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## Comparison of Unsafe Driving Across Medical Conditions

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Manuscript title: Comparison of unsafe driving across medical conditions

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## **Key points**

**Question:** What are the risks of unsafe driving across medical conditions?

**Findings:** In this cohort study of more than 6,500 patients undergoing a formal driving evaluation, risks of unsafe driving varied greatly across medical conditions. Patients with psychiatric conditions or substance abuse were at higher risks of unsafe driving than other medical conditions.

**Meaning:** Varied risks of unsafe driving depending on medical conditions should be recognized by physicians and driver licensing authorities through sensitization campaigns, additional education, and better guidelines for assessing driving fitness.

## **Abstract**

**Importance:** The manner and extent to which different medical conditions impact the ability to drive vary according to the nature of the condition. Identifying risks of unsafe driving across medical conditions offers substantial implications for physicians, policymakers, and driver licensing authorities.

**Objective:** To compare risks of unsafe driving in patients with medical conditions.

**Design:** Cohort study

**Setting:** Center for Evaluation of Fitness to Drive and Car Adaptations (CARA), Belgian Road Safety Institute, Brussels, Belgium.

**Participants:** Patients with various medical conditions who were referred for a driving evaluation.

**Main Outcomes and Measures:** Risks of unsafe driving including physician's fitness-to-drive recommendation, comprehensive fitness-to-drive decision, motor vehicle crash history, and traffic violation history.

**Results:** A total of the 6,584 patients with medical conditions who visited a driving evaluation center from 2013 to 2014 were included in the study. Risks of unsafe driving across medical conditions were significantly different for physician's fitness-to-drive recommendation ( $p < 0.001$ ), comprehensive fitness-to-drive decision ( $p < 0.001$ ), motor vehicle crashes ( $p < 0.001$ ), and traffic violations ( $p < 0.001$ ). Patients with neurological conditions comprised the majority of the database (74%), but were not at highest risk for unsafe driving. Patients with psychiatric conditions or substance abuse did worse on most driving safety outcomes, despite their low representation in the total sample (6% and 1%, respectively).

**Conclusions and Relevance:** The risks of unsafe driving varied greatly across medical conditions. Sensitization campaigns, education, and medical guidelines for physicians and driver licensing authorities are warranted to identify patients at risk, especially for those with psychiatric conditions and substance abuse problems.

## Introduction

The ability to drive a car is vital for independence and freedom, especially in smaller towns and rural areas where public transportation is sparse and not a viable alternative for outdoor mobility.<sup>1,2</sup> Driving is an overlearned, yet complex activity that requires intact visual, cognitive, and motor skills to accurately and timely respond to a constantly changing environment<sup>3</sup>. Medical conditions may adversely affect the visual, cognitive, and motor prerequisites for safe driving<sup>4</sup>.

Traditionally, the influence of medical factors as direct cause of motor vehicle crashes (MVCs) is considered to range between 1 and 2% of all MVCs<sup>5</sup>, with one study reporting 12.7% of all MVCs to have a direct medical cause<sup>6</sup>. Epidemiological studies and meta-analyses revealed that some medical conditions pose higher risks of MVCs than others<sup>5-8</sup>. Particularly, epilepsy, neurological conditions, psychiatric conditions, alcohol abuse, and sleep apnea were postulated to substantially increase the risk of MVCs<sup>7</sup>. Cardiovascular conditions and visual deficits slightly increased the risk of MVCs<sup>9,10</sup>. Thus, the variability in the risk of MVCs across medical conditions is an important consideration for physicians, policymakers, and driver licensing authorities.

Although MVCs are a key indicator of driving safety, they are of limited use to driver licensing authorities. MVCs are rare events and unsafe drivers may not necessarily have had a crash. Some MVCs are inevitable, caused by factors extrinsic to the driver<sup>4</sup>. Obtaining crash information from the drivers' self-report or their caregivers may be subject to inaccurate recall or unwillingness to provide accurate information. Likewise, official motor vehicle records may not be comprehensive or may vary among local motor vehicle offices<sup>11</sup>. Ideally, MVCs due to medical conditions should not occur due to the medical regulations that are in place to pro-actively screen for unsafe driving before an actual MVC occurs<sup>12</sup>.

In addition to MVCs, another quantifiable measure of safe driving is the fitness-to-drive decision. According to the American Medical Association, fitness-to-drive criteria are increasingly based upon an evidence-based model reflecting the policies on the medical aspects of safe driving and the requirement to justify medical standards for drivers when they are challenged in court<sup>12,13</sup>. The decision-making process of fitness-to-drive involves informing patients about their rights and duties regarding driving, verifying whether patients comply with the medical criteria stipulated in the law, and assessing the minimum medical prerequisites for driving. In most jurisdictions, fitness-to-drive decisions are medical procedures to identify patients who may be at risk of MVCs. Although fitness-to-drive decisions reflect different constructs of driving safety than MVCs, they have shown to significantly decrease the rates of MVCs and traffic violations<sup>12,14</sup>.

The physician may also refer to a driving assessment expert, who will make a fitness-to-drive recommendation based on a comprehensive off-road and on-road driving evaluation. Studies have reported inconsistencies in fitness-to-drive agreements made by referring physicians and driving assessment experts in several neurological conditions<sup>15-17</sup>. Yet, it is unclear which medical conditions physicians struggle most with to determine fitness-to-drive.

The overall objective of this study was to compare different constructs of unsafe driving (physician's fitness-to-drive recommendations, and comprehensive fitness-to-drive decisions, self-reported MVCs, and self-reported traffic violations) across medical conditions. A secondary aim was to compare the fitness-to-drive recommendation made by the referring physician with the comprehensive fitness-to-drive decision across medical conditions.

## **Methods**

### ***Participants***

From 2013 to 2014, a total of 10,519 drivers underwent a formal fitness-to-drive evaluation at the Center for Evaluation of Fitness to Drive and Car Adaptations (CARA) of

Belgian Road Safety Institute, which is the only legal fitness-to-drive authority for drivers with functional deficits in Belgium<sup>18</sup>. Of those, we excluded duplicate records, drivers without a comprehensive fitness-to-drive decision, and drivers with no information regarding their medical condition. We only used the data of 2013 when visitors returned in 2014. Finally, 6,584 drivers were included in the analysis. They were referred to CARA because of (i) a change in their medical status; (ii) an extension of the validity period of their driver's license; (iii) a new driver's license category; or (iv) a mandatory referral by insurance company, court, or medical expert.

The study protocol was approved by the Institutional Review Board of Augusta University.

### ***Procedure***

All patients completed medical questionnaires together with their referring physician that included demographic, driving, and clinical history (Table 1). Detailed information regarding the individual medical condition was also collected, including type of diagnosis, date of diagnosis, medications, and symptoms. The primary diagnoses were categorized in ten conditions: (i) neurological conditions; (ii) psychiatric conditions; (iii) musculoskeletal conditions; (iv) visual conditions; (v) vestibular or hearing conditions; (vi) cardiovascular or pulmonary conditions; (vii) liver or renal conditions; (viii) sleep disorders; (ix) diabetes mellitus; and (x) substance abuse. The classification of medical categories was adopted from the National Highway Traffic Safety Administration of the United States Department of Transportation<sup>19</sup>. The driving assessment at CARA lasted between one and four hours and encompassed a medical examination, visual, road tests, and, if necessary, neuropsychological testing.

### ***Outcome measures***



The four outcome measures of driving safety were: (a) first tier fitness-to-drive recommendation by the referring physician, (b) final tier comprehensive fitness-to-drive decision, and (c) number of self-reported MVCs and (d) traffic violations in the five years preceding the fitness-to-drive evaluation.

The referring physician was the patient's primary care physician or specialist and was blind to the comprehensive fitness-to-drive decision. The team of physicians, neuropsychologists, and driving assessment experts, all affiliated with CARA, made the comprehensive fitness-to-drive decision based on the patient's overall performance on medical, visual, and road tests, complemented with neuropsychological testing if deemed necessary.

The referring physician and CARA team categorized each patient into one of three classes: (i) fit-to-drive without restrictions, (ii) fit-to-drive with restrictions, and (iii) unfit-to-drive. This three-class fitness-to-drive recommendation or decision was dichotomized to pass and fail categories. The pass category included drivers who were found fit to continue driving without or with restrictions in use of time (e.g., daylight only), distance (e.g., familiar area only), or speed (e.g., no highways). The fail category involved those judged as unfit-to-drive. This dichotomization was reasonable for the final tier of the fitness-to-drive evaluation, since drivers who passed would be allowed to continue driving. Of note, our previous work used a different classification to discern patients who had concerns on the road from those with no concerns on the road in the first tier of the fitness-to-drive evaluation<sup>15,20</sup>. In those studies, the aim was to screen out patients who should undergo a detailed driving evaluation because they exhibited functional limitations that may impair safe driving.

### ***Data analysis***

Variables were assessed for normality using Kolmogorov-Smirnov tests. Differences between groups were examined using Kruskal-Wallis tests (KW) or Pearson's chi-squared

tests ( $\chi^2$ ). Post-hoc analyses including Mann-Whitney U tests or  $\chi^2$  were employed with Bonferroni correction for multiple comparisons ( $p = 0.001$  or  $0.05/45$ ). The medical categories were entered into four separate logistic regression analyses to determine the odds ratios (OR) of unsafe driving across all medical conditions.

The prevalence-and bias-adjusted kappa (PABAK) was utilized to compare the referring physician's recommendation with the comprehensive fitness-to-drive decision<sup>21</sup>. The PABAK values were interpreted according to Landis and Koch's criteria<sup>22</sup>. All statistical analyses were performed using SPSS 22 and SAS Enterprise Guide 6.1.

## **Results**

### ***Patient characteristics***

A total of 6,584 individuals visited CARA during the two years were analyzed (Table 1). The median age of patients was 55 years old. The majority (70%) were male. Almost 18% were first-time visitors to CARA whereas 82% were recurring visitors. The most common reason for CARA application was extension of validity period of driver's license (42%), followed by change in medical condition (34%), mandatory referral (16%), and new driver's license (8%).

The majority of patients (74%) were diagnosed with neurological conditions as their primary condition, followed by musculoskeletal conditions (12%) and psychiatric conditions (6%). All other medical conditions accounted for less than five percent of the total sample. More than half of patients (58%) had no comorbidity other than their primary condition, while the rest of patients (42%) had one or more comorbidities.

Only 2% of patients were judged as fail by the referring physician, while 10% of the same cohort failed the comprehensive test at CARA. The majority of patients (81%) reported no MVCs in the past five years. Among the patients involved in MVCs, 13% reported one MVC and 6% reported two or more MVCs. The majority of patients (75%) reported no traffic

violations. Among the patients reporting traffic violations, 13% reported one traffic violation and 12% reported two or more traffic violations.

### ***Evaluation of unsafe driving across medical categories***

Overall, few drivers with medical conditions exhibited concerns with driving safety. The failure rate in physician's recommendation ranged from 0 to 10% across medical categories (Figure 1), which was lower than the failure rate in comprehensive fitness-to-drive decision in most medical categories (4 to 25%). The rates of MVCs and traffic violations in the past five years presented a similar trend across most of the medical categories.

- (a) *Fitness-to-drive recommendation by the referring physician.*** Significant differences were found in physician's fitness-to-drive recommendation across medical categories ( $p < 0.001$ ). Substance abuse showed the highest failure rate (10%), significantly higher than neurological conditions ( $p < 0.001$ ), musculoskeletal conditions ( $p < 0.001$ ), and cardiovascular or pulmonary conditions ( $p < 0.001$ ).
- (b) *Comprehensive fitness-to-drive decision.*** Significant differences were observed in the comprehensive fitness-to-drive decision over the medical categories ( $p < 0.001$ ). Two medical categories that showed higher failure rates were psychiatric conditions (25%) and substance abuse (22%) compared to other medical conditions. The failure rate for musculoskeletal conditions was significantly lower than neurological conditions ( $p < 0.001$ ), psychiatric conditions ( $p < 0.001$ ), visual conditions ( $p < 0.001$ ), cardiovascular or pulmonary conditions ( $p < 0.001$ ), diabetes mellitus ( $p < 0.001$ ), and substance abuse ( $p < 0.001$ ). The failure rate was significantly lower in neurological conditions compared with psychiatric conditions ( $p < 0.001$ ) and visual conditions ( $p < 0.001$ ).
- (c) *Self-reported MVCs.*** Significant differences were observed in the self-reported MVCs across the medical categories ( $p < 0.001$ ). The rate of MVCs in neurological conditions was 17%, significantly lower than cardiovascular or pulmonary conditions ( $p < 0.001$ ),

diabetes mellitus ( $p < 0.001$ ), and substance abuse ( $p < 0.001$ ). The rate of MVCs in musculoskeletal conditions was 22%, significantly lower than cardiovascular or pulmonary conditions ( $p < 0.001$ ) and substance abuse ( $p = 0.001$ ).

**(d) *Self-reported traffic violations.*** Significant differences were found across the medical categories ( $p < 0.001$ ). The rate of traffic violations in substance abuse (53%) was significantly higher than neurological conditions ( $p < 0.001$ ) and cardiovascular or pulmonary conditions ( $p < 0.001$ ).

### ***Demographic and clinical characteristics across medical categories***

Demographic and clinical characteristics were analyzed for each medical category (Table 2). Significant differences across medical categories were observed in age ( $p < 0.001$ ), sex ( $p = 0.007$ ), previous CARA visits ( $p < 0.001$ ), reason for application ( $p < 0.001$ ), and comorbidity ( $p < 0.001$ ). Patients with cardiovascular or pulmonary conditions were the oldest (median = 77), whereas patients with psychiatric conditions were the youngest (median = 39). The percentage of males varied from 53% in vestibular or hearing conditions to 80% in diabetes mellitus. Patients with musculoskeletal conditions had visited CARA more often prior to the current evaluation compared to patients with neurological conditions ( $p < 0.001$ ), psychiatric conditions ( $p < 0.001$ ), cardiovascular or pulmonary conditions ( $p < 0.001$ ), and diabetes mellitus ( $p < 0.001$ ).

Reasons for CARA application varied across medical categories (Table 2). Sleep disorders, liver or renal conditions, and substance abuse presented higher percentages (> 40%) of mandated referral by insurance company, court, or medical expert. The percentage of mandated referral in neurological conditions was 13%, which was the lowest among medical categories and significantly lower than psychiatric conditions ( $p < 0.001$ ), cardiovascular or pulmonary conditions ( $p < 0.001$ ), sleep disorders ( $p < 0.001$ ), and substance abuse ( $p < 0.001$ ).

Per comorbidity, only 8% of the patients with visual conditions had more than one comorbidity, significantly lower than neurological conditions ( $p < 0.001$ ), psychiatric conditions ( $p < 0.001$ ), musculoskeletal conditions ( $p < 0.001$ ), vestibular or hearing conditions ( $p < 0.001$ ), liver or renal conditions, sleep disorders ( $p < 0.001$ ), diabetes mellitus ( $p < 0.001$ ), and substance abuse ( $p < 0.001$ ) (Table 2).

A logistic regression model was fitted with medical categories as independent variable and each of the four driving safety outcomes as dependent variables. Musculoskeletal conditions were considered the reference category in each model due to their representation (12%) in the total sample and their relatively low risk of unsafe driving. Only significant ( $p < 0.05$ ) OR are described. Per physician's recommendation, neurological conditions (OR, 3.20 [95% confidence interval (CI), 1.30-7.88]), psychiatric conditions (OR, 3.23 [95% CI, 1.02-10.26]), and substance abuse (OR, 16.62 [95% CI, 4.27-64.60]) were more likely to receive a fail compared with musculoskeletal conditions. Likewise, neurological conditions (OR, 2.23 [95% CI, 1.60-3.12]), psychiatric conditions (OR, 6.36 [95% CI, 4.26-9.49]), visual conditions (OR, 2.66 [95% CI, 1.44-4.91]), and substance abuse (OR, 5.36 [95% CI, 2.48-11.58]) were more likely to be judged unfit-to-drive by the CARA team. Substance abuse (OR, 3.14 [95% CI, 1.49-6.63]) continued to emerge as the most unsafe medical category in terms of MVCs, along with cardiovascular or pulmonary conditions (OR, 2.09 [95% CI, 1.43-3.06]). Finally, substance abuse (OR, 2.61 [95% CI, 1.24-5.40]) again was the most unsafe category in terms of traffic violations.

### ***Comparison between physician's recommendation and comprehensive fitness-to-drive decision***

Overall, strong ( $>0.80$ ) reliability was observed between physician's recommendation and comprehensive fitness-to-drive decision (PABAK = 0.84; 95% CI, 0.83-0.86;  $p < 0.001$ ). Referring physicians correctly identified the comprehensive fitness-to-drive decision in 90%

of the cases. A total of 615 (10%) of the patients were judged differently by referring physicians and the CARA team. Among the disagreed cases, 61 patients (10%) were overestimated and 554 patients (90%) were underestimated by the physicians.

Whereas strong reliability was found for most medical categories, only substantial (0.60-0.80) reliability was found in psychiatric conditions and substance abuse (Table 3). In psychiatric conditions, 76 (24%) of the patients were judged differently in the comprehensive fitness-to-drive decision compared to the physician's recommendation. Among those, 74 who were initially judged as pass by the referring physician, were unfit to drive according to the comprehensive fitness-to-drive decision. Similarly, in substance abuse, 9 (23%) of the 39 patients were judged differently between referring physicians and the CARA team. Among those, seven patients initially judged as a pass by the referring physician were finally judged as fail.

## **Discussion**

In this population-based study, we compared the risks of unsafe driving across ten categories of medical conditions. Our main findings were: (1) the majority of patients referred for a specialized driving evaluation center have a neurological condition; (2) the distribution of unsafe driving across medical conditions depends on the outcome measure used; and (3) the agreement between the medical fitness-to-drive recommendation and the comprehensive fitness-to-drive decision varies greatly across medical conditions.

About 1 in 6 in the world's population have neurological conditions<sup>23</sup>. In our study, neurological conditions accounted for almost 75% of CARA referrals. The high representation for neurological conditions may be attributed to the diverse range of visual, cognitive, and motor impairments that might impair safe driving<sup>24</sup>. Also, patients with neurological conditions are often referred because of car adaptations that need to be mounted

to their vehicle. Despite their high representation in the sample, none of the driving safety outcome measures indicated that patients with neurological conditions were most unsafe. By contrast, the distribution of unsafe driving greatly varied across medical conditions and across the four outcome measures. These results suggest that the four outcome measures evaluate distinct constructs of driving safety.

Overall, physicians were conservative in issuing a favorable fitness-to-drive recommendation, resulting in an overestimation of their patients' actual fitness-to-drive as judged by driving experts. Several reasons have been suggested for this ambiguity. Physicians are guided by vague and equivocal legislative requirements for fitness-to-drive<sup>25</sup>, little knowledge about fitness-to-drive requirements<sup>26,27</sup>, lack of accurate screening tools to assist with their recommendations<sup>27</sup>, fear of jeopardizing the patient-doctor relationship<sup>25,27</sup>, and risk of liability suits<sup>28</sup>. Although the percentage fails according to physician's recommendation across medical conditions was low, physicians were more vigilant in issuing a positive recommendation to patients with substance abuse. The impact of substance abuse on driving is widely recognized by general public<sup>29</sup>, which may make physicians more hesitant in giving a favorable recommendation.

Likewise, substance abuse was also considered a risk factor for unsafe driving according to comprehensive fitness-to-drive decision, along with psychiatric conditions. There is no clear evidence showing that patients with psychiatric conditions are less fit-to-drive than the general population<sup>30</sup>, but a previous study cautiously suggested that patients with psychiatric conditions may experience delusions, anxiety and depression, or reduced ability to react, which consequently adversely affects their fitness-to-drive<sup>31</sup>. The higher risk of unsafe driving in the drivers with a history of substance abuse or dependency on alcohol, cannabis, and other drugs was also suggested in previous studies<sup>31</sup>. Further studies are required to determine the type of psychiatric conditions that may affect driving safety. By

contrast, musculoskeletal conditions presented a significantly lower risk of unsafe driving according to the comprehensive fitness-to-drive decision than most of other medical conditions, which may be explained by the fact that musculoskeletal conditions are only limited in physical fitness and a variety of adaptive driving devices and vehicle modifications are available to compensate for their physical impairments<sup>32</sup>.

MVCs in patients with various medical conditions have been investigated in numerous studies. In our study, the highest rate of MVCs was found in substance abuse, which is in accordance with previous findings<sup>33,34</sup>. Interestingly, the rate of MVCs in cardiovascular or pulmonary conditions was the second highest among the medical categories. Although there is insufficient evidence available on the relationship between cardiovascular or pulmonary conditions and driving, they can cause dizziness or loss of consciousness at any time<sup>35</sup>, which may place drivers at high risk of MVC. Moreover, we observed that patients with cardiovascular or pulmonary conditions were significantly older than those with other medical conditions. Age is one of the major risk factors for cardiovascular diseases<sup>36</sup> and its prevalence increases with increasing age<sup>37</sup>. Indeed, one study reported an increasing trend in the rate of MVCs with increasing age in drivers with cardiovascular conditions<sup>38</sup>. Although patients' medical conditions could cause an increase in MVC rates, MVC itself could be the main reason for their referral to CARA, which may affect the higher rates of MVCs in both substance abuse and cardiovascular or pulmonary conditions.

Few studies have investigated the risk of traffic violations in medical conditions. Yet, traffic violations are an important outcome as they may be an early indicator of driving unsafety before MVCs occur. Our finding showed that patients with substance abuse reported the highest rate of traffic violations in the past five years, which was consistent with previous findings<sup>39</sup>. Cardiovascular or pulmonary conditions did not show any distinctive result in the



rate of traffic violations, contrary to the rate of MVCs. Further research should examine the associations between MVCs and traffic violations across medical conditions and determine which covariates contribute to the differences.

There were some limitations including missing data that are inherent to the retrospective study design. Physicians and the CARA team were not blinded to the patient's history of MVCs and traffic violations, which might have influenced their recommendation. A recent study, however, showed that access to MVC and traffic violations had little influence on their fitness-to-drive recommendation<sup>17</sup>. The numbers of MVCs and traffic violations were self-reported by the patients, which might be biased towards an underrepresentation of their true number of MVCs<sup>40</sup>. However, police-reported MVCs are also subject to bias, as only car crashes in which police were called, are reported<sup>41</sup>. Thus, none of the two reports necessarily reflect the actual number of MVCs. Further studies need to investigate the efficacy of the use of near-miss MVC reports for driving safety assessment, which may predict an actual MVC and risk of unsafe driving<sup>42</sup>. Finally, there was no information on whether the referring physician made a recommendation based on the primary medical condition or comorbid medical condition. It has been reported that the presence of comorbidity influenced on the physicians' fitness-to-drive recommendations<sup>20</sup>. In our study, 42% of the patients had more than one comorbidity. Therefore, the severity and type of comorbidities that affect safe driving need to be thoroughly studied in further studies.

## **Conclusions**

This large population-based study revealed that four outcome measures, including physician's recommendation, comprehensive fitness-to-drive decision, MVCs, and traffic violations, represented different constructs of driving safety. Patients with neurological conditions were not considered as most unsafe drivers despite their high prevalence.

Psychiatric conditions and substance abuse showed the highest risk of unsafe driving.

Physicians and driver licensing authorities should be particularly vigilant in determining safety to drive in these conditions.

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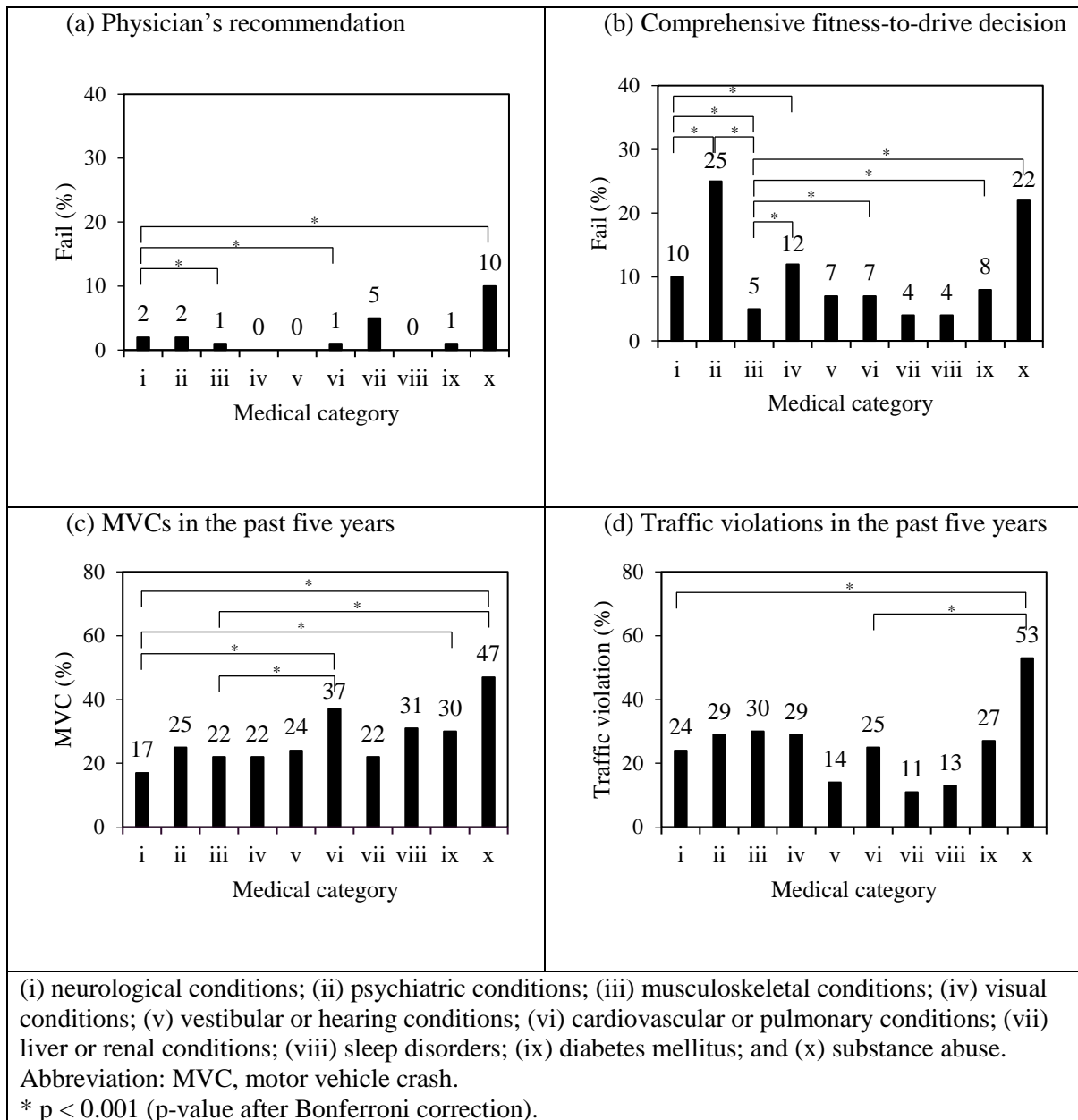


Figure 1. Percentage of unsafe driving across medical categories

Table 1. The demographic, clinical, and driving characteristics of total sample

Variable <sup>a</sup>	Total sample (N = 6584)
<i>Demographic</i>	
Age, y	55 (42-68)
Sex, male, n	4609 (70)
Previous CARA visits, n	1 (1-2)
Reason for application, n <sup>b</sup>	1957 (34) / 2385 (42) / 429 (8) / 893 (16)
<i>Clinical</i>	
Primary medical condition, n	
Neurological conditions	4837 (74)
Psychiatric conditions	359 (6)
Musculoskeletal conditions	791(12)
Visual conditions	132 (2)
Vestibular or hearing conditions	15 (0)
Cardiovascular or pulmonary conditions	228 (3)
Liver or renal conditions	23 (0)
Sleep disorders	26 (0)
Diabetes mellitus	125 (2)
Substance abuse	46 (1)
Comorbidity, n (%)	
No comorbidity	2919 (58)
1+ comorbidity	2123 (42)
<i>Driving</i>	
Physician's recommendation, n	
Pass	5828 (98)
Fail	116 (2)
Comprehensive fitness-to-drive decision, n	
Pass	5899 (90)
Fail	685 (10)
MVCs in past five years, n	
No MVC	3542 (81)
1+ MVCs	840 (19)
Traffic violations in past five years, n	
No traffic violation	3273 (75)
1+ traffic violations	1114 (25)
<p>Values are expressed as median (Q1-Q3) or frequency (%).</p> <p>Abbreviation: CARA, Center for Evaluation of Fitness to Drive and Car Adaptations; MVC: motor vehicle crash.</p> <p><sup>a</sup> Missing variables: age, n = 9; previous CARA visits, n = 272; reason for application, n = 920; medical condition other than primary categories, n = 2; MVCs in the past five years, n = 2202; traffic violations in the past five years, n = 2197; physician's recommendation, n = 640.</p> <p><sup>b</sup> Reason for application: (i) change in medical condition; (ii) extension of driver's license; (iii) new driver's license category; (iv) mandatory referral.</p>	

Table 2. Demographic and clinical characteristics across medical categories

Variable	i	ii	iii	iv	v	vi	vii	viii	ix	x	P-value	Post hoc <sup>a</sup>
Age, y	56 (43-67)	39 (29-53)	52 (39-64)	59 (37-81)	55 (26-80)	77 (63-83)	64 (56-77)	61 (52-70)	66 (56-74)	52 (36-64)	KW, < 0.001	i-ii, i-iii, i-vi, i-ix, ii-iii, ii-iv, ii-vi, ii-viii, ii-ix, ii-x, iii-iv, iii-vi, iii-ix, iv-vi, vi-viii, vi-ix, vi-x, ix-x
Sex, male, n (%)	3359 (69)	251 (70)	544 (69)	96 (73)	8 (53)	180 (79)	15 (65)	14 (54)	104 (83)	37 (80)	$\chi^2$ , 0.007	No significance
Previous CARA visits, n	1 (1-2)	1 (1-2)	1 (1-1)	1 (1-2)	1 (1-3)	1 (1-2)	1 (0-2)	1 (0-2)	1 (1-2)	1 (1-1)	KW, < 0.001	i-iii, ii-iii, iii-vi, iii-ix
Reason for application, n (%)											$\chi^2$ , < 0.001	<sup>b</sup>
Change in medical condition	1465 (35)	47 (15)	329 (48)	28 (24)	1 (8)	32 (17)	5 (24)	5 (23)	32 (29)	11 (30)		
Extension of driver's license	1864 (45)	120 (38)	169 (24)	46 (40)	7 (54)	101 (52)	6 (28)	7 (32)	56 (50)	9 (24)		
New driver's license	279 (7)	60 (19)	63 (9)	17 (15)	1 (8)	4 (2)	1 (5)	0 (0)	3 (3)	1 (3)		
Mandatory referral	537 (13)	89 (28)	128 (19)	25 (21)	4 (30)	55 (29)	9 (43)	10 (45)	20 (18)	16 (43)		
Comorbidity, n (%)											KW, < 0.001	i-ii, i-iii, i-iv, i-ix, ii-iv, ii-vi, ii-vii, ii-viii, ii-ix, iii-iv, iii-vii, iii-ix, iv-v, iv-vii, iv-viii, iv-ix, iv-x
No comorbidity	2720 (56)	238 (66)	517 (65)	121 (92)	9 (60)	98 (43)	7 (30)	10 (38)	55 (44)	30 (65)		
1+ comorbidity	2117 (44)	121 (34)	274 (35)	11 (8)	6 (40)	130 (57)	16 (70)	16 (62)	70 (56)	16 (35)		
<p>Values are expressed as median (Q1-Q3) or number (%).</p> <p>(i) neurological conditions; (ii) psychiatric conditions; (iii) musculoskeletal conditions; (iv) visual conditions; (v) vestibular or hearing conditions; (vi) cardiovascular or pulmonary conditions; (vii) liver or renal conditions; (viii) sleep disorders; (ix) diabetes mellitus; and (x) substance abuse.</p> <p>Abbreviation: KW, Kruskal-Wallis test; <math>\chi^2</math>, Chi-squared test; CARA, Center for Evaluation of Fitness to Drive and Car Adaptations.</p> <p><sup>a</sup> p &lt; 0.001 (p-value after Bonferroni correction, 0.05/45 = 0.001).</p> <p><sup>b</sup> Change in medical condition (i-ii, i-iii, i-vi, ii-iii, iii-iv, iii-vi); extension of driver's license (i-iii, ii-iii, iii-vi, iii-ix); new driver's license (i-ii, ii-iii, ii-vi, iv-vi); mandatory referral (i-ii, i-vi, i-viii, i-x).</p>												



Table 3. Inter-rater reliability between physician's recommendation and comprehensive fitness-to-drive decision using PABAK

	i	ii	iii	iv	v	vi	vii	viii	ix	x
PABAK	0.85	0.65	0.92	0.79	0.88	0.88	0.86	0.93	0.88	0.65
95 % CI	[0.83, 0.86]	[0.59, 0.70]	[0.88, 0.95]	[0.44, 1.13]	[0.61, 1.14]	[0.82, 0.95]	[0.66, 1.06]	[0.74, 1.13]	[0.80, 0.97]	[0.51, 0.80]
P-value	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
(i) neurological conditions; (ii) psychiatric conditions; (iii) musculoskeletal conditions; (iv) visual conditions; (v) vestibular conditions; (vi) cardiovascular or pulmonary conditions; (vii) liver and renal conditions; (viii) sleep disorders; (ix) diabetes mellitus; and (x) substance abuse. Abbreviation: PABAK, prevalence-and bias-adjusted kappa.										