

MEDICAL CONDITIONS AND CAR CRASHES

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ABSTRACT

Most previous studies of medical conditions associated with driver safety have focused on specific diseases. This analysis is based on a linkage of police report and hospital discharge data, and correlates various medical diagnostic categories and specific conditions with police determinations of driver culpability for all drivers admitted to Maryland hospitals during a 3-year period. Using odds ratios, various conditions have been identified which are associated with an increased risk of crash culpability. Further research is needed to confirm these findings, and to determine the role of the conditions vs. the possible influence of medications prescribed to treat these conditions.

Driving is a cognitively complex task related to multiple functions, many of which can be diminished or altered by chronic medical conditions. Numerous studies have addressed the role of medical conditions in the causation of motor vehicle crashes. Most have focused on specific conditions, such as epilepsy, or on specific subgroups of the population, such as the elderly. The populations studied are frequently medical populations known to departments of motor vehicles or those referred to specialty clinics for given conditions. Many have been case/control studies in which drivers involved in crashes are compared with others not involved in collisions. In a 1965 study of California drivers whose medical conditions were known to the Department of Motor Vehicles, drivers with diabetes, epilepsy, cardiovascular disease (CVD), alcoholism and mental illness averaged twice as many crashes per 1,000,000

miles of driving, as compared to a control group without such conditions [Waller, 1965]. However, the study was biased because of the fact that it was not possible to assume a similar degree of crash risk in unreported drivers with the same conditions.

Conditions such as epilepsy and diabetes mellitus, which can cause loss of consciousness or loss of body control, have always been of special concern with regard to traffic safety. However, studies have frequently been inconsistent or biased as a result of selection. Three studies suggested that the crash rate among drivers with epilepsy was 1.3 to 2 times greater than the rate among age-matched controls [Hormia, 1961; Waller, 1965; Crancer and McMurray, 1968]. However, these studies are several decades old, and recent advances in management of these disorders have led to improved medical control. In a more recent analysis, Hansotia and Broste (1991), in a study of Wisconsin drivers, concluded that drivers with epilepsy or diabetes have slightly increased crash risks as compared to controls. The authors conclude that these risks are too small to warrant further restrictions on driving privileges. Songer, La Porte et al. (1988) reported on a case control study comparing crash rates among insulin-dependent diabetes mellitus cases and a matched sample of their non-diabetic siblings. While overall there was no increase in the crash risk for cases and controls, female diabetic drivers did show a marked increase in motor vehicle collisions, as compared to their non-diabetic siblings.

Other studies have focused on the role of cardiovascular disease in motor vehicle crashes. A population-based case control study of male drivers aged 45-70 showed that drivers suffering from CVD were less likely to be involved in motor vehicle crashes; however, the response rate to the study questionnaire (36%) was low [Guibert, Potvin et al., 1998]. In a 30-year-old study of Washington State drivers, a random sample of drivers restricted for specific heart diseases was selected for study, along with a sample of non-restricted drivers. Drivers with arteriosclerotic and hypertensive disease were found to have significantly higher crash rates than their comparison group, but those with rheumatic and other heart disease were not significantly different from their controls [Crancer and O'Neill, 1970].

Many studies of medical conditions and driver risk have focused on older drivers, among whom the prevalence of chronic disease is considerably higher. A case control study of elderly Quebec drivers suggested that, with the exception of drivers with arrhythmias, those with chronic medical conditions were not at

increased risk of crashes [Gresset and Meyer, 1994]. In another population-based Canadian study, once again, no increased risk of motor vehicle crashes was shown for drivers with medical conditions; this study took into account driver characteristics and miles driven [Guibert, Duarte-Franco et al., 1998].

In a rural Iowa study of older drivers, an increased risk for motor vehicle crashes was associated with episodes of back pain, use of nonsteroidal anti-inflammatory drugs, and poor performance on a free-recall memory test [Foley et al., 1995]. Dementia of the Alzheimer type was implicated in a case/control study, resulting in an eightfold increase in crash risk [Friedland et al., 1988]. Koepsell et al. (1994) noted a significant increase in crash risk among elderly diabetic drivers, especially those treated with insulin or oral hypoglycemic agents.

Sims, Owsley et al. (1998) suggest that functional assessments may be of greater relevance than specific medical conditions in the identification of older at-risk drivers. Such assessments might include measures such as tests of visual processing, a history of falls, and a review of current medications.

Using linked data from police reports and hospital discharge data, we are able to create a database on all *drivers* hospitalized in the state of Maryland following a vehicular crash. In the past, we have utilized this linked data to examine the nature of injuries for drivers in different types of collisions, or to compare outcomes for those with and without seatbelts, for example. For the purpose of this analysis, however, we focus on diagnoses of pre-existing conditions among all drivers hospitalized in the state of Maryland between the years of 1994 and 1996. Based on the police report, driver culpability (yes/no) was analyzed in terms of various categories of medical conditions included in the hospital discharge summaries.

METHODS

SOURCE OF THE DATA - In order to examine injuries for all drivers hospitalized in the state of Maryland during the period 1994-1996, data were obtained from the following two sources: hospital discharge records from the Health Services Cost Review Commission (HSCRC), and police reports from the Maryland Automated Accident Reporting System (MAARS). These data were linked, using probabilistic linkage techniques, to obtain data on all drivers of cars, trucks, or vans, admitted to acute care hospitals during this period. The uniform hospital discharge abstract data were

obtained from all 52 non-federal acute care hospitals in the state. These data, by definition, exclude outpatient cases and deaths that occurred either at the scene, in transport, or in an emergency department. Thus, drivers who died following hospitalization are included.

DATA LINKAGE - A total of 10,002 eligible cases were selected from the hospital discharge records. The selection criteria included all patients with motor vehicle mechanism of injury and at least one International Classification of Diseases - 9th Revision (ICD-9) code between 800 and 959.9 (excluding late effect, foreign body, and complication). From the police reports, all drivers (N=545,105) were selected. The two databases were then linked, using probabilistic linkage techniques [Jaro, 1989; Jaro, 1995]. This technique is based on a computation of odds ratios for the variables in question; thus, not all variables hold the same weight with regard to the probability of a match. For example, due to its relative uniqueness, driver date of birth would carry more weight than driver gender. The variables used for linkage included date of crash, date of admission, date of birth, gender, mechanism of injury, and ambulance run sheet number. Because the crash database includes non-injured persons, it was expected that a substantial portion of the records in that database would not link with records in the hospital discharge database. Following the linkage, 84.5% (N=8,425) of the hospital discharge records were matched with crash records. The resulting database for this study included data on 7,750 hospital drivers of automobiles, light trucks, vans, and recreational vehicles.

DEFINITIONS OF KEY VARIABLES - Medical conditions were grouped into the following diagnostic categories: neoplasms (ICD-9 140-239), endocrine disorders (ICD-9 240-279), diseases of the blood (ICD-9 280-289), mental disorders (ICD-9 290-319), diseases of the nervous (ICD-9 320-389), circulatory (ICD-9 390-459), respiratory, (ICD-9 460-519), digestive (ICD-9 520-579), and genitourinary (ICD-9 580-629) systems, musculoskeletal disorders (ICD-9 710-739), and “ill-defined” conditions, i.e., those conditions that could not be easily categorized, such as alteration of consciousness, syncope and collapse, convulsions, dizziness, fatigue, palpitations, etc. (ICD-9 780-799).

A determination of crash culpability is included as part of each police report, and is based on an assessment by the investigating officer. Driver condition, including drinking/drugged status, was also based on police perception. For the majority of cases, no diagnostic tests for alcohol or drugs were performed.

ANALYSES - Preliminary analyses were based on associations between crash culpability and general diagnostic categories, such as circulatory or respiratory disease. For each set of analyses, comparisons were based on Pearson's chi-square statistic for categorical variables. Further analyses were then conducted within diagnostic categories, to examine the role of specific medical conditions, such as coronary heart disease or asthma. Odds ratios were determined, and confidence intervals were calculated to determine those conditions having an increased or decreased risk for causing a crash.

As this is an exploratory examination of the association between pre-existing medical conditions and crash culpability, a probability level below 0.05 was considered suggestive of a significant trend. Stricter statistical guidelines would be more practical for future prospective studies conducted to confirm these findings.

RESULTS

Linkage of the hospital discharge and police report databases over the three-year period yielded 7,750 drivers admitted to Maryland hospitals following motor vehicle collisions. As noted in Table 1, a majority of hospitalized drivers were male. Also, more than half were aged 39 or less, with 17.5% aged 60 or older. In addition, approximately two-thirds (67.7%) were deemed by the police to be culpable for the crash. Approximately one-quarter of the drivers were involved in single vehicle crashes; of this group, 90% were deemed culpable by the investigating officer. Of the total group, 15.9% were determined by the police to have been drinking or using drugs.

**Table 1 - Characteristics of Drivers/Crashes
(N=7,750)**

	<u>n</u>	<u>%</u>
Male	4,636	59.8
Age (years)*		
≤39	4,491	58.0
40-59	1,898	24.5
60+	1,356	17.5
Culpable*	4,747	67.7
Single vehicle	1,686	90.4
Multi-vehicle	3,045	59.5
Drinking/Drugged	1,143	15.9

* Totals may vary due to missing data.

Analyses presented in Table 2 show the association between driver characteristics and crash culpability. Men were significantly more likely than women to have been judged culpable for their crash. Culpability rates were similar for the youngest (39 or less) and oldest (60 and older) drivers, with the lowest rates noted for the middle-aged group of drivers aged 40-59. For drivers determined to have been drinking or using drugs, the rate of culpability was 95.6%, as compared with 61.6% for drivers who were not intoxicated.

**Table 2 - Culpability by Driver Characteristics
(N=7,750)**

	<u>% Culpable</u>	<u>p</u>
Sex		
Male	70.6	
Female	63.3	<0.001
Age		
≤39	70.5	
40-59	58.1	
60+	71.6	<0.001
Drinking/Drugged		
No	61.6	
Yes	95.6	<0.001

The distribution of pre-existing conditions for the 7,750 drivers is presented in Table 3. Overall, 32.6% of drivers had no documented medical condition. Approximately one third (33.9%) had one condition, while 17.1% had two; 16.4% had three or more conditions. There was an association between number of conditions and driver culpability. Among drivers with no pre-existing conditions, 62.2% were culpable, compared to 70.4% for those with a condition. However, although there was a slight increase in the rate of culpability by number of conditions, the increase between one and three or more conditions was only 3%.

The medical conditions are also summarized, by major diagnostic categories, in Table 3. The largest category was that of mental disorders (25.1%), followed by circulatory disease (20.6%), respiratory (15.4%), and endocrine (15.3%) diseases. Diseases of the nervous system (5.7%), diseases of the digestive system (5.0%), and neoplasms (0.9%) were the least prevalent conditions among the drivers. Since, as mentioned previously, some drivers had multiple conditions, these percentages total more than 100%.

**Table 3 - Distribution and Type of Pre-Existing Conditions
(N=7,750)**

	<u>n</u>	<u>%*</u>	<u>% Culpable</u>
Number of Conditions			
0	2,524	32.6	62.2
1	2,626	33.9	70.7
2	1,323	17.1	66.8
3+	1,277	16.4	73.5
Type of Conditions			
Mental Disorders	1,762	25.1	80.0
Circulatory	1,447	20.6	67.2
Respiratory	1,077	15.4	72.1
Endocrine	1,074	15.3	69.1
Ill-Defined Conditions	931	13.3	68.6
Blood	796	11.4	72.7
Genitourinary	548	7.8	71.2
Musculoskeletal	475	6.8	61.3
Nervous	397	5.7	70.3
Digestive	352	5.0	69.9
Neoplasms	66	0.9	77.3

*The percentages total more than 100% since some drivers had multiple conditions.

Table 4 shows the association between each diagnostic category and crash culpability, for each of the three age groups of drivers. Those diagnostic categories showing positive associations with driver culpability are: endocrine disorders (for drivers 40-59), blood diseases (for older drivers), mental illness (for all age groups of drivers), respiratory disease (for drivers less than 60), genitourinary disorders (for older drivers), ill-defined conditions (for all drivers). For musculoskeletal disorders, for drivers less than 60, there was a negative association with crash culpability—that is, those drivers were more likely to not have caused the crash.

Table 4 - % Culpability by Diagnostic Category and Age (N=7,750)

Type of Conditions	AGE GROUP		
	<39	40-59	60+
Mental Disorders	82.4 [^]	71.9 [^]	83.1 [^]
Circulatory	71.5	57.6	71.0
Respiratory	75.3*	63.4*	75.1
Endocrine	68.6	63.8*	73.9
Ill-Defined Conditions	65.6*	65.2*	77.2*
Blood	73.8	63.9	78.4*
Genitourinary	72.4	58.5	79.6*
Musculoskeletal	53.3 [^]	49.6*	75.3
Nervous	72.3	64.4	72.3
Digestive	70.1	63.0	75.2
Neoplasms	62.5	77.8	84.4

* p<.05 [^] p<0.001

As described in the methods, for diagnostic categories that were significantly associated with crash culpability, further analyses were conducted in order to identify which specific conditions might be involved. These conditions are shown in Table 5. Age-adjusted odds ratios and confidence intervals are presented for each of these statistically significant conditions. The odds ratio tells the extent to which the risk of culpability is elevated or reduced, given the medical condition and after adjustment for driver age, as compared with the culpability for drivers without the condition (i.e., those who have no medical conditions as well as those having other medical conditions). For example, for syncope, which was the condition with the highest odds ratio, drivers with the condition were 4.06 times more likely to have caused the crash than drivers without such a history. The next highest odds ratios were for nephritis, nephrotic syndrome, and

nephrosis (OR= 3.15), and alcohol dependence syndrome, with an odds ratio of 2.63. Other conditions found to be positively associated with crash culpability included cerebrovascular disease, chronic obstructive pulmonary disease, anemias, other diseases of the urinary system (the majority [90%] of which were classified as "other disorders of the urethra and urinary tract"), and diabetes mellitus (of borderline significance). Both dorsopathies and rheumatism were associated with a decreased culpability rate, perhaps reflecting self-imposed driving limitations due to physical impairments resulting from these conditions.

Table 5 - Odds of Crash Culpability by Specific Medical Conditions (N=7,750)

Condition	<u>Odds Ratios</u>	<u>95% Confidence Interval</u>
Syncope	4.06	2.36 – 7.63
Nephritis, Nephrotic Syndrome, Nephrosis	3.15	1.33 – 9.26
Alcohol Dependence Syndrome	2.63	2.01 – 3.49
Cerebrovascular Disease	1.94	1.20 – 3.28
Chronic Obstructive Pulmonary Disease	1.38	1.08 – 1.77
Anemias	1.34	1.13 – 1.59
Other Disease of Urinary System	1.27	1.03 – 1.56
Diabetes Mellitus	1.26	0.99 – 1.60
Dorsopathies	0.70	0.52 – 0.94
Rheumatism	0.54	0.32 – 0.92

DISCUSSION

Using available sources of data within the state, we have examined the association between crash culpability and various pre-existing medical conditions among a cohort of injured drivers admitted to Maryland hospitals. The medical conditions selected for investigation are chronic conditions assumed to have been present at the time of the crash. Since the police report and hospital discharge data are independently collected, there should be no bias on the part of the investigating police officer with respect to the medical conditions and crash culpability. In addition, the hospital discharge data probably yield more accurate information on medical conditions than that obtained by drivers' self-reports or data reported to licensing authorities, since they were collected for another purpose.

While these associations do not necessarily prove causation for the crash, they do provide an objective way of comparing drivers with and without diseases which may have played a role in the circumstances leading up to the crash event. Given the limitations of the data, it is not possible to distinguish between effects of the disease itself vs. the effects of any medications that might have been prescribed for treatment of the condition. In addition, some conditions, such as anemias, are very non-specific and could be associated with multiple diseases/disorders. Another example is syncope, which showed the highest odds ratio for crash culpability. Since syncope is a symptom and not a condition, it may be associated with a variety of conditions, such as diabetes, high blood pressure, etc.

While some pre-existing conditions are associated with crash culpability only for older drivers, others exist across all age groups. However, some of this variability is obviously a function of population size, as effects may be too small to achieve statistical significance in smaller data cells. It is known that crash risk increases among older drivers, but it is not known to what extent this increase is a function of age-related sensory impairments -- for example, decreased vision and hearing, versus medical conditions which are a function of age. Many of these medical conditions may be associated with subclinical impairments which may be subtle in nature, and not the more obvious signs of severe disease.

With regard to the specific conditions associated with increased crash culpability, some have been previously mentioned in the literature. For others, however, such as chronic obstructive pulmonary disease and nephritis, nephrotic syndrome, and nephrosis,

no previous literature has been found which implicates these conditions with respect to crash causation. However, all of the conditions identified have the potential to, in some way, impair a driver's cognitive abilities. More detailed prospective studies should be conducted in order to replicate these findings in other populations, clarify the possible risks associated with these conditions, and separate the contributions of the illness per se and the medications used to treat the illness.

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(Presenter: Patricia Dischinger)

Ted Miller: As you look at a hospital discharge record, just because you've been admitted for a motor vehicle crash injury, it obviously doesn't give you a catalog of your entire health condition. It just says these are the things that we treated and are entitled to get reimbursed for. So, for example, I might have diabetes, but they didn't have to do any special treatment for it so it doesn't get into the record. Doesn't that mean that your comparison category at the base of your odds ratios is really contaminated by people who belong in the other classes?

P. Dischinger: I definitely think that could be a problem. There are, however, 15 places for diagnoses to be listed. I think you are absolutely right, especially for a condition like alcohol dependence, and how that would end up in the medical record, I'm not sure. So this is sort of a fishing expedition and we do not imply causality but we think it would provide some interesting clues to conduct further prospective studies in a more controlled fashion.

Maria Segui-Gomez: I completely agree with your point about this being association, not causality, but the point I would like to hear more about is how this culpability variable gets assigned by the police. We've seen you use it, we've seen other authors use it. You made the point in the presentation that police do not know about these pre existing medical conditions and I'm not quite sure that that's completely true. There are some pre existing medical conditions that are quite obvious, particularly mental disorders, and so I wonder how much bias there is in the assignment of culpability and thus the association working in the direction that says those with those pre existing medical conditions are the ones being assigned as culpable. Also that applies for age and gender as you said.

P. Dischinger: That's a good point. We did actually call the police to try and get more details about how they assign culpability. They only added this variable I think three years ago. I got sort of a run around and never got a really good answer, just that it's up to the police officer's opinion who is at the scene if there's an obvious condition, but of course most of these would not be obvious; for example, dorsopathy or a mental condition or a psychosis that might be obvious. But many of these are like alcohol dependence and they may or may not have been BAC positive at the scene.

Urs Maag: Are there any that have to be reported to the licensing authority even when you renew the license?

P. Dischinger: I really don't know. I believe epilepsy and diabetes were in the past. That's a very good question. I don't know in Maryland if there are others.