUMPASSPOS value (111), then subtracting the SUMPASSPOS value for MVPT level = 4.00 (93); therefore, the number who failed at MVPT level = 5.00 is 18.

Table 27. MVPT/VC odds ratios for the MVA renewal sample, for all crashes.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	25.23	30.55	28.00	538.00	.
2	1.00	25.23	25.89	56.00	994.00	1.30
3	2.00	16.22	17.72	74.00	1306.00	1.27
4	3.00	7.21	11.19	82.00	1503.00	1.44
5	4.00	9.91	6.59	93.00	1619.00	2.06
6	5.00	11.71	3.80	106.00	1686.00	2.21
7	6.00	0.90	2.16	107.00	1724.00	1.06
8	7.00	3.60	1.14	111.00	1744.00	1.74
9	8.00	0.00	0.57	111.00	1754.00	.
10	9.00	0.00	0.28	111.00	1759.00	.
11	10.00	0.00	0.06	111.00	1760.00	.
12	11.00	0.00	0.06	111.00	1761.00	.

Table 28. MVPT/VC odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	19.40	30.64	13.00	553.00	.
2	1.00	25.37	25.87	30.00	1020.00	1.83
3	2.00	13.43	17.78	39.00	1341.00	1.60
4	3.00	8.96	11.02	45.00	1540.00	2.07
5	4.00	10.45	6.65	52.00	1660.00	2.84
6	5.00	14.93	3.88	62.00	1730.00	3.30
7	6.00	1.49	2.11	63.00	1768.00	1.86
8	7.00	5.97	1.11	67.00	1788.00	3.03
9	8.00	0.00	0.55	67.00	1798.00	.
10	9.00	0.00	0.28	67.00	1803.00	.
11	10.00	0.00	0.06	67.00	1804.00	.
12	11.00	0.00	0.06	67.00	1805.00	.

Table 29. MVPT/VC odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	13.95	30.62	6.00	560.00	.
2	1.00	23.26	25.92	16.00	1034.00	2.72
3	2.00	11.63	17.77	21.00	1359.00	2.19
4	3.00	6.98	11.04	24.00	1561.00	3.03
5	4.00	13.95	6.62	30.00	1682.00	4.61
6	5.00	18.60	3.94	38.00	1754.00	4.96
7	6.00	2.33	2.08	39.00	1792.00	3.08
8	7.00	9.30	1.09	43.00	1812.00	4.97
9	8.00	0.00	0.55	43.00	1822.00	.
10	9.00	0.00	0.27	43.00	1827.00	.
11	10.00	0.00	0.05	43.00	1828.00	.
12	11.00	0.00	0.05	43.00	1829.00	.

Table 30. Delayed Recall odds ratios for the MVA renewal sample, for all crashes.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	59.63	57.59	65.00	1002.00	.
2	1.00	22.02	27.99	89.00	1489.00	0.92
3	2.00	10.09	9.94	100.00	1662.00	1.33
4	3.00	8.26	4.48	109.00	1740.00	1.92

Table 31. Delayed Recall odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	60.00	57.57	40.00	1027.00	.
2	1.00	16.92	28.03	51.00	1527.00	0.85
3	2.00	13.85	9.81	60.00	1702.00	1.63
4	3.00	7.69	4.60	65.00	1784.00	1.73

Table 32. Delayed Recall odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	53.66	57.80	22.00	1045.00	.
2	1.00	19.51	27.82	30.00	1548.00	1.18
3	2.00	14.63	9.85	36.00	1726.00	2.18
4	3.00	12.20	4.54	41.00	1808.00	2.92

Table 33. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for all crashes.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	38.83	38.67	40.00	633.00	.
2	100.00	7.77	10.69	48.00	808.00	0.99
3	150.00	6.80	10.02	55.00	972.00	1.12
4	200.00	6.80	10.57	62.00	1145.00	1.28
5	250.00	7.77	7.51	70.00	1268.00	1.54
6	300.00	8.74	5.74	79.00	1362.00	1.62
7	350.00	5.83	3.97	85.00	1427.00	1.50
8	400.00	1.94	1.53	87.00	1452.00	1.44
9	450.00	0.97	0.12	88.00	1454.00	1.44
10	500.00	14.56	11.18	103.00	1637.00	1.35

Table 34. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	33.33	38.87	20.00	653.00	.
2	100.00	11.67	10.48	27.00	829.00	1.27
3	150.00	3.33	10.06	29.00	998.00	1.19
4	200.00	6.67	10.48	33.00	1174.00	1.56
5	250.00	8.33	7.50	38.00	1300.00	1.90
6	300.00	11.67	5.71	45.00	1396.00	1.98
7	350.00	6.67	3.99	49.00	1463.00	1.64
8	400.00	0.00	1.61	49.00	1490.00	1.51
9	450.00	0.00	0.18	49.00	1493.00	1.76
10	500.00	18.33	11.13	60.00	1680.00	1.79

Table 35. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	28.95	38.90	11.00	662.00	.
2	100.00	13.16	10.46	16.00	840.00	1.56
3	150.00	5.26	9.93	18.00	1009.00	1.34
4	200.00	2.63	10.52	19.00	1188.00	1.62
5	250.00	7.89	7.52	22.00	1316.00	2.31
6	300.00	10.53	5.82	26.00	1415.00	2.48
7	350.00	10.53	3.94	30.00	1482.00	2.28
8	400.00	0.00	1.59	30.00	1509.00	1.80
9	450.00	0.00	0.18	30.00	1512.00	2.08
10	500.00	21.05	11.16	38.00	1702.00	2.12

Table 36. Trail-Making Part B odds ratios for the MVA renewal sample, for all crashes.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.00	0.46	0.00	8.00	.
2	60.00	25.69	32.21	28.00	572.00	.
3	100.00	39.45	38.78	71.00	1251.00	1.40
4	140.00	21.10	17.99	94.00	1566.00	1.34
5	180.00	9.17	5.83	104.00	1668.00	1.35
6	220.00	2.75	2.74	107.00	1716.00	0.97
7	260.00	1.83	0.86	109.00	1731.00	0.92
8	300.00	0.00	0.40	109.00	1738.00	.
9	340.00	0.00	0.74	109.00	1751.00	.

Table 37. Trail-Making Part B odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.00	0.45	0.00	8.00	.
2	60.00	16.92	32.37	11.00	589.00	.
3	100.00	47.69	38.50	42.00	1280.00	2.40
4	140.00	15.38	18.27	52.00	1608.00	1.36
5	180.00	12.31	5.79	60.00	1712.00	2.15
6	220.00	4.62	2.67	63.00	1760.00	1.72
7	260.00	3.08	0.84	65.00	1775.00	1.60
8	300.00	0.00	0.39	65.00	1782.00	.
9	340.00	0.00	0.72	65.00	1795.00	.

Table 38. Trail-Making Part B odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.00	0.44	0.00	8.00	.
2	60.00	12.20	32.27	5.00	595.00	.
3	100.00	46.34	38.65	24.00	1298.00	3.50
4	140.00	21.95	18.09	33.00	1627.00	1.76
5	180.00	12.20	5.88	38.00	1734.00	2.05
6	220.00	4.88	2.69	40.00	1783.00	1.61
7	260.00	2.44	0.88	41.00	1799.00	1.24
8	300.00	0.00	0.38	41.00	1806.00	.
9	340.00	0.00	0.71	41.00	1819.00	.

Table 39. Dynamic Trails odds ratios for the MVA renewal sample, for all crashes.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	7.84	6.06	4.00	44.00	.
2	15.00	19.61	23.14	14.00	212.00	0.76
3	20.00	15.69	21.49	22.00	368.00	1.09
4	25.00	13.73	16.94	29.00	491.00	1.36
5	30.00	27.45	12.81	43.00	584.00	1.59
6	35.00	5.88	8.54	46.00	646.00	0.77
7	40.00	3.92	4.96	48.00	682.00	0.88
8	45.00	1.96	2.89	49.00	703.00	0.97
9	50.00	1.96	1.79	50.00	716.00	1.25
10	55.00	1.96	1.10	51.00	724.00	1.43
11	60.00	0.00	0.28	51.00	726.00	.

Table 40. Dynamic Trails odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	10.34	6.02	3.00	45.00	.
2	15.00	17.24	23.13	8.00	218.00	0.55
3	20.00	13.79	21.39	12.00	378.00	1.08
4	25.00	20.69	16.58	18.00	502.00	1.45
5	30.00	24.14	13.37	25.00	602.00	1.25
6	35.00	6.90	8.42	27.00	665.00	0.66
7	40.00	3.45	4.95	28.00	702.00	0.59
8	45.00	3.45	2.81	29.00	723.00	0.55
9	50.00	0.00	1.87	29.00	737.00	.
10	55.00	0.00	1.20	29.00	746.00	.
11	60.00	0.00	0.27	29.00	748.00	.

Table 41. Dynamic Trails odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	0.00	6.32	0.00	48.00	.
2	15.00	17.65	23.03	3.00	223.00	.
3	20.00	23.53	21.05	7.00	383.00	1.94
4	25.00	17.65	16.71	10.00	510.00	1.45
5	30.00	23.53	13.55	14.00	613.00	1.43
6	35.00	5.88	8.42	15.00	677.00	0.89
7	40.00	5.88	4.87	16.00	714.00	1.09
8	45.00	5.88	2.76	17.00	735.00	0.97
9	50.00	0.00	1.84	17.00	749.00	.
10	55.00	0.00	1.18	17.00	758.00	.
11	60.00	0.00	0.26	17.00	760.00	.

Table 42. Rapid Pace Walk odds ratios for the MVA renewal sample, for all crashes.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	8.74	11.19	9.00	179.00	.
2	5.25	36.89	38.19	47.00	790.00	1.32
3	6.75	28.16	26.56	76.00	1215.00	1.16
4	8.25	15.53	14.69	92.00	1450.00	1.12
5	9.75	6.80	5.56	99.00	1539.00	1.16
6	11.25	2.91	2.06	102.00	1572.00	1.02
7	12.75	0.97	1.12	103.00	1590.00	0.55
8	14.25	0.00	0.62	103.00	1600.00	.

Table 43. Rapid Pace Walk odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	6.56	11.21	4.00	184.00	.
2	5.25	37.70	38.12	27.00	810.00	1.80
3	6.75	22.95	26.80	41.00	1250.00	1.23
4	8.25	16.39	14.68	51.00	1491.00	1.56
5	9.75	11.48	5.42	58.00	1580.00	1.94
6	11.25	3.28	2.07	60.00	1614.00	1.32
7	12.75	1.64	1.10	61.00	1632.00	0.96
8	14.25	0.00	0.61	61.00	1642.00	.

Table 44. Rapid Pace Walk odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	5.26	11.17	2.00	186.00	.
2	5.25	36.84	38.14	16.00	821.00	2.26
3	6.75	26.32	26.67	26.00	1265.00	1.34
4	8.25	10.53	14.83	30.00	1512.00	1.46
5	9.75	15.79	5.41	36.00	1602.00	2.64
6	11.25	5.26	2.04	38.00	1636.00	1.41
7	12.75	0.00	1.14	38.00	1655.00	.
8	14.25	0.00	0.60	38.00	1665.00	.

Table 45. Foot Tap odds ratios for the MVA renewal sample, for all crashes.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	14.47	21.01	11.00	279.00	.
2	5.25	47.37	38.70	47.00	793.00	1.57
3	6.75	22.37	21.91	64.00	1084.00	0.91
4	8.25	9.21	8.66	71.00	1199.00	0.83
5	9.75	3.95	5.12	74.00	1267.00	0.65
6	11.25	2.63	2.79	76.00	1304.00	0.56
7	12.75	0.00	1.66	76.00	1326.00	.
8	14.25	0.00	0.15	76.00	1328.00	.

Table 46. Foot Tap odds ratios for the MVA renewal sample, for at-fault and unknown-fault crashes.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	10.53	20.94	4.00	286.00	.
2	5.25	47.37	38.95	22.00	818.00	2.25
3	6.75	28.95	21.74	33.00	1115.00	1.09
4	8.25	5.26	8.78	35.00	1235.00	0.67
5	9.75	5.26	5.05	37.00	1304.00	0.81
6	11.25	2.63	2.78	38.00	1342.00	0.57
7	12.75	0.00	1.61	38.00	1364.00	.
8	14.25	0.00	0.15	38.00	1366.00	.

Table 47. Foot Tap odds ratios for the MVA renewal sample, for at-fault-only crashes.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	8.33	20.87	2.00	288.00	.
2	5.25	41.67	39.13	12.00	828.00	2.90
3	6.75	37.50	21.67	21.00	1127.00	1.50
4	8.25	4.17	8.77	22.00	1248.00	0.64
5	9.75	4.17	5.07	23.00	1318.00	0.86
6	11.25	4.17	2.75	24.00	1356.00	0.92
7	12.75	0.00	1.59	24.00	1378.00	.
8	14.25	0.00	0.14	24.00	1380.00	.

APPENDIX G: CHI-SQUARE TABLES FOR TESTS OF SIGNIFICANCE AT PEAK VALID ODDS RATIO VALUES FOR CRASH DATA

The following output from SYSTAT is all based on the calculated odds ratio values presented in appendix G. In the tables that follow, drivers with 1 or more (at-fault) crashes 1 year prior and up to 3 years after testing were assigned a (–1); this is done to ensure that the crashing group appears in the left column, which is important for calculating odds ratios.

Cutoffs were obtained from the peak valid OR calculated for each measure listed below, as reported in the analysis and results chapter. The failing criteria (coded as a 0 in the first row) for each of the performance measures is as follows:

- MVPT/VC: 5 or more responses are incorrect
- Delayed Recall: 2 or more responses are incorrect
- Useful Field of View Subtest 2: Target duration is 275 msec or longer
- Trail Making Part B: Completion time is 80 seconds or more
- Dynamic Trails: Completion time is 22.5 seconds or more
- Rapid Pace Walk Time: Completion time is 9 seconds or more
- Foot Tap Time: Completion time is 6 seconds or more
- Head/Neck Rotation: N/A (binary measure)

Table 48. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the MVPT/VC (OR=4.96, $G2 = 26.48$, df=1, $p<.001$).

	-1	0	Total
0	13	147	160
1	30	1682	1712
Total	43	1829	1872

Table 49. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Delayed Recall test (OR=2.92, $G2 = 5.25$, df=1, $p<.02$).

	-1	0	Total
0	5	82	87
1	36	1726	1762
Total	41	1808	1849

Table 50. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Useful Field of View Subtest 2 (OR=2.34, $G2 = 6.95$, df=1, $p<.01$).

	-1	0	Total
0	17	438	455
1	21	1264	1285
Total	38	1702	1740

Table 51. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Trail-Making Part B test (OR=3.50, $G2 = 7.72$, df=1, $p<.01$).

	-1	0	Total
0	36	1224	1260
1	5	595	600
Total	41	1819	1860

Table 52. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Dynamic Trails test (OR=1.45, $G2 = 0.57$, df=1, $p<.45$).

	-1	0	Total
0	10	377	387
1	7	383	390
Total	17	760	777

Table 53. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Rapid Pace Walk (OR=2.64, $G2 = 6.11$, df=1, $p<.01$).

	-1	0	Total
0	8	153	161
1	30	1512	1542
Total	38	1665	1703

Table 54. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Foot Tap test (OR=1.50, G2 = 0.98, df=1, p<.32).

	-1	0	Total
0	12	552	564
1	12	828	840
Total	24	1380	1404

Table 55. Frequencies of at-fault crashes in the MVA renewal sample, as a function of performance on the Head/Neck Rotation test (OR=2.56, G2 = 4.69, df=1, p<.03).

	-1	0	Total
0	8	215	223
1	14	964	978
Total	22	1179	1201

APPENDIX H. RAW SYSTAT OUTPUT FOR ODDS RATIO CALCULATIONS WITH VIOLATIONS AS THE OUTCOME MEASURE

Example Key:

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	24.49	30.91	48.00	518.00	.
2	1.00	30.61	25.30	108.00	942.00	1.38
3	2.00	18.37	17.54	144.00	1236.00	1.05
4	3.00	8.67	11.22	161.00	1424.00	1.01
5	**4.00**	6.63	6.80	**174.00**	1538.00	1.23
6	**5.00**	6.12	4.06	186.00	1606.00	1.41
7	6.00	2.55	2.03	191.00	1640.00	1.23
8	7.00	1.53	1.25	194.00	1661.00	1.19
9	8.00	0.51	0.54	195.00	1670.00	1.14
10	9.00	0.51	0.24	196.00	1674.00	1.43
11	10.00	0.00	0.06	196.00	1675.00	.
12	11.00	0.00	0.06	**196.00**	1676.00	.

MVPT *[Note: This variable name changes for each performance measure.]*: The values are the actual labels for bins in the corresponding plots. [NOTE: For continuous measures, the bins represent the midpoint of the interval containing a range of values. The range can be determined by taking the difference between bin values. Half of the range is then subtracted from the bin label to obtain *minimum* value included in the bin (> minimum value) and half of the range is added to the bin label to obtain *maximum* value included in the bin (<= maximum value.]

PERCENTPOS: This is the percent of total *positive events* (i.e., the event occurred – crash or conviction - which is *positive* event….gets very confusing) that occur for an individual with a corresponding score on the performance measure. For example, in the table above 24.49% of drivers (or 48 divided by 196 drivers with convictions) with positive events (outcome event occurs) had a score of 0 on MVPT. For each row, PERCENTPOS is the number of cases in the bin divided by total number of positive events.

PERCENTNEG: Same as above variable calculated separately for drivers without negative event convictions.

PERCENTPOS and PERCENTNEG are used to plot distributions in the OR plots. The conversion to percentages of the distribution allows direct comparison of the shapes of the distributions.

The following variables are used to calculate odds ratios:

SUMPASSPOS: Cumulative number of drivers for whom the outcome event occurred.

SUMPASSNEG: Cumulate number of drivers for whom the outcome event did not occur.

NPOS: Number of drivers for whom event occurred which is the number in the last bin for SUMPASSPOS

NNEG: Number of drivers for whom event did not occur which is the number in the last bin for SUMPASSNEG

ODDSRATIO: Odds ratio calculated using formula (a/b)/(c/d) where values are as follows:

a = NPOS - SUMPASSPOS
b = NNEG - SUMPASSNEG
c = SUMPASSPOS
d = SUMPASSNEG

⇨ The number of drivers who fail at each performance level for a given measure is found by taking the highest value for the “SUMPASSPOS” column, then subtracting the “SUMPASSPOS” value for the performance level immediately above in these appendix tables. For MVPT level = 5.00, above, the number who fail is found by taking the highest SUMPASSPOS value (196.00), then subtracting the SUMPASSPOS value for MVPT level = 4.00 (174); therefore, the number who failed at MVPT level = 5.00 is 22.

Table 56. MVPT/VC odds ratios for the MVA renewal sample, for all moving violations.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	24.49	30.91	48.00	518.00	.
2	1.00	30.61	25.30	108.00	942.00	1.38
3	2.00	18.37	17.54	144.00	1236.00	1.05
4	3.00	8.67	11.22	161.00	1424.00	1.01
5	4.00	6.63	6.80	174.00	1538.00	1.23
6	5.00	6.12	4.06	186.00	1606.00	1.41
7	6.00	2.55	2.03	191.00	1640.00	1.23
8	7.00	1.53	1.25	194.00	1661.00	1.19
9	8.00	0.51	0.54	195.00	1670.00	1.14
10	9.00	0.51	0.24	196.00	1674.00	1.43
11	10.00	0.00	0.06	196.00	1675.00	.
12	11.00	0.00	0.06	196.00	1676.00	.

Table 57. MVPT/VC odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	17.65	30.96	18.00	548.00	.
2	1.00	29.41	25.65	48.00	1002.00	2.09
3	2.00	20.59	17.46	69.00	1311.00	1.47
4	3.00	7.84	11.13	77.00	1508.00	1.37
5	4.00	10.78	6.55	88.00	1624.00	1.87
6	5.00	6.86	4.12	95.00	1697.00	1.77
7	6.00	1.96	2.09	97.00	1734.00	1.71
8	7.00	2.94	1.19	100.00	1755.00	2.48
9	8.00	0.98	0.51	101.00	1764.00	2.34
10	9.00	0.98	0.23	102.00	1768.00	2.91
11	10.00	0.00	0.06	102.00	1769.00	.
12	11.00	0.00	0.06	102.00	1770.00	.

Table 58. MVPT/VC odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	MVPT	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	16.13	30.47	5.00	561.00	.
2	1.00	29.03	25.80	14.00	1036.00	2.28
3	2.00	19.35	17.60	20.00	1360.00	1.56
4	3.00	3.23	11.08	21.00	1564.00	1.56
5	4.00	9.68	6.74	24.00	1688.00	2.69
6	5.00	6.45	4.24	26.00	1766.00	3.22
7	6.00	6.45	2.01	28.00	1803.00	4.53
8	7.00	9.68	1.14	31.00	1824.00	5.08
9	8.00	0.00	0.54	31.00	1834.00	.
10	9.00	0.00	0.27	31.00	1839.00	.
11	10.00	0.00	0.05	31.00	1840.00	.
12	11.00	0.00	0.05	31.00	1841.00	.

Table 59. Delayed Recall odds ratios for the MVA renewal sample, for all moving violations.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	56.19	57.89	109.00	958.00	.
2	1.00	27.32	27.67	162.00	1416.00	1.07
3	2.00	13.40	9.55	188.00	1574.00	1.17
4	3.00	3.09	4.89	194.00	1655.00	0.62

Table 60. Delayed Recall odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	53.47	57.95	54.00	1013.00	.
2	1.00	28.71	27.57	83.00	1495.00	1.20
3	2.00	12.87	9.78	96.00	1666.00	1.28
4	3.00	4.95	4.69	101.00	1748.00	1.06

Table 61. Delayed Recall odds ratios for the MVA renewal sample, for moving violations without speeding or occupant restraint.

Case number	DRINCORREC	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	0.00	51.61	57.81	16.00	1051.00	.
2	1.00	25.81	27.67	24.00	1554.00	1.28
3	2.00	12.90	9.90	28.00	1734.00	1.72
4	3.00	9.68	4.62	31.00	1818.00	2.21

Table 62. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for all moving violations.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	42.25	38.25	79.00	594.00	.
2	100.00	9.63	10.62	97.00	759.00	0.85
3	150.00	10.16	9.79	116.00	911.00	0.89
4	200.00	11.76	10.17	138.00	1069.00	0.87
5	250.00	6.95	7.60	151.00	1187.00	0.78
6	300.00	3.74	6.18	158.00	1283.00	0.77
7	350.00	4.28	4.06	166.00	1346.00	0.87
8	400.00	1.60	1.55	169.00	1370.00	0.82
9	450.00	0.00	0.19	169.00	1373.00	0.80
10	500.00	9.63	11.59	187.00	1553.00	0.81

Table 63. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	36.46	38.81	35.00	638.00	.
2	100.00	9.38	10.58	44.00	812.00	1.11
3	150.00	9.38	9.85	53.00	974.00	1.15
4	200.00	10.42	10.34	63.00	1144.00	1.18
5	250.00	8.33	7.48	71.00	1267.00	1.20
6	300.00	6.25	5.90	77.00	1364.00	1.18
7	350.00	5.21	4.01	82.00	1430.00	1.20
8	400.00	1.04	1.58	83.00	1456.00	1.14
9	450.00	0.00	0.18	83.00	1459.00	1.21
10	500.00	13.54	11.25	96.00	1644.00	1.24

Table 64. Useful Field of View Subtest 2 odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	UFOV	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	50.00	27.59	38.87	8.00	665.00	.
2	100.00	13.79	10.46	12.00	844.00	1.67
3	150.00	10.34	9.82	15.00	1012.00	1.38
4	200.00	13.79	10.29	19.00	1188.00	1.35
5	250.00	6.90	7.54	21.00	1317.00	1.20
6	300.00	6.90	5.90	23.00	1418.00	1.27
7	350.00	6.90	4.03	25.00	1487.00	1.26
8	400.00	0.00	1.58	25.00	1514.00	1.06
9	450.00	0.00	0.18	25.00	1517.00	1.23
10	500.00	13.79	11.34	29.00	1711.00	1.25

Table 65. Trail-Making Part B odds ratios for the MVA renewal sample, for all moving violations.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.52	0.42	1.00	7.00	.
2	60.00	32.64	31.73	64.00	536.00	0.81
3	100.00	37.31	38.99	136.00	1186.00	0.96
4	140.00	22.28	17.70	179.00	1481.00	1.03
5	180.00	3.63	6.30	186.00	1586.00	0.62
6	220.00	2.07	2.82	190.00	1633.00	0.74
7	260.00	0.52	0.96	191.00	1649.00	0.76
8	300.00	0.52	0.36	192.00	1655.00	0.96
9	340.00	0.52	0.72	193.00	1667.00	0.72

Table 66. Trail-Making Part B odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.00	0.45	0.00	8.00	.
2	60.00	27.27	32.08	27.00	573.00	.
3	100.00	32.32	39.18	59.00	1263.00	1.29
4	140.00	29.29	17.55	88.00	1572.00	1.72
5	180.00	5.05	6.08	93.00	1679.00	1.04
6	220.00	3.03	2.73	96.00	1727.00	1.32
7	260.00	1.01	0.91	97.00	1743.00	1.59
8	300.00	1.01	0.34	98.00	1749.00	2.00
9	340.00	1.01	0.68	99.00	1761.00	1.49

Table 67. Trail-Making Part B odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	TRAILSB	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	20.00	0.00	0.44	0.00	8.00	.
2	60.00	27.59	31.90	8.00	592.00	.
3	100.00	37.93	38.83	19.00	1303.00	1.25
4	140.00	27.59	18.02	27.00	1633.00	1.30
5	180.00	0.00	6.12	27.00	1745.00	0.61
6	220.00	3.45	2.73	28.00	1795.00	1.50
7	260.00	0.00	0.93	28.00	1812.00	1.78
8	300.00	3.45	0.33	29.00	1818.00	3.41
9	340.00	0.00	0.71	29.00	1831.00	.

Table 68. Dynamic Trails odds ratios for the MVA renewal sample, for all moving violations.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	7.29	6.02	7.00	41.00	.
2	15.00	25.00	22.61	31.00	195.00	0.81
3	20.00	16.67	21.73	47.00	343.00	0.84
4	25.00	19.79	16.30	66.00	454.00	1.06
5	30.00	10.42	14.24	76.00	551.00	0.91
6	35.00	9.38	8.22	85.00	607.00	1.12
7	40.00	6.25	4.70	91.00	639.00	1.06
8	45.00	2.08	2.94	93.00	659.00	0.84
9	50.00	2.08	1.76	95.00	671.00	0.97
10	55.00	1.04	1.17	96.00	679.00	0.71
11	60.00	0.00	0.29	96.00	681.00	.

Table 69. Dynamic Trails odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	3.39	6.41	2.00	46.00	.
2	15.00	27.12	22.56	18.00	208.00	1.95
3	20.00	16.95	21.45	28.00	362.00	0.93
4	25.00	20.34	16.43	40.00	480.00	1.13
5	30.00	10.17	14.07	46.00	581.00	0.96
6	35.00	11.86	8.08	53.00	639.00	1.20
7	40.00	3.39	5.01	55.00	675.00	0.92
8	45.00	3.39	2.79	57.00	695.00	1.14
9	50.00	1.69	1.81	58.00	708.00	1.06
10	55.00	1.69	1.11	59.00	716.00	1.22
11	60.00	0.00	0.28	59.00	718.00	.

Table 70. Dynamic Trails odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	DYNASECOND	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	10.00	0.00	6.32	0.00	48.00	.
2	15.00	27.78	22.79	5.00	221.00	.
3	20.00	16.67	21.21	8.00	382.00	1.07
4	25.00	27.78	16.47	13.00	507.00	1.27
5	30.00	11.11	13.83	15.00	612.00	0.77
6	35.00	11.11	8.30	17.00	675.00	0.83
7	40.00	0.00	5.01	17.00	713.00	0.47
8	45.00	0.00	2.90	17.00	735.00	0.91
9	50.00	0.00	1.84	17.00	749.00	1.80
10	55.00	5.56	1.05	18.00	757.00	4.41
11	60.00	0.00	0.26	18.00	759.00	.

Table 71. Rapid Pace Walk odds ratios for the MVA renewal sample, for all moving violations.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	10.65	11.08	18.00	170.00	.
2	5.25	46.75	37.16	97.00	740.00	1.05
3	6.75	26.63	26.66	142.00	1149.00	0.69
4	8.25	11.24	15.12	161.00	1381.00	0.57
5	9.75	2.37	6.00	165.00	1473.00	0.45
6	11.25	1.18	2.22	167.00	1507.00	0.59
7	12.75	0.00	1.24	167.00	1526.00	0.67
8	14.25	1.18	0.52	169.00	1534.00	2.28

Table 72. Rapid Pace Walk odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	7.87	11.21	7.00	181.00	.
2	5.25	43.82	37.79	46.00	791.00	1.48
3	6.75	29.21	26.52	72.00	1219.00	0.90
4	8.25	11.24	14.93	82.00	1460.00	0.73
5	9.75	3.37	5.76	85.00	1553.00	0.81
6	11.25	2.25	2.11	87.00	1587.00	1.20
7	12.75	0.00	1.18	87.00	1606.00	1.35
8	14.25	2.25	0.50	89.00	1614.00	4.61

Table 73. Rapid Pace Walk odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	WALKTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	11.54	11.03	3.00	185.00	.
2	5.25	46.15	37.98	15.00	822.00	0.95
3	6.75	34.62	26.54	24.00	1267.00	0.71
4	8.25	0.00	14.97	24.00	1518.00	0.26
5	9.75	3.85	5.66	25.00	1613.00	0.80
6	11.25	0.00	2.15	25.00	1649.00	1.01
7	12.75	0.00	1.13	25.00	1668.00	2.36
8	14.25	3.85	0.54	26.00	1677.00	7.41

Table 74. Foot Tap odds ratios for the MVA renewal sample, for all moving violations.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	25.64	20.03	40.00	250.00	.
2	5.25	35.90	39.58	96.00	744.00	0.73
3	6.75	21.79	21.96	130.00	1018.00	0.92
4	8.25	8.97	8.65	144.00	1126.00	0.89
5	9.75	3.85	5.21	150.00	1191.00	0.77
6	11.25	0.64	3.04	151.00	1229.00	0.84
7	12.75	3.21	1.36	156.00	1246.00	2.14
8	14.25	0.00	0.16	156.00	1248.00	.

Table 75. Foot Tap odds ratios for the MVA renewal sample, for moving violations without speeding.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	20.78	20.65	16.00	274.00	.
2	5.25	32.47	39.56	41.00	799.00	0.99
3	6.75	24.68	21.78	60.00	1088.00	1.33
4	8.25	10.39	8.59	68.00	1202.00	1.29
5	9.75	6.49	4.97	73.00	1268.00	1.27
6	11.25	1.30	2.86	74.00	1306.00	1.18
7	12.75	3.90	1.43	77.00	1325.00	2.52
8	14.25	0.00	0.15	77.00	1327.00	.

Table 76. Foot Tap odds ratios for the MVA renewal sample, for moving violations without speeding and occupant restraint.

Case number	TAPTIME	PERCENTPOS	PERCENTNEG	SUMPASSPOS	SUMPASSNEG	ODDSRATIO
1	3.75	8.00	20.88	2.00	288.00	.
2	5.25	36.00	39.23	11.00	829.00	3.04
3	6.75	28.00	21.83	18.00	1130.00	1.92
4	8.25	12.00	8.63	21.00	1249.00	1.76
5	9.75	12.00	4.93	24.00	1317.00	1.83
6	11.25	4.00	2.76	25.00	1355.00	0.89
7	12.75	0.00	1.60	25.00	1377.00	.
8	14.25	0.00	0.15	25.00	1379.00	.

APPENDIX I: CHI-SQUARE TABLES FOR TESTS OF SIGNIFICANCE AT PEAK VALID ODDS RATIO VALUES FOR VIOLATION DATA

The following output from SYSTAT is all based on the calculated odds ratio values presented in appendix I. In the tables that follow, the drivers with 1 or more violations (non-speeding and occupant restraint) 1 year prior and up to 3 years after testing were assigned a (–1); this is done to ensure that the group with violations appears in the left column which is important for calculating odds ratio.

Cutoffs were obtained from the peak valid OR calculated for each measure listed below, as reported in the analysis and results chapter of the report. Peak OR was found in analysis of moving violations without speeding and occupant restraint for some measures; for moving violations without speeding for other measures; and in one case, for all moving violations, as noted in the body of the report and in the table titles that follow. The failing criteria (coded as a 0 in the first row) for each of the performance measures is as follows:

- MVPT/VC: 6 or more responses are incorrect
- Delayed Recall: 2 or more responses are incorrect
- Useful Field of View Subtest 2: Target duration is 75 msec or longer
- Trail Making Part B: Completion time is 120 seconds or more
- Dynamic Trails: Completion time is 25 seconds or more
- Rapid Pace Walk Time: Completion time is 4.5 seconds or more
- Foot Tap Time: Completion time is 12 seconds or more

Table 77. Frequencies of violations (without speeding or occupant restraint) in the MVA renewal sample, as a function of performance on the MVPT/VC (OR=4.53, G2 =10.83, df=1, p<.001).

	-1	0	Total
0	5	75	80
1	26	1766	1792
Total	31	1841	1872

Table 78. Frequencies of violations (without speeding or occupant restraint) in the MVA renewal sample, as a function of performance on the Delayed Recall test (OR=1.72, G^2 =1.58, df=1, p<.21).

	-1	0	Total
0	7	264	271
1	24	1554	1578
Total	31	1818	1849

Table 79. Frequencies of violations (without speeding or occupant restraint) in the MVA renewal sample, as a function of performance on the Useful Field of View Subtest 2 (OR=1.67, G^2 =1.53, df=1, p<.22).

	-1	0	Total
0	21	1046	1067
1	8	665	673
Total	29	1711	1740

Table 80. Frequencies of violations (without speeding) in the MVA renewal sample, as a function of performance on the Trail-Making Part B test (OR=1.72, G^2 =6.70, df=1, p<.01).

	-1	0	Total
0	40	498	538
1	59	1263	1322
Total	99	1761	1860

Table 81. Frequencies of violations (without speeding or occupant restraint) in the MVA renewal sample, as a function of performance on the Dynamic Trails test (OR=1.27, G^2 =.24, df=1, p<.62).

	-1	0	Total
0	10	377	387
1	8	382	390
Total	18	759	777

Table 82. Frequencies of violations (without speeding) in the MVA renewal sample, as a function of performance on the Rapid Pace Walk test (OR=1.48, G2 =.96, df=1, p<.33).

	-1	0	Total
0	82	1433	1515
1	7	181	188
Total	89	1614	1703

Table 83. Frequencies of violations (all moving violations) in the MVA renewal sample, as a function of performance on the Foot Tap test (OR=2.14, G2 =2.34, df=1, p<.13).

	-1	0	Total
0	5	19	24
1	151	1229	1380
Total	156	1248	1404

DOT HS 809 583
May 2003

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