Chronic medical conditions and their association with crash risk and changes in driving habits: a prospective study of the GAZEL cohort

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ABSTRACT

Objectives To assess crash risk and driving habits associated with chronic medical conditions among drivers entering old age.

Design Prospective cohort study.

Setting French cohort GAZEL.

Participants 12 460 drivers in the analysis of road traffic crash, among whom 11 670 completed the follow-up period (2007–2014). We assessed driving cessation among 11 633 participants over the same period, and mileage and driving avoidance among the 4973 participants who returned a road safety questionnaire in 2015.

Main outcome measures Yearly occurrence of at least one road crash as a driver; time to driving cessation; mileage; driving avoidance: at night, with bad weather, in heavy traffic, with glare conditions, over long distances.

Results Several potentially risky conditions (*angina, myocardial infarction, coronary disease*; stroke; *nephritic colic, urinary stones*; glaucoma) were associated with lower mileage and/or driving avoidance and did not increase crash risk. Neither driving avoidance nor lower mileage was found for other conditions associated with an increased crash risk: hearing difficulties (adjusted OR 1.19, 95% CI 1.06 to 1.34); joint disorders (1.17, 95% CI 1.06 to 1.30). *Depression, anxiety and stress* was associated with an increased crash risk (1.23, 95% CI 1.01 to 1.49) despite increased driving avoidance. Parkinson's disease was associated with driving cessation (adjusted HR 32.61, 95% CI 14.21 to 65.17).

Conclusions Depending on their condition, and probably on the associated risk perception, drivers entering old age report diverse driving habits. For example, hearing difficulties is a frequent condition, rarely considered a threat to road safety, and nonetheless associated with an increased crash risk.

INTRODUCTION

The proportion of people over the age of 75 is expected to almost double by 2050 in high-income countries because of the transformation of demography resulting from the Baby Boom Generation, increased longevity and declining birth rates.[1] As a result, and also because older women are now mainly driving licence holders, the number of elderly drivers on the roads is increasing. Road safety has improved in the European Union (EU) (and most high-income countries) in recent decades, but the share of injured and killed older drivers is on the rise.[2] More affected by the increased enforcement of traffic rules, particularly the speed limit, in the EU policy orientations, the decrease in mortality has been greater among young drivers. The decline in perceptual, motor and cognitive abilities with age may also explain the greater contribution of older drivers to road safety statistics. Driving is indeed a complex task that involves cognition, sensory function and physical function/health condition.[3] Safe driving, thus, requires older drivers to adapt their behaviour and driving habits according to their abilities. It is now well documented that most older adults adapt their driving behaviour when faced with impaired abilities,[4–8] in particular driving abilities.[9 10] However, older drivers only self-regulate to an extent that does not negatively interfere with their lifestyle.[9] The key question may, therefore, be whether these adaptations are sufficient to counterbalance a potential increased risk.[11]

The second edition to the Monash University report on the influence of medical conditions on crash involvement of motor vehicle drivers[12] listed the following conditions found to be associated with various levels of risk: alcohol abuse and dependence, dementia, epilepsy, multiple sclerosis, psychiatric disorders, schizophrenia, sleep apnoea and cataract. Moreover, a large database linkage study conducted in Quebec on 5 187 049 drivers showed that crash risk increases slightly but significantly with the number of conditions.[13] In some countries, drivers with certain medical conditions have their licences revoked. While this may be sensible for some conditions, any decision concerning driving cessation must take into account its impact on lifestyle, independence, quality of life and mental health.[14] Specific licence restrictions[15] and education programme[16] are promising alternatives to reduce crash risk while still allowing for some degree of autonomy. Anyhow, whatever measures are available, it is important to identify the medical driving disabilities that are not regulated to compensate for the risk.

The aim of this study conducted among volunteers or the French GAZEL cohort was to assess driving cessation, mileage and avoidance, and crash risk for the chronic medical conditions reported by drivers aged 61–75 years at the end of the follow-up period.

METHODS

Study population

The GAZEL cohort is a multipurpose research platform. The participants were employees of

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Electricité de France–Gaz de France who volunteered to participate in a research cohort.[17] This cohort was established in 1989 and originally included 20 625 subjects, men aged 40–50 years (n=15 011) and women aged 35–50 years (n=5614) at baseline. Since 1989, this cohort has been followed up by means of yearly self-administered questionnaires and data collection from the company's human resources and medical departments.

Study design

The study consisted in three separate analyses: (1) a longitudinal analysis on the associations of self-reported chronic conditions with road traffic crash over the 2007–2014 period, (2) a longitudinal analysis on the associations of self-reported chronic conditions with driving cessation over the 2007–2014 period and (3) an analysis of the association of self-reported chronic conditions with mileage and driving avoidance in 2015 (online supplementary table 1).

Sample selection

1. Participants included in the analysis of road traffic crash were drivers who held a driving licence, and who did not stop driving before 2007 or on an unknown date.
2. Participants included in the analysis of driving cessation were subjects of the road traffic crash analysis sample with non-missing driving cessation status in 2015.
3. Participants included in the analysis of mileage and driving avoidance were subjects of the road traffic crash analysis sample who returned the road safety questionnaire in 2015.

Data

Chronic conditions

The part of the annual questionnaire related to medical conditions includes 58 prespecified items. Every year, participants are invited to indicate which medical condition(s) they have been suffering from during the 12 previous months. The reporting rates had been previously evaluated item by item.[18] Participants reported their hearing difficulties by means of a yes/no question: 'do you have hearing difficulties?', which changed to: 'do you have hearing difficulties, even with hearing aids?' from 2014 onwards. In the analysis, a chronic disease was defined as a medical condition declared to be present during at least two consecutive years.

For statistical power reasons, medical conditions were grouped in clinically homogeneous categories: (1) angina, myocardial infarction, coronary disease; (2) stroke; (3) nephritic colic and urinary stones; (4) glaucoma; (5) hearing difficulties; (6) joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis; (7) gout and complications; (8) persistent dental and gum problems; (9) depression, or feeling depressed, anxious or stressed; (10) sleep disorders; (11) cataract; (12) Parkinson's disease; (13) arteritis of the lower limbs, phlebitis, venous circulatory disorders; (14) hypertension; (15) haemorrhoids; (16) diabetes; (17) biliary stones; (18) neck pain, middle or low back pain, sciatica; (19) retinal detachment and (20) migraine.

Potential confounders

The variables considered in all three analyses as potential confounders were: gender, age, family status (single or widowed, living with a partner, separated or divorced), maximum daily alcohol consumption (abstinent; light consumption: 1–3 glasses for men and 1–2 for women; moderate consumption: 4 glasses for men and 3–4 for women; and heavy consumption: 5 glasses or more), and (for the analysis of driving cessation only) occurrence of at least one road traffic crash in the previous year.

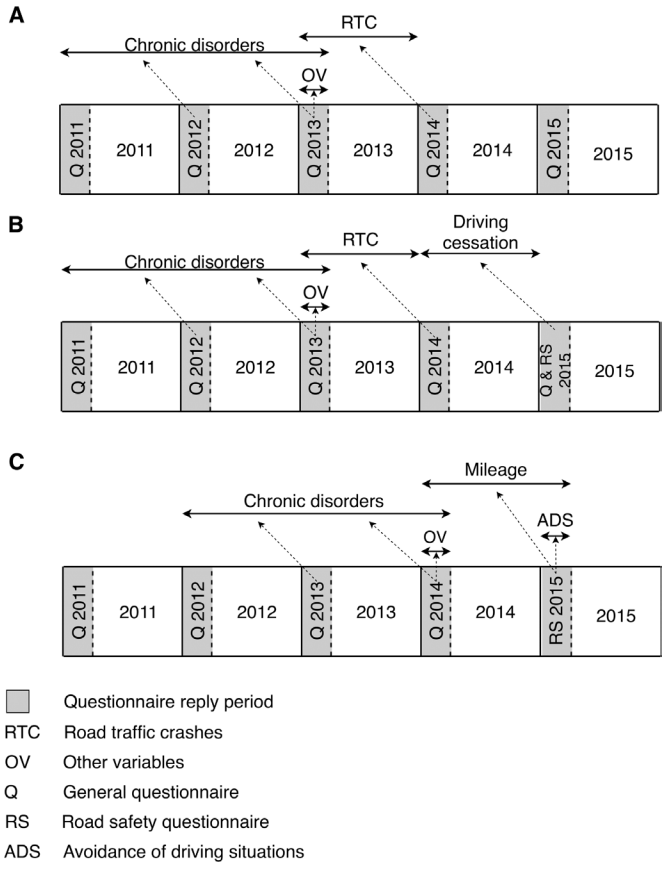

Figure 1 Summary of the data collection process: (A) analysis of road traffic crash (occurrence reported in 2014, eg); (B) analysis of driving cessation in 2014; (C) analysis of self-regulation.

Response variable

1. The analysis of road traffic crash assessed the occurrence of at least one road traffic crash as a driver, causing personal injury and/or material damage. Participants reported this variable each calendar year of the study period.
2. The analysis of driving cessation assessed the time to driving cessation. Year of driving cessation was reported in both the 2015 road safety questionnaire and the 2015 yearly questionnaire. We used other available driving-related variables to check the consistency of these values and, when in doubt, we assumed the valid value was the latest.
3. The analysis of mileage and driving avoidance compared mileage, and the avoidance of each of five specific driving situations (driving at night, with bad weather, in heavy traffic, with glare conditions and over long distances). In the 2015 road safety questionnaire, participants reported their mileage and selected each of the driving situations they avoided from a list of 16 (online supplementary table 8).

We considered the temporal order so that the values of chronic conditions and confounders antedated the value of the response variable (figure 1). We included chronic conditions and confounders as time-dependent variables in the longitudinal analyses of road traffic crash and driving cessation.

Statistical methods

1. In the analysis of the risk of road traffic crash, we used the lme4 R package[19] to fit a multivariable mixed effects logistic model,[20] which accounts for correlation between the observations of each subject over time. We reported OR point estimates with 95% CIs.
2. In the analysis of driving cessation, we used the glm function of the stats R package to fit a multivariable discrete-time model,[21] which accounts for the discrete nature of event times and allows for explanatory variables whose values change over time. We reported HR point estimates with 95% CIs.
3. We fitted a multivariable linear model (lm function of the stats package) to study the association of chronic conditions with mileage, and five multivariable logistic regressions (glm function) to study the association with the avoidance of the five specific driving situations. We reported linear coefficients for the linear model and OR point estimates for the logistic models. We also reported 95% CIs.

In order to check consistencies within groups of conditions, we performed the analyses (odds of crash and mileage) for the following separate conditions: angina, myocardial infarction, coronary artery disease, joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis, arteritis of the lower limbs, phlebitis and venous circulatory disorders.

All the analyses were performed on the complete observations set and computations were done in R version 3.5.1.

RESULTS

Analysis of road traffic crash

Of the 20 625 participants enrolled in the cohort in 1989, 19 123 were solicited in 2007 and 14 321 answered the 2007 questionnaire (online supplementary figure 1). After exclusion of people without a driving licence, who had never driven, who stopped driving before the study period and who stopped driving on an unknown date, 12 460 participants were included in 2007, of which 355 men (3.7%) and 774 women (26.8%) were still working on 1 January 2007. A total of 532 participants died during the study period, 137 stopped driving and 121 were excluded from the study. Consequently, 11 670 (93.7%) were observed throughout the 2007–2014 follow-up period. Among them, 0 men and 41 women (1.5%) were still working on 31 December 2014. The proportion who reported at least one road traffic crash during the previous year increased during the study period, from 2.8% in 2007 to 3.2% in 2014 (online supplementary table 2); 17.8% reported to have been victims of road traffic crash in at least 1 year of the 8-year follow-up period, 3.8% in at least 2 years and 0.6% in at least 3 years. In 2007, 76.8% of the participants were men, the mean age was 62.4 years old (SD=3.4), with ages ranging between 54 and 68 at the beginning of the study period and between 61 and 75 at the end of the study period. Most of them were living with a partner (online supplementary table 3).

The most prevalent chronic conditions throughout the whole study period were: neck pain, middle back pain, low back pain and sciatica (33.5%), joint, muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis (30.9%), hypertension (19.5%), hearing impairment (18.5%) and sleep disorders (10.5%). The prevalence of several medical conditions increased between 2007 and 2014 (online supplementary tables 3 and 16), namely Parkinson's disease (0.1%–0.4%), cataract (1.0%–2.5%), diabetes (4.4%–6.8%), glaucoma (3.0%–4.5%), gout (0.9%–1.1%), stroke (0.3%–0.4%), hypertension (19.6%–24.8%), hearing impairment (18.3%–23.5%), biliary stones (0.4%–0.5%), urinary calculus (0.5%–0.6%), angina, myocardial infarction, coronary artery disease (2.0%–2.2%), sleep disorders (10.5%–11.7%) and joint, muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis (30.5%–32.4%).

In the multivariable mixed-effects logistic model, several diseases were associated with increased odds of crash: hearing impairment (OR 1.19, 95% CI 1.06 to 1.34), joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism or rheumatoid polyarthritis (OR 1.17, 95% CI 1.06 to 1.30) and depression, feeling depressed, anxious or stressed (OR 1.23, 95% CI 1.01 to 1.49) (table 1, online supplementary table 4).

Analysis of driving cessation

People who did not report their driving cessation status in 2015, such as people who died during the follow-up period, were excluded from this part of the study, comprised 11 633 participants in 2007 (online supplementary table 6). Among them, 1.2% stopped driving during the study period; 1984 participants had incomplete data in 2007 and 2181 in 2014. Parkinson's disease was the only condition associated with increased driving cessation (HR 32.61, 95% CI 14.21 to 65.17, online supplementary table 7).

Analysis of mileage and driving avoidance

A total of 4973 participants were included in the assessment of mileage and avoided driving situations in 2015, after exclusion of people who did not complete the period 2007–2014 or who did not return the road safety specific questionnaire. There were 777 participants with incomplete data in the sample of the mileage analysis, and 807 in the sample of the avoided driving situations analysis. The mean mileage was 13 094 km (SD=8080). A proportion of 39.1% of the participants reported to avoid driving at night, 28.8% with bad weather, 21.2% in heavy traffic, 14.0% with glare conditions and 12.0% over long distances (online supplementary table 8). The corresponding multivariable models are presented in online supplementary tables 9, 11–15.

Among conditions found in the previous steps not to be associated with increased odds of crash, angina, myocardial infarction, coronary artery disease was associated with the avoidance of driving with heavy traffic (table 2, figure 2). Stroke was associated with mileage reduction, and with avoidance of driving with bad weather and long distances. Participants with nephritic colic and urinary stones were more likely to avoid driving at night and had decreased odds of road traffic crash. Glaucoma was associated with mileage reduction.

Among conditions found to be associated with increased odds of crash, participants with hearing difficulties reported neither decreased mileage nor avoidance of any driving situation, whereas gout, and joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism or rheumatoid polyarthritis, were associated with increased mileage. Gout, and dental and gum problems were associated with increased odds of crash, though not significantly ($0.20 \geq p > 0.05$). Other conditions were associated with increased odds of crash, in spite of reduced mileage and/or avoidance of driving situations. This was the case for participants feeling depressed, anxious or stressed, who were more likely to avoid driving at night, with bad weather, in heavy traffic and over long distances in 2015. Sleep disorders and cataract increased odds of crash, though not significantly

Table 1 Analysis of road traffic crash 2007–2014

	2007	2014	
	N 12 460	N 11 670	
	%	%	ORs (95% CI)
Gender (ref: women)	23.2	23.1	–
Men	76.8	76.9	1.56 (1.33 to 1.82)***
Age at baseline (centred at 60 years old)	–	–	0.99 (0.97 to 1.01)
Family status (ref: living with a partner)	83.0	78.8	–
Divorced or separated	7.8	8.1	1.45 (1.21 to 1.73)***
Living alone or widow(-er)	5.6	7.3	1.38 (1.13 to 1.70)**
Maximum daily alcohol consumption (ref: abstinent)	13.7	15.2	–
Light drinkers	46.4	48.8	1.07 (0.92 to 1.24)
Moderate drinkers	17.7	15.6	1.16 (0.98 to 1.37)
Heavy drinkers	17.5	14.0	1.20 (1.01 to 1.43)*
Chronic conditions (ref: absence of the particular disorder)	–	–	–
Angina, myocardial infarction, coronary artery disease	2.0	2.2	1.00 (0.73 to 1.37)
Stroke	0.3	0.4	1.10 (0.52 to 2.34)
Nephritic colic and urinary stones	0.5	0.6	0.42 (0.18 to 0.99)*
Glaucoma	3.0	4.5	0.93 (0.72 to 1.22)
Hearing difficulties	18.3	23.5	1.19 (1.06 to 1.34)**
Joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis	30.5	32.4	1.17 (1.06 to 1.30)**
Gout and complications	0.9	1.1	1.46 (0.99 to 2.17)
Persistent dental and gum problems	2.1	1.6	1.23 (0.92 to 1.66)
Depression; feeling depressed, anxious or stressed	6.2	4.7	1.23 (1.01 to 1.49)*
Sleep disorders	10.5	11.7	1.14 (0.98 to 1.32)
Cataract	1.0	2.5	1.27 (0.91 to 1.76)
Parkinson's disease	0.1	0.4	1.57 (0.62 to 4.02)
Arteritis of the lower limbs, phlebitis, venous circulatory disorders	4.4	3.9	0.96 (0.75 to 1.22)
High blood pressure	19.6	24.8	1.02 (0.91 to 1.15)
Haemorrhoids	8.3	6.6	1.10 (0.93 to 1.30)
Diabetes	4.4	6.8	1.07 (0.87 to 1.32)
Biliary stones	0.4	0.5	0.75 (0.36 to 1.57)
Neck pain, middle back pain, low back pain, sciatica	33.1	31.8	0.96 (0.86 to 1.07)
Retinal detachment	0.1	0.1	0.99 (0.37 to 2.70)
Migraine	6.3	3.9	1.13 (0.92 to 1.40)

Multivariable mixed-effects logistic regression.
*P≤0.05, **p≤0.01, ***p≤0.001.

(0.20≥p>0.05). Participants with sleep disorders were more likely to avoid driving at night, with glare conditions and over long distances, whereas cataract was associated with mileage reduction.

Sensitivity analysis

Joint or muscle pain showed increased odds of crash and no mileage reduction, while arthrosis and rheumatism were associated with increased mileage but did not impact the crash risk (online supplementary tables 10 and 5, respectively). Carpal tunnel syndrome showed a non-significant, but potentially meaningful association with increased odds of crash.

DISCUSSION

To our knowledge, this study is the first to assess the impact of chronic conditions, jointly on driving habits and the risk of road traffic crashes. Eleven conditions were found to be of interest, with three distinct patterns.

The first pattern includes conditions associated with lower mileage (stroke and glaucoma) and/or the avoidance of specific driving situations (cardiovascular conditions, stroke, nephritic colic and urinary stones), and no crash risk.

A second pattern could be distinguished, probably the most interesting in terms of public health, with conditions associated with increased odds of crash and not associated with mileage reduction or driving avoidance: hearing problems, joint disorders, gout, and dental and gum problems. We observed a higher mileage for gout, possibly related to walking difficulties and arguably explaining the increased odds of crash.

Finally, people who reported depression, anxiety or stress exhibited a third pattern as they reported more avoidance strategies but still had increased odds of crash. Participants with sleep disorders and cataract may also fit into this group although their associations with the odds of crash were not significant. Parkinson's disease represents a particular case, essentially defined by massive driving cessation.

We previously conducted, among volunteers of the same cohort, an analysis of road traffic crashes over the 1989–2000 period and found an association with pain and pain treatment.[22] In this new study period, participants were on average 17 years older and were likely to have changed their driving habits, for example, because of retirement.

Our results seem to support the hypothesis that the potential crash risk carried by cardiovascular conditions is mitigated by self-regulation. However, to assume self-regulation, changes must occur in response to an awareness of functional declines or feelings of discomfort or lack of safety,[23] which we cannot confirm in our study. Stroke had relatively large effects on mileage reduction, and the avoidance of driving over long distances and in adverse weather conditions. Nevertheless, several studies showed that poststroke drivers have difficulties in self-evaluating their fitness to drive.[24 25] Angina, myocardial infarction or coronary disease were associated with the avoidance of driving in heavy traffic, a potentially stressful situation. Consistently with our results, associations with driving self-regulation have been already reported for cataract[26 27] and glaucoma.[28] People suffering from nephritic colic and urinary stones reported to avoid driving at night, a time when the symptoms of kidney stone emergencies typically begin.[29] Interestingly, our previous analysis found a similar association for treated urinary stone and the risk of road crash among men.[22]

The second pattern is more problematic as it includes conditions for which we found increased risks of crash and no self-regulation. Associations between rheumatoid arthritis and driving difficulties have been reported elsewhere.[30] Our result raises the hypothesis that the crash risk among people who suffer from gout, with potential walking impairment, may be related to an increased exposure to driving. A recent study conducted among older adults found that drivers with hearing impairment did not reduce their mileage[31] while this condition may hamper driving performance in the presence of distracters.[32]

Table 2 Point estimates of the multivariable models

		Avoided driving situations‡						
	Mileage†	Night	Bad weather	Heavy traffic	Glare	Long distance	Driving cessation§	Road traffic Crash¶
Gender (ref: women)								
Men	9 070*	0.25*	0.87	1.39*	0.46*	0.36*	0.31*	1.56*
Age at baseline (years)	−274*††	1.06*††	1.06*††	1.01††	1.05*††	1.06*††	1.12*‡‡	0.99‡‡
Family status (ref: living with a partner)								
Divorced or separated	971*	1.02	1.21	0.98	0.89	1.12	1.66*	1.45*
Living alone or widow(-er)	724	0.91	1.29	0.89	0.89	1.30	1.21	1.38*
Maximum daily alcohol consumption (ref: abstinent)								
Light drinkers	−67	1.19	1.02	0.94	0.91	1.02	0.65*	1.07
Moderate drinkers	634	1.07	0.90	1.06	0.77	0.81	0.58	1.16
Heavy drinkers	876*	1.25	0.96	0.84	1.35	0.99	0.31*	1.20*
(At least one) road traffic crash (ref: no)	–	–	–	–	–	–	1.31	–
Chronic conditions (ref: absence of the particular disorder)								
Angina, myocardial infarction, coronary artery disease	769	0.93	0.99	1.70*	0.72	1.03	0.58	1.00
Stroke	−5 737*	1.57	3.06*	0.22	1.45	3.46*	3.32	1.10
Nephritic colic and urinary stones	811	2.63*	0.92	0.56	1.36	0.39	-**	0.42*
Glaucoma	−1 434*	1.25	1.05	1.21	1.34	1.08	1.60	0.93
Hearing difficulties	212	1.13	1.02	1.01	1.05	0.95	1.08	1.19*
Joint or muscle pain, carpal tunnel syndrome, arthrosis, rheumatism, rheumatoid polyarthritis	538*	0.96	1.01	0.99	1.10	0.99	1.11	1.17*
Gout and complications	2 425*	1.01	1.04	1.31	0.97	0.52	0.91	1.46
Persistent dental and gum problems	57	1.04	0.86	0.78	1.40	1.21	0.78	1.23
Depression; feeling depressed, anxious or stressed	−415	1.56*	1.41*	1.45*	1.21	1.80*	1.39	1.23*
Sleep disorders	−309	1.27*	1.04	1.07	1.40*	1.33*	1.14	1.14
Cataract	−2 517*	1.26	0.91	0.82	1.26	0.94	1.79	1.27
Parkinson's disease	−3 758	1.59	1.61	1.70	1.70	1.32	32.61*	1.57
Arteritis of the lower limbs, phlebitis, venous circulatory disorders	157	0.70	0.96	1.05	0.87	1.21	1.35	0.96
High blood pressure	278	1.01	0.98	1.08	1.09	0.92	1.10	1.02
Haemorrhoids	255	1.13	1.05	1.14	0.98	1.03	1.16	1.10
Diabetes	−426	1.17	1.00	1.02	1.17	1.17	1.68	1.07
Biliary stones	−1 453	0.92	0.29	1.02	1.85	0.75	-**	0.75
Neck pain, middle back pain, low back pain, sciatica	−304	1.10	0.89	0.97	1.19	1.08	0.92	0.96
Retinal detachment	1 359	2.54	1.15	0.95	2.47	0.72	-**	0.99
Migraine	236	1.03	1.00	0.88	1.02	1.32	1.23	1.13

*p≤0.05.
†Linear regression coefficients, in kilometres (2015).
‡ORs from logistic regression (2015).
§HRs from a discrete-time model (2007–2014).
¶ORs from mixed-effects logistic regression (2007–2014).
**Few cases of driving cessation among participants with these disorders lead to wide CIs that include zero.
††Age centred at 70 years old.
‡‡Age centred at 60 years old.

People with depression, anxiety or stress suffer from increased odds of crash, although they were more likely to avoid four out of the five driving situations studied. Depression was previously found to be associated with slower reaction time in a driving simulator[33] and with lower scores in attention abilities.[34] It cannot be excluded that some psychotropic or analgesic drugs prescribed in the context of these conditions increased the risk of crash.[35 36] The observed decrease in the prevalence of these conditions between 2007 and 2014 (table 1) is compatible with a previous study on this cohort, which showed an association between retirement and a reduction in fatigue and depressive symptoms.[37] Parkinson's disease has been typically observed as a trigger to driving cessation,[38] in accordance with our results.

The GAZEL cohort is characterised by a low lost to follow-up and active participation is high: in 2013, only 555 (2.6%) either never answered the annual questionnaire after 1989 or formally decided to stop their participation; 135 (0.6%) were lost to follow-up.[39]

One weakness of the study is the self-reported nature of health questions and the lack of health examination. Even if data gathered over the 30 years of follow-up showed that those reports are valuable and accurate proxy for most chronic conditions, it is not the case for all of them, in particular cognitive conditions, which were therefore not included. The proportions of missing values in the reporting of chronic conditions were found to increase from 2007 to 2014 (online supplementary table 3).

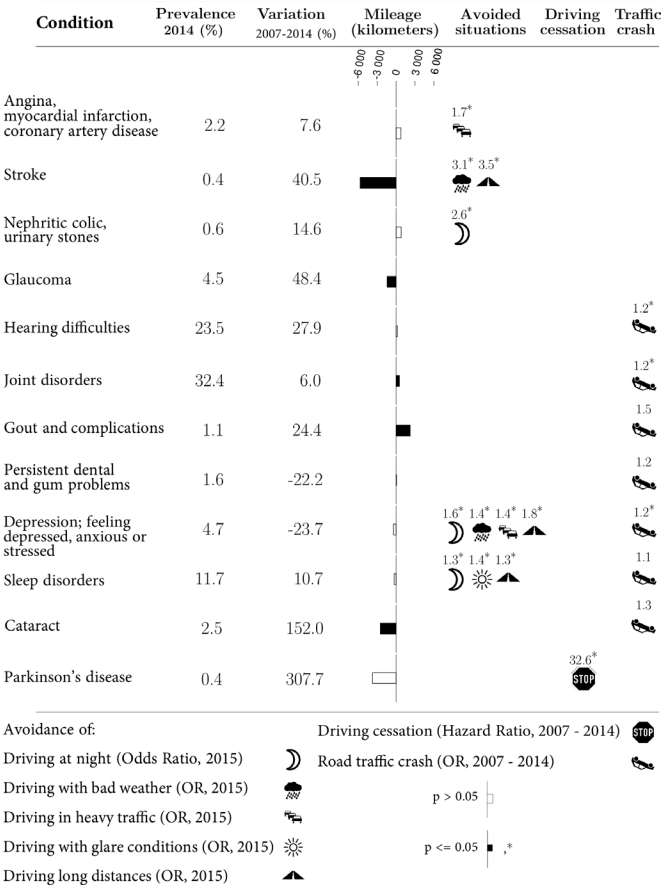

Figure 2 Effects of chronic disorders on mileage, avoidance of specific driving situations (multivariable cross-sectional analyses, 2015), driving cessation and road traffic crash (multivariable longitudinal analyses, 2007–2014). The chronic disorders shown were associated (p≤0.05) with the avoidance of at least one specific driving situation, or with road traffic crash (p≤0.20).

What is already known on the subject

- Overall health status and several medical conditions have been found to be associated with the risk of road traffic crash in the general population of drivers.
- Most older adults adapt their driving behaviour when faced with impaired driving ability.
- Conditions with no or inappropriate compensatory behaviours need to be identified.

What this study adds

- Our data suggest that drivers who enter old age and suffer from some medical conditions use condition-specific strategies of self-regulation to mitigate the potentially increased risk of road traffic crash.
- For people with a number of risk conditions, including hearing loss and diseases that reduce walking mobility, there is no self-regulation, suggesting the need to initiate or strengthen specific focuses and to improve the level of awareness.

Because the road safety questionnaires were sent in 2007 and 2015, the number of kilometres driven was only available for those 2 years. Consequently, the results may be confounded by changes in annual mileage between 2007 and 2015.

In summary, our data suggest that drivers entering old ages use self-regulation strategies likely to mitigate a potentially increased risk of road traffic crash. This regulation depends, however, on the condition. Therefore, specific focus should be initiated or strengthened to question risk perception and level of knowledge,[40] and to improve the level of awareness of conditions such as hearing loss, which is rarely cited as a threat to road safety, and those that reduce walking mobility, which are likely to increase the vulnerability toward road injuries.

Contributors Conception of the work: LO, BC, MZ, L-RS, SL and EL; data analysis and interpretation: JNT, LO and EL; drafting the article: all; critical revision of the article: all; final approval of the version to be published: all. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All the authors had full access to all the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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Author note The lead author (JNT) affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned (and, if relevant, registered) have been explained.

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