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ANALYSIS OF DRIVING RECORDS OF DRIVERS HAVING MEDICAL REVIEWS IN 1988-1992

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Analysis of Driving Records of Drivers Having Medical Reviews in 1988-1992.

The Highway Safety Research Center has periodically carried out analyses of the driving records of drivers participating in the North Carolina Medical Evaluation Program. The most recent such analysis reported by Popkin, Stewart, Martell and Little (1991), involved drivers who were 55 years old or older and who had a medical review between January 1st, 1983 and December 31, 1987. These drivers were grouped according to primary and secondary disabilities and the driving records of drivers within these groups were compared with those in a control group of drivers not in the Medical Evaluation Program.

The current study represents an update and extension of the previous study in that all drivers participating in the Medical Review Program who had medical reviews between January 1988 and December 1992 were included. As in the earlier study, the driving records of those in the Medical Review Program were compared with those of drivers in a control group. Driving records over the time period 1993 and 1994 were used for these analyses.

The Study File

Driver history records indicated that a total of 44,853 drivers had received medical reviews between the dates of January 1st, 1988 and December 31, 1992. This Medical review population together with a control sample of 10,000 drivers, made up the study file.

Tables 1-3 show the distributions by primary disability code, race, and age and sex, respectively, for the Medical review population.

Table 1. Distribution of primary disabilities of Medical review population.

Primary Disability	Frequency	Percent
No Disability	372	0.8
Cardiovascular	2958	6.6
Stroke	1194	2.7
Disability/End	1742	3.9
Blackout	770	1.7
Seizure/Nar	5368	12.0
Neuro	1052	2.3
Cong N/M	171	0.4
Cere/Vas MLFRM	16	0.0
Paralysis-Trauma	78	0.2
Mus/Skel	269	0.6
Misc	360	0.8
Visual	13,420	29.9
Mental	812	1.8
Schizophrenia	483	1.1
Bi-Polar	245	0.5
Neurotic	89	0.2
Pers Disorder	40	0.1
Alc/Drug	14,736	32.9
Organic Brain	253	0.6
Patholog. Driver	262	0.6
Aging (75+)	163	0.4
Total	44,853	100.0

Table 2. Distribution of Medical review population by race.

Race	Frequency	Percent
White	36,357	81.1
Black	7862	17.5
Indian	475	1.1
Other	159	0.4
Total	44,853	100.0

Table 3. Distribution of Medical review population by age and sex, frequency and (percent).

	Sex		
Age	Male	Female	Total
17-35	4804 (10.72)	3212 (7.17)	8016
36-50	7825 (17.46)	2327 (5.19)	10,152
51-65	6963 (15.54)	1939 (4.33)	8902
66-80	6403 (14.29)	3316 (7.40)	9719
81+	4479 (10.00)	3542 (7.90)	8021
Total	30,474	14,336	44,810

For the control sample, a total of 10,000 drivers were selected by a systematic procedure with random starting points. The sample was stratified by age categories and sex to have the same distributions as that of Table 3. Thus, 1072 male control drivers were selected with ages

between 17 and 35, 717 female drivers in this age range, etc. While race was not used as a stratification factor, Table 4 below shows that the race distribution of the control sample was quite similar to that of the Medical review population.

Table 4. Distribution of control sample by race.

Race	Frequency	Percent
White	7589	75.9
Black	2194	21.9
Indian	112	1.1
Other	105	1.0
Total	10,000	100.0

Methods and Results

Accident and violation records for the years 1993 and 1994 were analyzed using the combined study file to determine which of a number of factors were associated with higher and lower accident and violation rates. While most of the drivers in the study file had no accidents and no violations in 1993 and 1994, a few had a s many as five accidents and/or 15 violations. Table 5 shows the distribution of drivers having 0, 1, 2+ accidents and 0, 1, 2, 3+ violations for the control group and 23 subgroups of the Medical review population based on primary disabilities. The specific codes shown in table 5 are listed in the appendix.

In previous analyses, driver subgroups based on primary and secondary disabilities were identified and the proportion of drivers in each subgroup having one or more accidents or one or more violations in a specified time interval was compared to the similar proportion from a control group. The comparisons were carried out using a statistical model (categorical logistic model) which also factored in effects due to differences in age, sex, and race among the subgroups. Many of the subgroups were quite small, so that a substantial amount of collapsing into more major subgroups was required prior to the modelling.

Since the last such analysis, computer software has become available which now permits the application of more computationally intensive methods to relatively large data sets. The analyses which follow made use of one such method, namely Poisson regression. With this method a model is fit to the data on accident frequencies (or violation frequencies). More specifically, it is assumed that the number of, say, accidents N_A occurring to a given driver is a realization of a Poisson random variable with a probability function

$$P(N_A = k) = \frac{e^{-\mu}\mu^k}{k!}, \quad k = 0, 1, 2, \ldots .$$

It is assumed, moreover, that the parameter μ, (the mean), varies from driver to driver and is a function of characteristics such as age, race, sex, and medical disability. Specifically it is assumed that

$$\log \mu = \beta_0 + \sum_{j=1}^{J} \beta_i X_i \quad ,$$

where β_0 is a constant term, the X_j are the variables mentioned above, and the β_j are effects to be estimated by fitting the model. The output from the fitted model also provides an estimated standard error for each β, and a test of its statistical significance. If an estimate β_j is positive and significant, then the mean value μ and the probability of accidents tends to increase with increasing values of the variable X_j; conversely for negative values of β.

In order to estimate and test the effects of the various medical disabilities on accident rates, a set of dummy or indicator variables was defined corresponding to disability groups 1-22 of Table 5 as follows,

$$X_1 = \begin{cases} 1 \text{ if driver classified into group j,} \\ 0 \text{ otherwise} \end{cases}$$

$j = 1, 2, \ldots, 22.$

For the control group all of the X_j's = 0.

Thus, in a model containing $X_1, \ldots, X_{22}$ the estimated coefficients yield a comparison of accident rates in each disability group with the control group.

In addition to the dummy variables described above the models also contained the variables age, $(age)^2$, sex (coded 1 for male, 2 for female), and three dummy race variables indicating black, indian and other, respectively. A few other dummy variables indicating certain secondary disabilities and license restrictions were also included. These will be described later in the model building process.

Due to the size of the data set, the large number of variables, and some uncertainty concerning limitations of the computational procedure, the accident model was built up by first splitting the data and disability variables into three subsets and fitting submodels which compared the included disability variables with the controls while adjusting for age and sex. After initial estimation each submodel was reduced by:

a) removing nonsignificant variables, (i.e., disability groups with accident rates that did not differ significantly from the control group; these groups were essentially combined with the controls into the reference group), and

b) combining disability groups whose estimated effects (accident rates) were so similar that they did not differ significantly.

As an illustration, the first submodel contained the disability variables personality disorders, neurotic disorders, seizure/narcolepsy, diabetes/other endocrine, congenital neuro-muscular disease, and no disability, along with variables for age and sex. After the initial fit, congenital neuro-muscular was omitted from the model and personality and neurotic disorders were combined into a single group with its own indicator variable. Based on criterion (b) above, the no disability subgroup could have been combined with the diabetes/end group. It seemed, however, that it might be more reasonable not to include the no disability subgroup in these analyses, so it was taken out of the model and the data base and not used in subsequent models.

The data and variables from the three submodels were then combined into an overall accident model and dummy variables for race, license restrictions, and two variables based on

secondary disabilities were also included. Four license restriction variables were included. These were dummy variables which indicated the following restrictions:

1. driver was required to wear glasses,
2. where and when restrictions of speed limit ≤ 45, no interstate driving, daylight only,
3. driving restricted to certain vehicles.
4. other special restrictions

The secondary disability variables were:

$$SD1 = \begin{cases} 1 \text{ if any secondary disability indicated,} \\ 0 \text{ otherwise} \end{cases}$$

$$SD2 = \begin{cases} 1 \text{ if secondary disability code in (30, 31, 32, 35, 36, 37, 39, 40, 41, 42, 60, 62, 63, 64, 75, 77),} \\ 0 \text{ otherwise} \end{cases}$$

The disability codes indicates by SD2 were those with the highest accident rates as secondary disabilities.

Further reductions were done with the overall accident model by again removing non-significant variables. No further combining of variables was done, though, perhaps, some could have been. At last, the results of the reduced overall accident model are shown in Table 6. The table lists the significant variables that remained in the model, the estimated effect (β coefficient), its standard error, a X^2 test of the variables significance and its P-value. To illustrate the meaning of the model coefficient estimates, consider a white male, 40 year old driver. With only this information, his expected accidents (in 2 years) would be given by

$$\begin{aligned} \hat{A}_1 &= \exp(-.2691 - .0514(40) + .003(40)^2 - .3137) \\ &= e^{-2.1588} = .1155. \end{aligned}$$

If the driver had a medical classification of diabetes/end., then this expectation would be increased by the factor $e^{.4322} = 1.5406$ to yield the value $\hat{A}_2 = (1.5406)(.1155) = .1779$. A where or when driving restriction (e.g., daytime, no interstate) would result in a further increase of $e^{.5272} = 1.6942$ to give $\hat{A}_3 = .3014$.

Thus, the estimated coefficients of Table 6 show how expected accidents or 2 year accident rates increase or decrease as a function of each of the significant variables. Drivers in disability groups not listed in table 6 would have the same estimated accident rates as the controls.

Table 6. Accident model results.

Variable	Estimate	Standard Error	X^2	P-Value
Intercept	-.2691	.1061	6.43	.0112
Age	-.0514	.0038	185.55	.0001
$(Age)^2$	.0003	.00003	80.51	.0001
Sex	-.3137	.0310	102.32	.0001
Race/Black	.3427	.0319	115.80	.0001
Seizure/Nar.	.2744	.0410	44.87	.0001
Pers./Neu. disorder	.8300	.1762	22.19	.0001
Diabetes/End.	.4322	.0602	50.75	.0001
M-group*	.2700	.0561	23.19	.0001
Path. driver	.6100	.1657	13.56	.0002
Org. brain syn.	-.9747	.3815	6.53	.0106
Glasses (rest.)	.2954	.0299	97.34	.0001
Where & When (rest.)	.5272	.1055	24.99	.0001
Special Veh. (rest.)	-.9567	.1557	37.73	.0001
SD2	.1817	.0531	11.70	.0006

*M-group is a combined group consisting of acquired neuro-muscular disorders, mental disorders, schizophrenia, bi-polar disorder.

A model of the same type was also developed for violations over the 2 year period. The results from this model are shown in Table 7.

Comparison of the results in Tables 6 and 7 show that the models for accidents and violations differ in several respects. Violation rates tend to decrease linearly with driver age while for accident rates the positive age^2 term causes the decrease to be less than linear. Two of the race indicator variables (black and other) appear in violation model while only one was statistically significant in the accident model. Also, it may be noted that several of the medical disability and restriction variables which appear in both models have positive algebraic signs in

Table 7. Violation model results.

Variable	Estimate	Standard Error	X^2	P-Value
Intercept	1.2628	.0713	313.31	.0001
Age	-.0504	.0011	2294.60	.0001
Sex	-.5727	.0384	222.38	.0001
Race/Black	.5304	.0320	274.14	.0001
Race/Other	.6325	.1092	33.55	.0001
Cardiovascular	-.5389	.1120	23.13	.0001
Stroke	-.4153	.1714	5.87	.0154
Seizure/Nar.	-.4283	.0507	71.24	.0001
Diabetes/End.	-.3446	.0852	16.38	.0001
M-group	-.2015	.0700	8.30	.0040
Path. driver	.4607	.2164	4.53	.0333
Alcohol/drugs	.2622	.0369	50.55	.0001
Visual	-.2403	.0648	13.77	.0002
Special Veh.	-.4770	.1929	6.48	.0134
Glasses	-.1366	.0370	13.64	.0002

the accident model but negative signs in the violation model. This shows that drivers in these groups tend to have higher accident rates than the controls, but lower violation rates. The alcohol/drug disability variable did not appear in the accident model indicating that accident rates of drivers in this group did not differ significantly from the controls. They do tend, however, to have higher violation rates as shown in Table 7.

In summary, Poisson regression models were used to compare accident and violation rates of drivers participating in the Medical Review Program with those of drivers in a control sample. Mean accident and Violation rates were modelled as functions of the drivers' age, sex, race, primary and secondary disability classification, and the presence of certain license restrictions. Accident rates were significantly higher than those of the control drivers for drivers with primary disability codes of seizure, personality , or neurotic disorder, diabetes/endocrine disorder, acquired neuro-muscular, mental or bi-polar disorders, schizophrenia, or pathological driver. Accident rates were also increased by a secondary disability of any of the following: blackout, seizure, narcolepsy, neuro-muscular disease, cerebral vascular malformation, paralysis, head or brain trauma, brain tumor, emotional or mental illness, bi-polar, neurotic or personality disorder, mental deficiency or pathological driver. License restrictions of glasses or where and when restrictions also added to increased accident rates. Drivers classified as having organic brain syndrome and/or with special vehicle license restrictions had lower accident rates than the control drivers.

Drivers with primary disability classifications involving alcohol or drugs or pathological drivers had higher violation rates than the controls. Those having license restrictions of glasses or special vehicle restrictions, or primary disabilities of cardiovascular, stroke, seizure/narcolepsy, diabetes/end., visual, acquired neuro-muscular disorder, mental or bi-polar disorder, or schizophrenia had violation rates that were significantly lower than those of the control drivers.

Some characteristics of drivers released from the medical review program 1988-1992

The driver history file contained a code indicating a release from the medical review program for a total of 82 drivers in the period 1988-1992. Curiously, the release date for all but

six of these drivers was a 1988 date. The age of these drivers ranged from 20 to 91. Percentiles of the age distribution were:

35 - 25th percentile
43 - 50th percentile
46 - 75th percentile

Race and sex distributions of these drivers were:

Male - 74.4%
Female - 25.6%

White - 82.9%
Non-white - 17.1%

Driving records of the 82 drivers in the released group were scanned to determine how often an accident or violation appeared on the driving record after the release date, and/or how often the record indicated further contact with the medical review program. Results are tabulated below:

Accident or violation following release

yes - 53 (64.6%)
no - 29 (35.4%)

Later medical evaluation

yes - 68 (82.9%)
no - 14 (17.1%)

Later Accident or Violation	Later Med. Evaluation: Yes	Later Med. Evaluation: No	
Yes	49 (92.5%)*	4 (7.5%)	53
No	19 (65.5%)	10 (35.5%)	29
	68	14	82

*row percent

These records would indicate that a large proportion of drivers released from the program had subsequent evaluations at a later date. Often these subsequent evaluations may have been triggered by a driving accident and/or violation.

REFERENCE

Popkin, C.L., Stewart, J.R., Martell, C., Little, C. (1991). Two North Carolina Programs for Assuring the Safe Mobility of Older Drivers: Alternative Transportation and Driver Medical Evaluation. HSRC Report.

APPENDIX
DISABILITY CODES USED IN DRIVER HISTORY FILE

00	No physician-diagnosed disease of consequence
11	Hypertension
12	Cardiovascular disorder - coronary artery disease, myocardial infarctions, cardiomyopathy, HCVD, etc.
13	Valvular heart disease and all congenital heart disease
14	Cerebrovascular accidents (including ruptured aneurysms, etc)
15	Cardiac arrhythmias
16	Peripheral vascular disease (non-cerebral), aneurysms, obstructive, TIAs, etc.; and non-cardiac vascular surgery
17	Congestive heart failure
18	Pacemaker
19	Cardiac surgery - coronary by-pass, angioplasty, valvular replacement, etc.
20	Diabetes mellitus
25	Other endocrine disorders
30	"Blackout spells" syncope, dizziness, vertigo, etc.
31	Seizure disorder (all types) - Grand mal, petit mal, etc.
32	Narcolepsy, sleep apnea, & related disorders
35	Acquired neuro-muscular disease - multiple sclerosis, Parkinson's disease, muscular dystrophy, etc.
36	Congenital neuro-muscular disease - cerebral palsy, myelomeningocele, spinal bifida, hydrocephalus, etc.
37	Cerebral vascular malformations (A-V malformations, aneurysms, etc.)
39	Paralysis - complete or partial, secondary to trauma (CNS, cord injury, etc.)
40	Paralysis, complete or partial, of any other etiology
41	Head and/or brain trauma, sub-dural hematoma, etc.
42	Brain neoplasm or tumor (including acquired hydrocephalus)
45	Arthritis, rheumatism, and bursitis
46	Absent extremity(ies) or part(s) thereof
47	Non-paralytic back impairments (including cervical spine), LOM, kyphosis, short statue, etc.
48	Other impairments involving bones, joints, and/or muscles
50	Hearing impairments
55	Visual defects - General eye condition (refractive errors, trauma, glaucoma, etc.
56	Cataracts (including post-operative), corneal scars, Fuch's corneal dystrophy, etc.
57	Visual field changes (including optic atrophy, glaucoma, retinitis, etc.)
58	Retinitis pigmentosa, Stagart's Retinitis
60	Emotional or mental illness (including Alzheimer's and other dementias)
61	Schizophrenia and schizoid disorders - paranoid, chronic, undifferentiated
62	Bi-polar disorders (manic and/or depressive) - with and/or without psychosis
63	Neurotic disorders (anxiety, panic, hysteria, conversion, phobias)
64	Personality disorders (socio-pathic, anti-social, passive-aggressive, hyperaggressive, borderline, oppositional)
65	Alcohol related - all cases coded prior to 7/1/69
66	Alcohol related - no record of DWI or other evidence of drinking while driving
67	Alcohol related - convicted of DWI or other evidence of drinking while driving, record of abstinence for 18 months or longer
68	Alcohol related - convicted of DWI or other evidence of drinking while driving, abstinence for 18 months NOT DEMONSTRATED
70	Illegal and/or improper drug use and/or drug use contraindicating driving
75	Mental deficiency
76	Organic brain syndrome (of any etiology)
77	"Pathological Driver"? (secondary to any disorder) - multiple accidents, bad driving habits, etc.
80	Respiratory disorders
89	Aging driver (by definition age 75 or older) - may or may not be impaired
90	Miscellaneous diseases or impairment (specify - renal, anemia, cancer, obesity, etc.)