The development of a scientifically based driving assessment and standardization procedures for evaluating medically at-risk drivers

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Abstract

The vehicle collision rate of medically impaired drivers is a growing concern, especially given the aging of the driving population. The complexities of co-morbidities and multiple medications of many drivers (especially older drivers) make judgments about fitness-to-drive based on medical criteria untenable. Those criteria were developed for drivers with single medical conditions. The most direct approach to evaluating a person's competence to drive safely is to evaluate their actual driving performance. Currently, many different driving evaluations are in use. Most of these tests are unlikely to meet the Supreme Court of Canada's (1999, Grismer vs. BC Counsel of Human Rights) ruling regarding driving and discrimination against persons with medical disabilities. In addition, most available driving evaluations lack the scientific basis to ensure only competence defining driving errors are scored and that they are revealed during road tests of medically impaired drivers. Standardization across the evaluation sites of a jurisdiction is mostly limited to defining minimal numbers and types of driving maneuvers and monitoring regarding overall pass/fail rates. Moreover, the difficulty of the road test commonly varies widely from site to site across jurisdictions. Given the expected increases in drivers with medical conditions that threaten their ability to drive safely, there is a need for legally and scientifically justifiable driving assessment protocol. This research and resulting driving evaluation described in this paper was developed at the request of physicians to enable evidence-based decisions about the continued driving of their medically at-risk patients. The science compared the driving errors of drivers with cognitive impairments against the driving errors of healthy normal drivers. All drivers drove a standard road course that emphasized the crash conditions typical of older drivers. Driving errors associated with cognitively impaired drivers were identified and disassociated from the driving errors of healthy normal drivers. The driving maneuvers, road conditions, and visual aspects of the driving environment sufficient to reveal driving errors of medically impaired (unsafe) drivers were identified, and rules set out to enable replicating those driving conditions across locations. A short in-office evaluation using tests requiring mental abilities relevant for safe driving was developed and validated against actual driving. A performance criterion meeting the criteria of the Supreme Court's ruling was developed. Standardization procedures include the accommodation of differences in road course difficulty in the performance criterion. The evaluation has been scientifically demonstrated to be equally fair for urban and rural drivers. The move from research to the formation of a University of Alberta spin-off company (DriveABLE Assessment Centres Inc.) to deliver the evaluation service is discussed. The DriveABLE™ assessment protocol is available to physicians, licensing authorities, and insurers through 21 Centres in Canada and in 6 Centers in the United States.

Résumé

Le nombre de collision de véhicules impliquant des conducteurs qui présentent un état pathologique est un problème qui prend de l'ampleur, principalement en raison du vieillissement de la population des conducteurs. La complexité des cas de co-morbidité et de médication multiple de plusieurs conducteurs (surtout les plus âgés) rend inutiles les critères médicaux jugeant leur aptitude à conduire. Ces

critères ont été mis en place pour les conducteurs n'ayant qu'une seule médication. Le moyen de plus direct pour évaluer l'aptitude d'une personne à conduire de façon sécuritaire est d'évaluer son rendement actuel. Plusieurs évaluations de la conduite sont utilisées. Mais la plupart des examens ne respectent pas la réglementation de la Cour suprême du Canada (1999, Grismer vs. BC Counsel of Human Rights) en matière de conduite, de déficience et de discrimination. La question est importante. De plus, la plupart des évaluations de conduite disponibles n'ont pas suffisamment de fondement scientifique pour que seules les compétences permettant de définir les erreurs de conduite se voient attribuer une note et pour qu'on les communique aux conducteurs qui présentent un état pathologique lors de leur examen sur la route. L'uniformisation entre les sites d'évaluation dans les différentes circonscriptions se résume principalement aux mesures suivantes : définir le nombre et le type de manœuvres minimum à effectuer, et vérifier les notes globales de réussites/d'échecs. De plus, la difficulté des essais sur la route varie grandement d'un site à l'autre, selon les compétences. En raison de l'augmentation prévue du nombre de conducteurs ayant des conditions médicales qui limitent leur aptitude à conduire de façon sécuritaire, nous avons besoin d'un protocole d'évaluation légalement et scientifiquement justifiable. Cette recherche ainsi que les évaluations des aptitudes à la conduite décrites dans ce document ont été réalisées à la demande de médecins pour qu'ils puissent prendre des décisions fondées sur des preuves afin de définir si leurs patients à risque peuvent continuer de conduire. On a comparé les erreurs commises par les conducteurs ayant une déficience cognitive aux erreurs commises par des conducteurs ayant une santé normale. Tous les conducteurs ont suivi un parcours normalisé qui mettait l'accent sur les éléments favorisant les collisions propres aux conducteurs plus âgés. Les erreurs de conduite des conducteurs ayant une déficience cognitive ont été définies et séparées des erreurs commises par des conducteurs ayant une santé normale. On a pu définir les manœuvres, conditions routières et aspects visuels de l'environnement de conduite qui se sont avérés suffisants pour révéler les erreurs commises par les conducteurs ayant une déficience cognitive, ainsi qu'énoncer des règles pour qu'on reproduise les mêmes conditions de conduite partout. On a mené et validé une petite évaluation des examens exigeant des aptitudes mentales nécessaires à la conduite sécuritaire. Un critère de rendement respectant les critères de la Cour suprême a été élaboré. Les procédures de normalisation prévoient l'insertion, dans les critères de rendement, de la variation des difficultés dans le trajet. On a prouvé scientifiquement que l'évaluation était aussi bonne pour les conducteurs urbains que ruraux. On discute d'une entreprise dérivée de l'Université de l'Alberta (DriveABLE Assessment Centres Inc.) créée à la suite de recherches et qui fournit des services d'évaluation. Le protocole d'évaluation DriveABLE™ est offert aux médecins, aux autorités de délivrance de permis et aux assureurs par le biais de 21 centres au Canada et de 6 centres aux Etats-Unis.

Older driver crashes are of increasing concern across North America and elsewhere (US Department of Transportation[1], Li, Braver & Chen[2]). In Canada, older driver casualty crashes *increased* 47% between 1979 and 1995 (Transport Canada [3] [4]). Casualty crashes for drivers under the age of 65 *decreased* by 8% during the same time period. Similar statistics are found for the United States (US National Highway Traffic Safety Administration[5]; Barr[6]; Barron[7]). The current situation is that when the amount of driving is taken into account, drivers over the age of 70 have the highest crash rates of all drivers, except the youngest group (Evans[8], Transportation Research Board[9], Carr, Jackson, & Alquire [10]).

Unless effective interventions are put in place, continuing increases in older driver casualty crashes can be expected. Demographic trends indicate that the number of older drivers will increase rapidly, and outpace the growth in the older population. This is because a greater percentage of the older population will be driving, mainly due to increases

in the numbers of older females who will be driving. Overall, this will mean an increase in the numbers and the percentage drivers who will be over the age of 65. Current estimates are that by 2020 one in every four drivers will be over the age of 65. In addition, older drivers are driving more and driving longer into old age (Stutts, Waller & Martell[11], Eno Transportation Foundation[12]).

Driving longer into old age is an especially relevant statistic because the number of casualty crashes rise sharply beginning at about age 70. The societal challenges are to ensure that the problem is correctly framed and that interventions are fair and defensible. The solution must be appropriately and effectively targeted in a cost effective way.

Although there is a strong orientation toward talking about 'older drivers', this is an orientation that needs to be corrected. Age itself is a poor predictor of driving problems. Talking in terms of an 'older driver problem' inappropriately taints all older drivers. Older drivers are not all alike. It is inappropriate to talk about 'older drivers' as though that label somehow characterizes a group of like persons. There is a need, both in terms of fairness and in terms of targeting the problem areas for intervention, to move beyond talking about 'an older driver problem'.

The primary reason for declines in driving competence is the change in abilities that comes with debilitating medical conditions. Medical conditions are the issue, not age. Medical conditions that alter the ability to drive safely can occur at any age. That being said, the unfortunate fact is that as we grow older all of us are more likely to have one or more medical conditions that can alter abilities necessary for safe driving. The trend for seniors to drive more and longer into old age is cause for concern only because many of the debilitating medical conditions are increasingly likely at older ages. Again, age per se is not the concern, medical impairments that are associated with age (but occur in only some older people) are the concern.

The Problem Correctly Framed

Correctly framed, the problem is the increasing crash rates of medically impaired drivers. The safety associated with medically impaired drivers is relatively recent and growing because of the increasing numbers of persons in the age categories where impairing medical conditions are most likely. It is critical, however, that the focus is clearly and explicitly on the medically impaired driver as the problem and not on older drivers. If the causal focus for the increasing crash rates should inadvertently or deliberately drift to the older driver, the safe, competent older drivers (who constitute the majority) will be unjustly tainted. This could have untoward reduced mobility consequences and most certainly will be met with a political backlash.

Interventions intended to identify medically unsafe drivers must meet several challenges if there is to be progress in reducing injuries and fatalities caused by these drivers, without inadvertent or undue negative consequences. As a matter of convenience, the challenges have been grouped into three categories: Identification, Evaluation, and Consequences.

Challenges of Identifying Medically At-Risk Drivers

Several means of identifying drivers whose skills may have been reduced to an unsafe level have been suggested and are in practice. The seemingly most innocuous is that drivers with declining skills will identify themselves, and *self-regulate* their driving to times and places where they remain safe, and stop driving altogether when appropriate (B Dobbs[13]). This approach often does lead adult drivers who are insightful and mentally competent to make reasoned limitations in their driving. For example, it is well reported that older drivers tend to restrict when (daylight hours, not during inclement weather, not during rush hour) and where (avoid high traffic areas) they drive (B Dobbs[13]; Janke[14]; Rothe[15]). Current statistics showing the dramatic rise in crashes for older drivers is evidence that society can not rely solely on this approach. In fact,

the rising crashes rates for older drivers are occurring despite self-restrictions in driving.

Drivers seem to limit self restrictions mostly to changes in driving patterns, but usually stop short of complete driving cessation even when it is needed. Studies of drivers with cataracts presents even a more disappointing conclusion. The research showed drivers with cataracts did not restrict their driving (Owsley, Stalvey, Wells, & Sloane [16]). Data from the Public Health Survey[17] show that very few drivers actually give up their driving license, even when they have potentially very debilitating medical conditions and/or medications. For example, the report indicated only a 3% drop in the number of licensed senior drivers with 'some cognitive problems', and 26% of the senior drivers with 'serious cognitive problems' continued to be licensed.

The limitation of relying on self-restrictions is more obvious when attention is turned to drivers who have illnesses that affect insight and reduce cognitive abilities. 'Cognitive abilities' is used here to connote what people usually mean when they talk of mental abilities, for example, attention, memory, judgment, decision making, thinking and reasoning. Dr. B Dobbs[13] studied the self-restrictions in driving of participants from a larger project which included several hundred drivers. She reported that persons with cognitive impairment restricted their driving less than did comparable healthy, normal adults. Video tapes showed that many of those impaired drivers did not recognize even very serious driving errors at the time they were making them.

A recent trend is to promote self-restrictions through the use of self-administered questionnaires or 'screens'. These screens are simple tests of physical or mental abilities that can be self-administered or taken with the assistance of a lay person, such as a family member. The idea is that the person can complete the screen in a private and/or non-threatening environment. A recent version of this approach is available from the American Automobile Association (see their web page). The objective of this approach is to raise awareness of ability declines with the presumption that this will promote positive actions.

Everyone hopes this is the outcome. Supporting evidence, however, is lacking and there are reasons for caution. Driving is a highly *treasured* privilege. Giving up driving is not just giving up a preferred form of transportation. It is a very concrete acknowledgement of declining abilities. Moreover, moving from the driver's seat to the passenger's seat is a public display of that decline. One fear is that because screens reveal deficits in the context of driving, the outcome of the screen may cause persons with apparent difficulties to 'go underground' to avoid the possibility their declines can be detected. This could work to the disadvantage of the person (therapeutic remedies may not be sought) and could lead to dangerous drivers remaining on the road.

There is even reason to suspect self-screening may disadvantage persons who do well on the screen. Disadvantages could result if self confidence is elevated and results in an inappropriate decrease in restricting when and where the person drives. This could result in the driver being exposed to more dangerous situations. In this regard, research indicates that driver training to increase skills in a specific area (e.g., coming out of a skid on a slick road) can lead to a false sense of competence to handle driving situations beyond those for which training was provided, with the unintended and unfortunate consequence of an overall *increase* in crashes. Similar unintended negative outcomes could result from self- or buddy-administered screens: The point is that we just do not know the consequences of self- or buddy-administered driving screens. A call for research into the outcome of these screens seems appropriate, given the increased attention to this approach.

The medical community has been called on to play a key role in the identification of medically impaired drivers. The Canadian Medical Association[18] recently published new guidelines to

assist physicians in evaluating a patient's medical fitness-to-drive. Even more recently, the American Medical Association[19] published guidelines specifically directed toward evaluating older patients regarding driving, and identifies these evaluations as a physician responsibility.

Unfortunately, medical diagnosis is a poor predictor of driving ability. To make things worse, older patients often have not just one medical condition, but several, and several medications. People over the age of 65 have, on average 4 medical conditions, and take 5 prescription and 2 over-the-counter drugs. The co-morbidities and multiple medications often interact in unpredictable ways. The potential for sporadic events (e.g., seizure, heart attack) excepted, the most obvious and direct approach to determining a person's medical fitness-to-drive is to measure the functional outcome of the medical conditions on the person's ability to drive safely. Driving evaluations are the most direct approach.

The medical community is well placed for early identification of medically at-risk drivers. In order to allow the physicians (and others in the medical community) to make a societal contribution to traffic safety and to act in accordance with the directives of their professional organizations, several things are needed: Effective training regarding medical conditions and driving, protection against litigation, appropriate financial compensation related to the identification of medically at-risk drivers, and available, evidence-based, timely, and appropriate driving evaluations for their questionable patients.

Challenges of Testing Medically At-Risk Drivers

Not just any road test is acceptable. Entry level-road tests emphasize basic skills and strict adherence to the rules of the road. Few people, however, would hold the position that successful completion of an entry-level driver test truly certifies the driver as having the skill level necessary to be a safe driver. The high crash rates of young drivers provide ample evidence for the deficiencies. Although it is tempting to attribute the high crash rates to poor judgment or risk taking, it needs to be acknowledged that the poor judgment and risk taking are in the context of the novice driver's relatively weak skills and limited experience. As experience increases, the basis for judging what is risky becomes more realistic and broader, and driving skills improve. With new drivers, the presumption is that skills and experience will increase after licensing to put the driver at a better level of safety.

The experienced driver whose declines in driving competence are due to medical conditions is substantially different from the entry level driver. In most cases, it is unreasonable to expect that skills will improve with further experience. When the driver's medical condition(s) and medication(s) leave him or her with cognitive impairment, it is not only unreasonable to expect driver training to be effective, it is of questionable ethics to provide or require training. Such training is likely to be financially draining, and to provide false hope which can impede the needed acceptance of driving cessation.

For experienced drivers with declining competence, testing basic skills and rules of the road are not the central issue. Basic skills are highly over-learned, and over-learned skills and actions are the ones best preserved when mental abilities are reduced by trauma or disease. Moreover, experienced drivers may have well entrenched 'bad habits', which, although not to be encouraged, are not justifications for license removal. For example, it may be appropriate to fail an entry level driver for failing to come to a complete stop at a stop sign, but it is completely unjustifiable to revoke driving privileges of an experienced driver for making the same error, as though it was a measure of driver *competence*. Research shows that such an error, even if committed on multiple driving tests, should not be the sole reason for permanent suspension of a person's driving privileges.

What driving errors provide justification for driver license revocation? One aspect of our own research demonstrates the importance of differentiating competence defining driving errors from the 'bad habit' errors of competent drivers. Using a standard road course consistent with government test standards, a large sample of experienced, healthy, normal drivers were evaluated. Fully 28% of the healthy, normal drivers *failed* the road test using government scoring criteria. These drivers did not receive a failing score because of highly dangerous actions. This finding provides strong research evidence that government road testing procedures are not appropriate for evaluating the competence of experienced drivers with medical problems.

An important challenge of driver testing for experienced drivers with potentially impairing medical conditions is to define, with justification, the driving errors that indicate competence declines.

A second, and equally important, challenge is knowing how to reveal competence defining driving errors when testing medically impaired drivers. The structure of the driving course provides the tool to reveal driving problems. Not just any road course will do. Delineating the attributes of a road course (e.g., turns, merges, types of crossings, speed, visual conditions) that are sufficient to reveal the driving problems of medically impaired drivers is something that needs to be demonstrated, not just presumed by individual evaluators or consensus groups.

It should be noted that the issues regarding the granting of driving privileges are less complex than are the issues concerning revoking driving privileges. Criteria for revoking driving privileges of drivers with medical disabilities carry with them issues of discrimination. In Canada, the Supreme Court ruled that standards for testing a driver with visual disabilities could not require a level of driving safety that exceeded 'reasonable road safety', where reasonable road safety was meant to denote the level of road safety of healthy drivers who are permitted to drive (Supreme Court of Canada[20]). This likely is a precedent setting ruling for all medical disabilities (physical and cognitive impairments).

The Supreme Court ruling[19] does not say that the testing of healthy and disabled drivers needs to be the same. It is explicit in allowing the testing of disabled drivers to be different. The ruling instead emphasizes that the testing of the disabled driver can not require a higher standard of driving safety than is required for healthy road users. This focus calls for a criterion for evaluating medically disabled drivers that embodies a comparison between of the driving of the disabled driver and a known level of performance of healthy drivers.

This leads to the third challenge for the testing of drivers with medical conditions. That challenge is to ensure that the performance criterion embodies a comparison against a measure of the driving performance of experienced healthy drivers. If this is to be taken seriously, then an entry-level road test is not acceptable, given the knowledge that many healthy drivers would fail that test.

The final two challenges for identifying medically at-risk drivers considered here are difficult and have received little attention. One of these challenges is standardization of assessments across testing sites. As a measure of fairness, it is important to have procedures to ensure that every person would receive the same evaluation outcome regardless which testing site that person attended throughout a jurisdiction.

The final challenge is one of maintaining consistent quality across time. Quality assurance measures mostly have been limited to training standards and sporadic re-testing of driving examiners. There has been little in the way of quality assurance procedures that provide a constant monitoring of the administration of driving tests.

What Driving Tests are Available for Medically At-Risk Drivers?

The limitations of entry-level driver tests have been discussed above. Although these continue to be widely used, inadequacies are apparent. Demonstrably, healthy competent drivers are at risk of failing when there is strict adherence of the scoring to rules-of-the-road. Relaxing those criteria often results in evaluations that vary from driving examiner to driving examiner and from reviewing officer to reviewing officer, and is without supporting data from research. At the same time there is no confirming evidence that scoring procedures that emphasize basic skills and rules-of-the-road will identify medically impaired drivers. Nor is there confirming evidence that typical road course layout criteria for entry level road tests are adequate to reveal the driving problems of medically impaired drivers. Some jurisdictions (e.g., Maryland, California) have responded by lengthening the road course. Perhaps a more considered approach would be to identify, through research, the driving conditions that reveal the competence-defining driving errors of medically impaired drivers.

Specialized driving evaluations with an occupational therapy orientation are offered by a number of driver evaluation centers. Often these not-for-profit (usually cost recovery) or private centers are staffed by an evaluator who has specialized training such as that given to Driving Rehabilitation Specialists. Driving Rehabilitation Specialists (DRS) need not be occupational therapists: The designation refers to a training program offered by The Association for Driver Rehabilitation Specialists. The recommended evaluation techniques strongly emphasize clinical judgment, as can be seen from an examination of their Best Practices Manual[21] (see especially Section 5: Behind the wheel evaluation).

The Driving Rehabilitation Specialist approach is a clinical orientation wherein each person is considered unique. Having a standardized and validated driving evaluation is not the goal of most of these driving evaluators. More important is determining the person's driving goals and assessing driving in the driving situations relevant to those goals. From a Licensing Authority point of view, this could be considered a restricted license approach, although it is not clear that Licensing Authorities intend to extend decision making about restricted licenses to driving examiners, nor is it clear that a suitable restricted license is issued, or how that could be monitored.

Perhaps because of this clinical orientation, there is a lack of criteria for laying out the road course, a lack of criteria for scoring driving problems, and a lack of criteria for passing or failing a driver. All of these areas are left to the individual driving assessor. Unfortunately, this ensures variability from evaluator to evaluator. A move away from subjective evaluations and the need for a move toward standardization has been noted by several practitioners from within this tradition (Springle, Morris, Nowachek & Karg[22]; Engum, Pendergrass, Cron, Lambert & Hulse[23]; Galaski, Bruno, & Ehle[24]; Korner-Bitensky, Sofer, Kaizer, Geninas & Talbot[25]; Nouri, Tinson, & Linclon[26]).

The idiosyncratic nature of the evaluations also provides a barrier to validating the effectiveness of the testing procedures. In addition, it is not clear how any individual evaluator (or the group collectively) would meet the requirements of the Supreme Court's ruling regarding discrimination against person's with disabilities, because meeting those requirements necessitates a comparison of the disabled person's performance vis a vis a determination of *reasonable road safety*. The 'reasonable road safety' criterion necessitates knowledge about the performance of experienced healthy drivers in like driving situations, and using that information to reach a decision about the driving safety of the person.

The evaluation methods of the DriveABLE™ protocol represent a break from the subjective, clinical approach to driving assessment. The underlying tenant of the DriveABLE™ approach is that knowledge beyond personal observation and even consensus opinion is necessary, and that

science provides the means to acquire that knowledge. The following sections provide a description of the research and an overview of the DriveABLE™ protocol that resulted from the research findings. The discussion of the research has been organized to illustrate how each of the *challenges of driver testing* presented above were addressed through the research and procedural developments. Accordingly, the following sections address: Scoring Procedures, Road Course Criteria, Road Test Performance Criterion, and Standardization Procedures. The development of In-Office Assessment Procedures used both for safety and road test standardization goals also are discussed followed by a discussion of Quality Assurance Procedures.

The Research Approach and Discoveries Underlying the DriveABLE™ Driving Evaluation.

Background

The DriveABLE™ evaluation procedures were developed in response to a strong appeal by the chief of geriatrics and physicians from the Memory Clinic (Edmonton General Hospital) for a driver assessment that would allow evidence-based decisions about the driving safety of patients. There was a focus on cognitive impairment because it poses special challenges for physicians and others making licensing decisions, and because of its high prevalence among seniors. The Canadian Study on Health and Aging[27] estimates 8% of the senior population has a dementia and a further 17% have cognitive impairment that is not a dementia (Graham, Rockwood, Beattie, Eastwood, Gautier, Tuokko, & McDowell[28]) but due to an illness such as heart disease, lung disease, kidney disease, diabetes, and/or medications. Epidemiological studies from other countries show similar findings.

A recent study provides a sobering estimate of the magnitude of the challenge regarding cognitive impairing illnesses (Hopkins RW, Kilik L, Dat DJA, Rows C & Tseng H[29]). Because dementing illness are increasingly likely in old age and because seniors are living longer and driving longer into old age, the combined effects are that dementia and driving will become an increasingly serious issue. The enormity of this issue was illustrated by Hopkins et al.[29] by considering one licensing jurisdiction having about 500,000 drivers over the age of 65 in 1986. By the year 2000 this number had increased to just under 1,000,000 senior drivers and is projected to be almost 2,500,000 by 2028. Using reasoned estimates of the increasing prevalence of community dwelling persons with dementia and the numbers of those persons who will drive, the estimates are that there were 14,909 drivers with dementia in 1986, this number rose to 34,105 in 2000, and is projected to be 98,032 by 2028.

In a study of senior drivers killed in a crash, Johansson, Bogdanovic, Kalimo, Winbald & Vitanen[30] reported an autopsy study of 98 drivers age 65-90 who were killed in an automobile crash. Using conventional (CERAD) criteria, 53% of the drivers had histopathological findings suggestive of Alzheimer's disease. This should not be taken to mean that persons with a diagnosis of dementia should be restricted from driving. Although all drivers with a progressive dementia must eventually stop driving, a significant minority are safe to drive and should be allowed to drive in the early stages, and as long as they remain safe. This percentage may actually increase, given that diagnosis is now coming earlier in the progression of the illness and therapeutic drugs can delay the clinical decline. Nevertheless, the problems of cognitive impairment and driving are real now and as Hopkins et al.[29] eloquently illustrate, the problems will escalate exponentially.

Other data indicate the seriousness of cognitive impairment for traffic safety. A large-scale study of drivers with medical conditions showed that cognitive impairment was associated with a 7.6 fold increase in the risk of an at-fault crash (Diller, Cook, Leonard, Dean, Reading & Vernon[31]). To put

this in context, a blood alcohol level of .08 puts the driver at a 5.0 fold increase in the risk of a crash.

As our discussions between the medical community, government departments, and other stakeholders progressed, several things were agreed upon: a) Adequate scientific evidence was not available to develop a research-based driving evaluation, 2) It was imperative that the new driving evaluation would have a strong scientific basis, 3) New scientific evidence would have to be acquired, 4) As a temporary measure, a *Clinical Driving Consult* involving Rehabilitation Medicine and Neuropsychology Departments would be developed and implemented based on consensus agreement of assessment techniques, 5) The new science-based driving assessment needed to be developed 'as a package' to enable implementation in a wide variety of cities and towns, 6) The evaluation should focus on cognitive impairment (because the needs of physically impaired persons often required individualized prosthetic devices or vehicle modifications for which the clinical interventions of some specialists [e.g., occupational therapists] were well suited).

A guiding aspect of the strategic orientation was that simply identifying the driving errors of cognitively impaired drivers would be insufficient, as some of those driving errors might be identical to those of healthy, normal drivers. Any driving errors that are equally common to both healthy, normal drivers and medically at-risk drivers clearly are not useful for isolating drivers with medically-related competence declines. This meant that the type and extent of driving problems of cognitively impaired drivers had to be compared against those of healthy, normal drivers in order to disassociate competence-defining driving errors from the 'bad habit' driving errors of competent drivers.

It was feared that restricting the drive-test to public roadways might be insufficient. This was because some suggest it is only when unexpected events occur that impaired drivers reveal their deficiencies. In any case, it seemed important to know whether the driving evaluation that was developed would identify drivers who would be dangerous in those types of unexpected situations.

For these reasons, two road courses were developed and used in the research. One was a closed course which was designed in an area of the city which had completed roadways and signage, but buildings were not yet constructed. The city allowed restricting traffic from entering that area, enabling a variety of contrived situations to be tested. For example, an emergency stop situation was tested in which the speed of the vehicle was measured and the time to arrival at a point ~30 yards away was calculated. A Styrofoam silhouette of a vehicle was released down a ramp to cross in front of the driver at a time when an attentive driver could safely stop. In another section of the closed course where the driver had just passed a 'children playing' sign (actual signage from the city), vehicle speed and time of arrival at a distant point were calculated. From behind a parked car, a soccer ball was automatically released at a time where the driver did not have time to stop and avoid hitting the ball. The ability to detect roadside signage under conditions of concurrent cognitive loads also was tested, as was the ability to modify judgments about their own driving skills on a skills course, when explicit feedback about driving errors was given. Testing on the Closed Course required about 30 minutes.

The driver then proceeded to a road test given on public roadways and requiring about 45 minutes to complete. This test course included a residential area with uncontrolled intersections, light business area with controlled intersections, roadways with speed changes, and urban freeway entrance and exit. All drivers drove both road courses, except when the driver was grossly incompetent. The nature of the driving error, its severity, and location were recorded. A research assistant sat in the backseat and recorded specific types of situations (e.g., missed opportunities to make a safe left turn). Two video recorders (one on the driver, one on the road ahead) were used on all drives. A mid-sized

car with an automatic transmission and fitted with a dual-brake was used.

A young group (30-40 years of age) and an older group (65+) of healthy volunteers participated in the initial study to define the type and severity of driving errors made by normal, healthy drivers. All of those drivers received extensive neuropsychological testing and an assessment by rehabilitation medicine before they were taken for in-car testing. This assessment was the Clinical Driving Consult alluded to above. Providing this testing to the healthy volunteer groups ensured these younger and older control-group drivers were mentally and physically within the normal range. Importantly, it also provided an opportunity to assess the effectiveness of the neuropsychological and rehabilitation medicine tests for predicting actual driving performance. Each control-group participant also completed a variety of research tests that were designed or selected because they were likely to be better predictors of driving than were the neuropsychological and rehabilitation medicine tests. An emphasis in the design or selection of these research tests was complexity (the need for concurrent mental processing). The strategy here began with the acknowledgement that driving requires complex mental processing, which led to the speculation that complex office-based tasks were likely to be required for strong predictions about driving performance.

A group of drivers diagnosed as having a dementia was selected to represent cognitively impaired, unsafe driver group in the first study. All were currently licensed and driving. It is reasonable to designate this as the "unsafe driver" group because contemporary research shows that, as a group, dementia patients are unsafe drivers: 30-50 percent have a crash within a few of years of diagnosis (Fitten, Perryman, Wilkinson, Little, Burns, Pachana, Mervis, Malmgren, Siembieca, & Ganzeil [32]; Lucas-Blaustein, Filipp, Dungan, & Tune[33] Friedland, Koss, Kumar, Gaine, Metzler, Haxby, & Moore[34]), 80 percent continue to drive and 40 percent of those have at least one more crash before stopping driving (Cooper, Tallman, Tuokko, & Beattie[35]). These drivers allowed us to identify the types of driving errors that are made by unsafe, cognitively impaired drivers. All of these drivers also completed the neuropsychological and rehabilitation medicine testing of the Clinical Driving Consult, as well as completing the research tasks.

Four-hundred and ninety-three drivers completed the Clinical Driving Consult, the research in-office testing, and the two driving tasks. The data from these drivers was used in the data analyses.

Development of Scoring Procedures

During the testing of the drivers on the public road way, 150 different driving errors were freely recorded. Using a combined rational and statistical methodology proposed by Trochin, these were reduced to 13 categories of driving errors. The critical analyses were comparisons of the frequency and severity of each category of driving error across the three groups. This resulted in differentiating three groupings of driving error categories (Dobbs, Heller & Schopflocher[36]). Two categories of driving errors were made exclusively by the cognitively impaired drivers. This meant that making one or more of these errors was sufficient to identify the driver as being from the cognitively impaired, unsafe driver group. Four categories of driving errors showed a pattern wherein the cognitively impaired drivers showed the highest number and severity of those errors, followed by the older and younger groups, respectively. The frequency and severity of this group of errors reliably differentiated the three groups. These errors also are important to score as they are associated with driver competence, but attention is required to the frequency and severity for a competence determination.

Finally, the frequency and severity of all remaining driving error categories did not differentiate the three groups. This latter finding provides very important knowledge. Firstly, it identifies, explicitly, the driving errors *not* to score, as they

demonstrably do not identify competence declines. Secondly, these driving errors are the driving errors made during a driving evaluation by healthy, normal drivers. As such, these driving errors arguably fit the intent of the Supreme Court (Grismer) ruling about 'reasonable road safety'. This knowledge will be key in the development of the performance criterion described below.

The comparisons of driving errors of the cognitively impaired drivers against those of the healthy, normal drivers in this research represents the only large scale evidence-based delineation of the driving errors that are, and are not, markers of driving competence declines. Through these discoveries, a science-based scoring scheme was developed that highly weights the competence markers and eliminates contamination by errors that are not competence related.

Development of Road Course Criteria

The identification of driving errors that are markers of driving competence declines is an important advancement, but it would be a shallow one if the conditions requisite to revealing the markers was left to speculation. To avoid that situation, an analysis of the driving situations associated with the competence markers was initiated. This involved first identifying the locations in the road course at which large numbers of competence related driving errors were made. An extensive examination of the attributes of those locations was then initiated. This resulted in discoveries regarding the type of driving maneuvers, road conditions (type of intersection, speed, number of lanes, traffic flow, etc.), and the characteristics of the driving environment that are necessary to reveal the important markers of driving competence declines. This information was then translated into a set of rules for laying out a road course that would have the attributes necessary for effective evaluations of medically at-risk drivers.

Development of a Performance Criterion

A justifiable and fair performance criterion for medically at-risk drivers must be based on evidence that clearly shows the driver is impaired, and it must not discriminate against that driver as compared to healthy drivers who are reasonably allowed continued driving privileges.

The research data allowed for meeting both of the conditions specified above. Having determined which driving errors are competence marking errors, and how to reveal those errors, we were able to develop a scoring scheme that weights only the driving errors that are competence markers. This ensures high scores for medically impaired drivers. Low scores for competent drivers are ensured by having identified and not scoring the 'bad habit' errors of healthy, normal drivers. The second condition is satisfied by having a normative base against which a driver's score is compared to determine whether competence has fallen to an unsafe level. This provides an explicit way of avoiding arbitrary or even unwitting discrimination against medically impaired drivers. DriveABLE™'s database for the healthy, normal drivers provides the relevant comparison base, because it defines the types and extent of driving errors that are made by healthy normal drivers. Discrimination is avoided by setting a fail criterion that requires the person make driving errors that place him or her outside the range of competence defining errors displayed by healthy, normal drivers in that situation. In the language of the Supreme Court, the fail criterion requires the driver's errors be 'beyond reasonable road safety' before driving cessation is recommended.

An interesting aspect of the research concerns the role of 'unusual' events such as those tested on the closed course. After identifying those drivers who were medically unsafe using the criterion described above (competence defining driving errors with a frequency and severity beyond that of healthy, normal drivers), we reviewed the closed course data to see if additional drivers would be identified. The finding was that no drivers were identified who had not already been identified by the open-road testing. This greatly simplified matters, in that unique and perhaps dangerous situations are not needed if the road conditions of the DriveABLE™ assessment

are used. A 'take-me-to' instruction also was included. Again, no drivers were identified who had not already been identified by the open-road testing.

Development of an In-Office Assessment

As mentioned above, each driver also completed a set of cognitive tests selected or developed because of their relationship to driving. On the basis of the research findings, a set of these tests was selected to form a short Cognitive Evaluation that was very strongly related to actual on-road performance. The approach was not a 'cognitive domain' approach in which there was an attempt to represent each of the presumed relevant cognitive abilities in isolation within the test battery. Instead, the strategy recognized that driving requires concurrent use of mental abilities from different domains and shifting among abilities in sometimes diverse domains. Tasks requiring the concurrent use of different mental abilities that were short, easy to instruct, and amenable to computer presentation were emphasized. Tests were selected from this set to form a battery of tests having high accuracy in predicting actual driving performance.

As always, the lowest level of predictive accuracy was for scores falling in the mid ranges. Predictions not approaching 100% accuracy were unacceptable, because accurate and fair decisions about continued driving are critical to the well-being of the person and to the safety of other road users. To maximize the in-office evaluation's predictive accuracy, high (pass) and a low (fail) criterion were selected that enabled exceptionally high accuracy in predicting driving performance in the ranges defined by those criteria. We designated those with scores falling between the two criteria as 'indeterminate' and requiring an in-car evaluation to resolve competency.

The DriveABLE™ In-Office Evaluation is computer presented and scored, and the testing procedures are client friendly. A DriveABLE™ trained professional guides the client through the assessment. Although the tests are computer presented, they require only 'touch-the-screen' or button-push responses. Computer knowledge, or even familiarity with a computer, is not a determiner of performance. Computer presentation enables precision measurements, unbiased scoring, and immediate results.

Validation

In the next phase of the research, the DriveABLE™ In-Office Assessment and the Road Evaluation procedures were validated using a large (over 400) new sample of drivers. The new testing sample included drivers across the age range and purposefully included patients having a wide variety of medical conditions, all of which had associated, non-specific mental decline (e.g., dementia, pulmonary disease, cardiovascular disease, renal disease, head trauma, including co-morbidities and poly pharmacy). These two extensions extended the applicability of the assessment procedures beyond older drivers and dementia to ***all driving age groups, and to any illness (or combination of illnesses) that results in generalized cognitive impairment***.

A new course for the road-test was defined using the criteria discovered in the research, which defined the road conditions, maneuvers, visual, and other attributes of driving situations needed to reveal the competence-defining driving errors. The mental ability tests identified as, collectively, providing the best prediction of actual in-car test performance were evaluated as a computerized test battery along with the scoring algorithms and cut-off criteria that maximized the predictive accuracy. The goal of the In-Office Assessment was to increase the safety of the evaluation protocol by identifying the most dangerous drivers without the necessity of on-road testing, and to increase the economy of the assessment by identifying as many as possible of the safe drivers, again using only the In-Office Assessment. If the cut-off scores could be validated as accurately identifying many of the dangerous and competent drivers, this would greatly reduce the number of medically at-risk and potentially dangerous drivers who would need to be tested on public roadways.

The results showed that the rules developed for setting up an effective road course were highly effective. One goal was to decrease the more dangerous errors and compensate overall by setting the circumstances to increase the number of less dangerous errors so that the overall outcome of identifying the unsafe drivers would be the same, but with a safer testing procedure. The data clearly show that the frequency of errors in the most dangerous categories were reduced while the numbers of competence marking, but less dangerous errors, were increased in all cases. Moreover, the driving error scoring system proved to be appropriate for categorizing all of the driving errors.

The research also showed that the cutoff scores defined in Phase I of the research for the In-Office Evaluation enabled exceptional (95%) accuracy in identifying the most dangerous drivers and the most competent drivers. This validated the use of the In-Office Assessment as an effective and accurate tool for increasing the safety and cost-effectiveness of the DriveABLE™ evaluation.

Development of Standardization Procedures

All licensing authorities need to be assured that the evaluation drivers receive is effective at all test sites. Critical driver deficiencies may not be revealed by easy road courses, whereas an overly difficult road course can put even a good driver in jeopardy. Moreover, it is vitally important to drivers and licensing authorities that the outcome of a driving assessment would be the same for any person regardless of which test center the person attended. This is a tough challenge. Even with careful attention to defining each road course in terms of types of maneuvers, intersections, road conditions, etc., differences will always remain. No two sites are ever the same.

Equating road course difficulty across all sites in a jurisdiction is, undoubtedly, an impossible task. An alternate means of attaining equivalence between driver testing sites is to adjust the performance criterion to accommodate differences in the difficulty of the road courses at different sites.

In the case of DriveABLE™, there was stringent attention to determining the driving errors that mark competence declines, and to the number and severity of these critical driving errors that put the driver out of the range of normal, healthy drivers. These findings are anchored to a road course having relevant attributes and a specific difficulty level.

The DriveABLE™ solution to equating road course difficulty across sites is to provide a criterion (the In-Office Assessment), external to the driving task, against which the performance on any particular road course can be measured. Because that criterion has a known relationship to the pass/fail ratio on the standard road course, it can be used to measure of the difficulty of any specific road course. This information is used to adjust the pass/fail criterion for each road course so that the performance outcome will match that of the standard road course.

Without an external criterion measure, and a calibration procedure such as that described above, it is not clear how standardization across sites can be achieved.

Determining Equal Fairness for Urban and Rural Drivers

To test the fairness of the evaluation protocol for urban and rural drivers, we directly compared the outcome of the assessment for 100 urban and 100 rural drivers sent to DriveABLE™ by physicians. The groups of rural and urban drivers were carefully matched on age, sex, diagnosis, and score on a test of mental abilities. The research showed only a 2% difference in the success/fail rates between the urban and rural drivers, confirming the appropriateness of the assessment protocol for urban and rural drivers.

Development of Quality Assurance Procedures

Test administrators and road test examiners must remain true to the training and administration criteria. For this purpose, all client data are encrypted for confidentiality and sent via the Internet to the DriveABLE™ home office. Quality Assurance monitoring includes:

- Confirming that known relationships among Cognitive Assessment tasks are preserved at each site over time.
- Periodic re-confirmation of calibration calculations for standardization
- Evaluation of road test examiner performance by confirming that expected errors occur at locations known to reveal specific error types.
- Evaluating stability of road test examiner scoring criteria through comparison of his/her ratings of driving attributes of the driver's performance with scores given for driver errors.

The Consequences of Forced Driving Cessation

When the driving of a family member has become unsafe, there are often a host of problems that besiege the driver and the family. First, the driver is ill, and the reality of that may not have been accepted. Sometimes, as is often the case with illnesses with no obvious onset and relatively slow progression, it takes some indisputable concrete event to force recognition of the illness. Too often, driving is that concrete event. When drivers have to stop driving, they have one or more illnesses that are seriously affecting their ability to function. Not being able to drive is a clear and very public marker of decline. Dealing with the loss of self-esteem, the decline in abilities, the illness, and the possibly changing role of the person within the family can be very difficult.

Dr. B. Dobbs and her colleagues have compared different types of support groups for persons who must stop driving and for their primary caregiver. The research identified how the issues differ for the ex-driver and the caregiver and how each needs to be addressed with a different approach and goals. Support groups based on the research are being implemented locally and a training manual to broaden the availability is under development. The goal is to make these manuals available to enable wide development of driving cessation support groups.

DriveABLE™ has developed a set of brochures to assist families in identifying when a family member's driving may have declined to an unsafe level and how to approach that person about the need for an assessment is available to families.

The DriveABLE™ Assessment

The DriveABLE™ Assessment Centres, Inc. assessment protocol is appropriate for drivers of all ages whose driving competence is questionable due to a medical condition, medications or a natural decline affecting mental abilities. Persons with physical disabilities requiring minor vehicle modifications may be accepted for evaluation on an individual approval basis. The test report was designed in collaboration with physicians and licensing authorities. The information needed for evidence-based decisions and patient discussions is presented in a clear, concise manner to facilitate processing and communication with the patient and family.

In the introduction of this paper, several challenges of testing medically at-risk drivers were identified. Each challenge can be addressed by science. In the research section, the scientific approach to meeting each challenge was described. The components of the DriveABLE™ Road Evaluation are firmly grounded in scientific discoveries: The scoring system, road-course layout criteria, and performance criterion all have a strong scientific basis. DriveABLE™'s In-Office Assessment was developed with the same scientific rigor to increase the safety by providing a means of identifying the most dangerous drivers without the need for in-car testing on public roadways. This test later became an important aspect of standardizing the road testing by providing an external criterion by which road course

difficulty could be determined. The DriveABLE™ assessment model was designed to meet the growing need for an objective, standardized assessment to evaluate drivers with medical conditions that may make them unsafe to drive. It can be implemented in any mid-sized town and urban center. For more information, visit www.driveable.com.

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