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Association between driving and depression in older adults: findings from an ancillary study of a prospective cohort

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Abstract

Background Depression is prevalent among older adults, particularly those with somatic comorbidities, and is linked to cognitive decline and reduced quality of life. Driving may act as a protective factor by enhancing cognitive function and social engagement. However, few prospective studies have investigated this association. This study aimed to assess whether driving was associated with a lower risk of new-onset depression and lower antidepressant medication.

Methods This ancillary study of the prospective S.AGES cohort (Sujets AGÉS—Aged Subjects) which included 3,434 participants (mean age 77.6 ± 6.2 years) with somatic comorbidities (chronic pain, type 2 diabetes, or atrial fibrillation) enrolled between 2009 and 2014. Driving status was recorded at baseline, and participants were monitored for 36 months. Depression was measured by the Geriatric Depression Scale (GDS), and antidepressant prescription was recorded at follow-up. Time-to-event analyses were performed on propensity-matched cohorts comparing drivers and non-drivers for new-onset depression (GDS ≥ 5/15) and antidepressant use.

Results In the first cohort (126 drivers and 126 matched non-drivers), drivers had a significantly lower risk of new-onset depression (hazard ratio [HR] = 0.58 [0.40–0.86]). In the second cohort (368 drivers and 368 non-drivers), drivers had a lower risk of antidepressant use (HR = 0.49 [0.29–0.84]).

Discussion Driving at baseline was associated with a reduced risk of depression and antidepressant prescription in older adults with somatic comorbidities, highlighting the potential importance of maintaining mobility and driving to support mental health in this population.

Trial registration The study was registered at ClinicalTrials.gov NCT01065909 with a first registration date of February 8, 2010.

Keywords Depression, Driving status, Antidepressant prescription, Geriatric psychiatry

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Introduction

Depression is a global concern, contributing to a substantial loss of health [1]. Among adults aged 65 and above, the prevalence of clinical symptoms of depression was estimated to be between 10 and 15% [2]. A meta-analysis estimated depression prevalence in older adults at 31.74% (95% CI 27.90–35.59), higher among those with somatic comorbidities [3].

Depression is a well-documented risk factor for the development of dementia, as well as for the increased prevalence of cardiovascular diseases and suicide-related morbidity and mortality [2, 4]. Moreover, depression has been demonstrated to be associated with cognitive impairment [5] and low quality of life [6]. Finally, depressed older adults may be at risk of iatrogenic harm due to the prescription of antidepressants [7]. Consequently, the identification of preventive factors against depression in older adults represents a significant public health issue.

Car driving is the most commonly used form of motorized transport among older adult [8]. It has been hypothesised that driving a car may act as a preventive factor against depression, as it enhances cognitive function, improves freedom and socialisation, and enhances quality of life in older adults [9–11]. Furthermore, cessation of driving has been linked to an increase in depressive symptoms [12], a decline in social, physical and cognitive health in this population [13]. Moreover, a cross-sectional Japanese study of a subgroup of 439 participants revealed that non-drivers exhibited a higher risk of depression than drivers (odds ratio = 2.17 [1.28–3.71]) [9]. To the best of our knowledge, no prospective study has yet assessed the association between driving a car and the incidence of depression and antidepressant prescriptions in older adults.

Consequently, the objective of this study was to assess whether driving was associated with a reduced incidence of depression and antidepressant medication over a three-year follow-up period in older adults with somatic comorbidities.

Materials and methods

Study design and participants

This study was ancillary to the prospective S.AGES (Sujets AGÉS—Aged Subjects) study (ClinicalTrials.gov NCT01065909). This study was carried out in a real-world clinical setting, aiming to observe outcomes as they naturally occurred in routine practice between 2009 and 2014. The primary objective was to describe the therapeutic management of ambulatory patients. The longitudinal design of this cohort and its focus on real-world data provide relevant insights that remain applicable today. The full methodology has already been published [14]. A total of 760 French general practitioners (GPs) included patients aged 65 years and older with chronic pain, type-2 diabetes mellitus, or atrial fibrillation. The protocol stipulated that one-third of the participants were to be aged between 65 and 75 years old while two-thirds were to be aged of 75 years and older. Follow-ups were scheduled at six-month intervals for a period of three years. The 36-month follow-up period was used to align with the original S.AGES cohort design and has been validated in previous studies as adequate for diagnosing new-onset depression [15].

Socio-demographic, clinical and treatment data were recorded at the time of inclusion, and updated at each visit, with the exception of driving status. Driving status was not updated during follow-up as the primary S.AGES study was not focused on driving, and this study was ancillary to it. Depressive symptoms were assessed using the Geriatric Depression Scale, 15-item variant (GDS-15) [16]. The level of autonomy was evaluated using the Activity of Daily Living (ADL) [17] and Instrumental Activity of Daily Living (IADL) [18] scales. The physiological age of the patients was determined by their general practitioners according to three modalities: the patients' physiological age was assessed and categorized as less than, equal to, or greater than their chronological age. The present study included only subjects with information on their driving status at baseline. The questionnaire used for this study is provided in Supplementary Method 1.

Ethical statement

Prior to their participation in the study, all participants were informed of the nature of the study and provided written consent. The study was approved by the local ethics committee (Comité de protection des personnes Ile de France XI) on 15 January 2009 (ref 09006) and the French National Agency for Medicines and Health Products (ANSM) on 6 February 2009 (ref B81333-40). This study adheres to the STROBE recommendations (Table S1).

Variables

Driving status

Car driving was evaluated at the time of their inclusion in the study on a declarative basis.

New-onset depression

Depressive symptoms were evaluated using the GDS-15. The GDS-15 is a hetero-questionnaire comprising 15 questions, each of which is rated as either 1 or 0 [19]. The total score is calculated by summing all responses, with a range of 0 to 15. A score of five or above is indicative of the presence of depressive symptoms [16].

Incident antidepressant prescription

The medication administered at the time of inclusion and during follow-ups was classified as an antidepressant using the Anatomical Therapeutic Chemical (ATC) classification with the code N06A [20].

Covariates

Living area was recorded at inclusion and categorized as urban, semi-rural, or rural based on the definitions provided by the French National Institute of Statistics and Economic Studies (INSEE). An urban unit was defined as a municipality or a group of municipalities with a continuous built-up area (no gap of more than 200 m between two buildings) and at least 2,000 inhabitant [21]. Semi-rural areas included groups of municipalities that did not meet this definition, while rural areas comprised isolated municipalities.

A Mini Mental State Examination (MMSE) score below 27/30 was found to be indicative of an increased risk of cognitive impairment [22]. Polypharmacy was defined the concurrent use of five or more medications [23]. The ADL was evaluated using six items, including bathing, dressing, toilet hygiene, transferring, self-feeding, and continence. Each item was assigned a score of either one or zero. The IADL was scored out of four items, including the use of the telephone, use of public transportation, drug management, and financial management. The number of comorbidities was calculated by summing the presence or history of several comorbidities. The following comorbidities were considered: history of stroke, heart disease (atrial fibrillation, valvulopathy, presence of pacemaker or implantable cardioverter-defibrillator, heart failure), peripheral arterial disease, venous thromboembolism, hypertension, Parkinson's disease, thyroid dysfunction, type-2 diabetes, osteoarthritis, osteoporosis, rheumatoid arthritis, chronic pain, cancer, liver diseases (cytolysis or cirrhosis), chronic respiratory diseases (chronic obstructive pulmonary disease, sleep apnoea, fibrosis) and peptic ulcer.

Outcomes

The analysis for new-onset depression was conducted separately from the analysis of antidepressant prescription, as not all subjects who receive antidepressants are clinically diagnosed with depression [24]. Antidepressant use was included as a secondary outcome because it captures treatment for various conditions beyond depression, which could impact overall well-being.

Statistical analysis

The data are presented with the mean and standard deviation (SD) for continuous variables and the count (percentage) for categorical variables. The normality of the distributions was evaluated graphically for continuous variables. Two groups were created (drivers and non-drivers) and descriptive statistics were calculated (t-tests for continuous variables and chi-squared tests or Fisher's exact tests for categorical variables).

The prevalence of depression (GDS ≥ 5) was compared between drivers and non-drivers using a propensity score (PS). The PS was designed to create a new dataset in which the probability of being a driver at inclusion or not was balanced on subjects' baseline characteristics. Patients were matched using a 1:1 nearest neighbour matching algorithm without replacement, with a calliper of 0.1 of the standard deviation of the PS on the logit scale [25]. The variables were selected based on their imbalance in the baseline characteristics and a recent comprehensive review addressing associations between somatic diseases and depression [3], including antidepressant treatment. The variables included in the PS score were as follows: age, physiological age, sex, educational level, presence of a professional caregiver at home, falls in the past year, ADL, IADL, MMSE < 27, chronic pain, BMI, living area, number of comorbidities, chronic pulmonary diseases, hypertension, AF, vascular diseases, history of stroke, history of coronary artery diseases, osteoporosis, and antidepressant treatment. The balance between the two groups was assessed after matching, with an absolute standardized difference of less than 0.1 considered evidence of balance [26]. Subsequently, a survival analysis was conducted on the matched dataset, employing a log-rank and Kaplan-Meier plot, followed by a hazard ratio estimation (HR [CI95]) with a univariate Cox model. Although this analysis involves matched pairs, which could introduce some correlation between observations within pairs, it still provides robust standard errors when used with clustered data [27]. Subjects with a GDS score of 5 or above at baseline, or with missing values for the GDS, were excluded from the analysis. Secondly, subjects who did not have at least one follow-up visit were excluded. Subjects receiving antidepressant at baseline with GDS < 5 were kept because antidepressant are also prescribed for pain, anxiety or prescribed inappropriately in this population [24, 28]. Finally, as the proportion of missing values in the remaining dataset for the variables used to calculate the PS score was less than 1%, these subjects were excluded.

To further investigate the potential differential effects of driving on depression across the three specific chronic conditions that served as inclusion criteria in the original cohort design (atrial fibrillation, diabetes, and chronic pain), subgroup analyses were conducted. For each subgroup, a survival analysis was performed using a log-rank test and Kaplan-Meier plot, followed by hazard ratio estimation models to assess the association between driving status and depression risk.

The same analysis plan was applied to the secondary objective (antidepressant prescriptions) with the exception that the variable "antidepressant treatment" at baseline for the PS score was replaced by the depression status at baseline. Subjects suffering from depression were kept as depression is not the only reason for antidepressant prescription [24]. Consequently, subjects receiving antidepressant treatment at baseline were excluded from the second cohort and depression status was included in the PS calculation.

All analyses were conducted using R 4.2.2.

Results

Driving status and new-onset depression

A total of 3,434 patients were included in the study, out of which 805 were excluded for missing values at inclusion, 1,021 because GDS ≥ 5 at baseline and 700 because of the absence of follow-up visits. A total of 717 patients were considered for the matched cohort. Detailed information is provided in flow chart Figure S1. The first matched cohort comprised 252 subjects, comprising 126 drivers and 126 non-drivers. Overall, the mean age of the subjects was 76.8 (5.8) years old, with 193 (76.6%) females and 104 (41.3%) having a GDS ≥ 5. The three-year incidence rate of new depression onset was 17.6 [14.3–21.2] per 1,000 person-months in the matched dataset. Table 1 presents the baseline characteristics of the study population before and after matching.

The log-rank and Cox analyses revealed a significant reduction in the risk of developing depression among drivers ($p = 0.0059$ and HR = 0.58 [0.40–0. 86]; $p = 0.007$ respectively) in comparison to non-drivers (Fig. 1).

Subgroup analyses

The subgroups analyses in the first matched PS cohort revealed that the same trend is observed in both atrial fibrillation (0.38 [0.18–0.81]; $p = 0.013$) and chronic pain (0.58 [0.37–0.91]; $p = 0.018$). However, the result was not significant for the type 2 diabetes subgroup (0.69 [0.37–1.28]; $p = 0.20$).

Driving status and incident antidepressant prescription

Out of the 3,434 subjects included in the SAGES cohort, 1,548 were excluded from matched cohort consideration mainly because missing value on variable for PS calculation (782 subjects), and because of the absence of follow-up visits (459 subjects). The second matched cohort comprised 736 subjects, 368 drivers and 368 non-drivers. A flow chart and descriptive statistics are provided in the supplementary materials, Figure S2 and Table S2. The risk of an incident antidepressant prescription was found to be significantly lower among drivers than among matched non-drivers (Fig. 2).

Discussion

Our findings suggest that older adults who self-identified as drivers at the time of inclusion exhibited a lower risk of depression over the three-year follow-up period. Moreover, the study revealed a reduced incidence of antidepressant prescriptions over the same period among drivers.

This is, to our knowledge, the first prospective study to report the risk of developing a depression in relation to car driving status. Although previous studies addressed more specifically driving cessation and depression, this study's results align with previous findings. A meta-analysis, including subjects aged of 55 and over found a higher risk of depression (OR 1.91 [1.61–2.27]) for those who ceased driving [13]. Moreover, depressive symptoms alter significantly quality of life, which was significantly correlated with driving frequency in subjects over the age of 65 who rely on car driving for mobility [9]. Overall, whereas previous studies explored either driving cessation and depression or driving status and quality of life (proxy of depressive symptoms), the present study provides a more direct evaluation of this relationship through its temporal design.

Additionally, we hypothesised that driving may act as a cognitive and behavioural enhancer. Indeed, the aforementioned study [9] found that although visual processing deteriorated with age, it demonstrated a positive correlation with the number of hours driven. Furthermore, a 2014 systematic review identified evidence suggesting that the use of a driving simulator may be beneficial for individuals with mild cognitive impairment (MCI) to enhance their visuo-cognitive abilities [29]. A recent randomised control trial including 40 subjects suffering from MCI compared the use of virtual reality-based cognitive–motor rehabilitation with conventional cognitive rehabilitation. The results demonstrated that the virtual reality group exhibited greater improvement on the Montreal Cognitive Assessment (MoCA) with a Cohen's d of 0.4 ($p = 0.045$) [30]. Conversely, depression can cause executive dysfunction [31, 32]. Thus, driving simulator may be useful for cognitive rehabilitation in older adults suffering from depression with executive dysfunction.

The cumulative incidence of depression after the three years in the first matched cohort was 104 (41.2%). This is higher than the 31.74% (95% CI 27.90–35.59) reported in a previous meta-analysis [5], likely due to our study inclusion of patients with chronic conditions known to be associated with depression. Interestingly, subgroup analyses focusing on the three specific chronic conditions that served as inclusion criteria in the original cohort—atrial fibrillation, chronic pain, and type 2 diabetes—revealed differing patterns of association. The lower risk of depression associated with driving was consistent for

Table 1 Baseline characteristics before and after propensity-score matching analysis

	Before matching ***N*** **= 717**		**After matching** ***N*** **= 252**		
	Non drivers ***n*** **= 229 (31.9%)**	**Drivers** ***n*** **= 488 (68.1%)**	**Non drivers** ***n*** **= 126 (50%)**	**Drivers** ***N*** **= 126 (50%)**	**SMD**
Age (years)*	79.0 (6.1)	75.3 (5.6)	76.9 (6)	76.8 (5.6)	0.01
Physiological age*					
Less than chronological age	74 (32.3)	146 (29.9)	45 (35.7)	37 (29.4)	0.06
Equal to chronological age	137 (59.8)	323 (66.2)	73 (57.9)	80 (63.5)	0.06
More than chronological age	18 (7.9)	19 (3.9)	8 (6.3)	9 (7.1)	0.01
Female (%)*	196 (85.6)	161 (33)	99 (78.6)	94 (74.6)	0.04
ADL*	5.9 (0.3)	6 (0.2)	5.9 (0.2)	5.9 (0.2)	0.05
IADL*	3.6 (0.7)	3.9 (0.5)	3.8 (0.6)	3.9 (0.5)	0.08
Professional caregiver*	58 (25.3)	50 (10.2)	18 (14.3)	17 (13.5)	0.01
BMI (kg/m^2)					
< 25	69 (30.1)	119 (24.4)	37 (29.4)	34 (27)	0.02
25–30	91 (39.7)	219 (44.9)	54 (42.9)	59 (46.8)	0.04
> 30	69 (30.1)	150 (30.7)	35 (27.8)	33 (26.2)	0.02
Education level*					
Primary school	121 (52.8)	180 (36.9)	63 (50)	58 (46)	0.04
Secondary school	74 (32.3)	184 (37.7)	40 (31.7)	44 (34.9)	0.01
High school or higher	34 (14.8)	124 (25.4)	23 (18.3)	24 (19)	0.01
Living area*					
Rural/Semi-rural	98 (42.8)	290 (59.4)	61 (48.4)	68 (54.0)	0.056
Urban area	131 (57.2)	198 (40.6)	65 (51.6)	58 (46.0)	
Professional status*					
Never had professional activity	71 (31.0)	31 (6.4)	27 (21.4)	23 (18.3)	0.03
Currently working or retired	158 (69.0)	457 (93.6)	99 (78.6)	103 (81.7)	
Number of comorbidities*	3.7 (1.4)	3.4 (1.5)	3.5 (1.3)	3.3 (1.5)	0.095
Arterial diseases	30 (13.1)	78 (16)	15 (11.9)	13 (10.3)	0.01
Atrial fibrillation*	63 (27.5)	181 (37.1)	33 (26.2)	38 (30.2)	0.04
Chronic pain*	169 (73.8)	271 (55.5)	87 (69)	87 (69)	0.00
Diabetes (type 2)	86 (37.6)	206 (42.2)	45 (35.7)	45 (35.7)	0.00
MMSE < 27*	76 (33.2)	100 (20.5)	32 (25.4)	37 (29.4)	0.04
Fall in the past year*	25 (10.9)	23 (4.7)	8 (6.3)	7 (5.6)	0.01
History of stroke	9 (3.9)	12 (2.5)	3 (2.4)	2 (1.6)	0.01
History of coronary artery disease	20 (8.7)	51 (10.5)	10 (7.9)	9 (7.1)	0.01
Hypertension	165 (72.1)	329 (67.4)	86 (68.3)	85 (67.5)	0.01
Osteoporosis*	43 (18.8)	33 (6.8)	17 (13.5)	13 (10.3)	0.03
Chronic respiratory diseases	20 (8.7)	68 (13.9)	13 (10.3)	10 (7.9)	0.01
Polypharmacy*	146 (63.8)	268 (54.9)	69 (54.8)	64 (50.8)	0.04
Antidepressant treatment at inclusion	12 (5.2)	20 (4.1)	6 (4.8)	7 (5.6)	0.01

Note. ADL: Activities of Daily Living; BMI: Body Mass Index; MMSE: Mini Mental State Evaluation; IADL; Instrument of activity daily living SMD: Standardized mean difference. Data presented as mean (SD) or count (%)

*$p < 0.05$ before matching

patients with atrial fibrillation and chronic pain, but not for those with diabetes. Although lack of power might be an explanation to this discrepancy, it may also be explained the high prevalence of vascular depression in subjects suffering from diabetes [2]. Vascular depression is thought to arise from small vessel diseases and is often more severe and resistant to standard antidepressant treatments [33].

The incidence of antidepressant prescriptions observed in our study was consistent with that reported in a large multinational study, in which the incidence of antidepressant use between 2009 and 2014 varied from 4.7 to 18.6% in a population aged 65 years and over [24]. Moreover, a significantly lower rate of antidepressant prescriptions was observed in the driver group, which supports the previous observation. In conclusion, these findings suggest that driving a car may help to lower the prescription of antidepressants due to the risk reduction of depression.

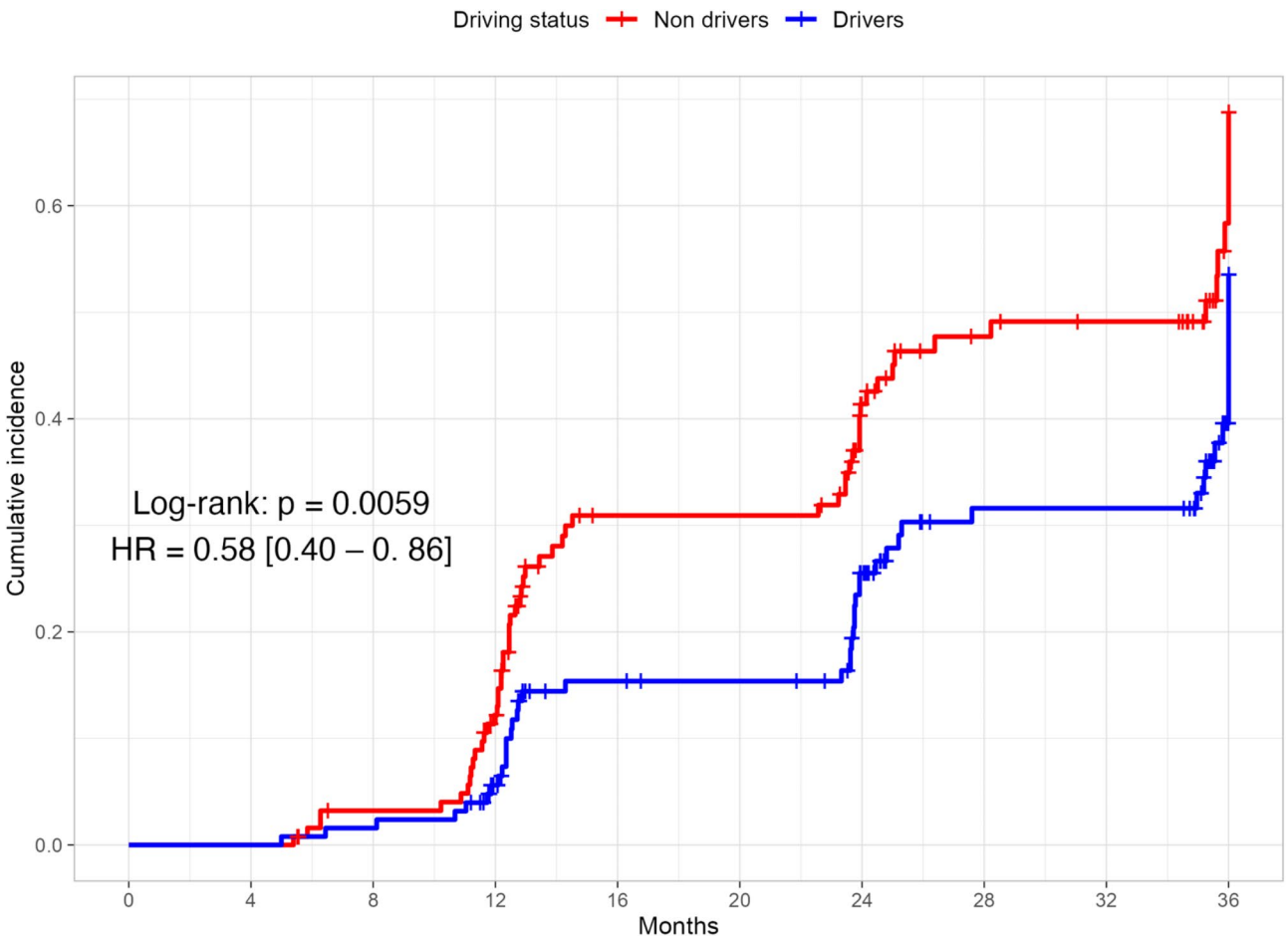

Fig. 1 Time to event analysis comparing drivers vs. non drivers cumulative incidence of depression over 3 years. *Note*: HR: Hazard Ratio

This study had several limitations. Firstly, although propensity score matching minimized baseline differences between drivers and non-drivers, the possibility of residual confounding cannot be excluded. Unmeasured variables, such as past history of depression (which could result in more severe depression), social support, or activity level (both of which are often diminished in individuals with depressive symptoms), may have influenced the observed associations. While autonomy measures such as ADL, IADL, presence of a professional care giver were included to partially mitigate these factors, they may not fully capture their impact. Secondly, this study may be subject to selection bias, as subjects with missing values for GDS and driving status at baseline were excluded. Additionally, healthcare-seeking behavior may have introduced further bias, as individuals who do not seek medical attention for depressive symptoms may have been underrepresented. However, this was partially mitigated by the inclusion criteria, which required that subjects suffered from at least one chronic condition (AF, type 2 diabetes or chronic pain) and underwent systematic assessment of depressive symptoms. Thirdly, while the data were collected through questionnaires filled out by GPs, which reduces the likelihood of recall, this method may have introduced inter-rater variability. To address this, standardized scales such as the GDS-15 were employed to ensure consistency in assessments. Finally, the absence of a driving assessment during follow-up may result in a classification bias, which may reduce the validity of these findings. Moreover, the absence of data on daily mileage precludes any definitive conclusion as to whether the observed effect was due to the actual act of driving or simply being identified as a driver. Future studies should address these limitations by tracking specific variables correlated to depressive symptoms, changes in driving status over time and collecting data on driving behaviors, including frequency and distance driven. Such methodology would allow for a more comprehensive understanding of the relationship between driving and depression.

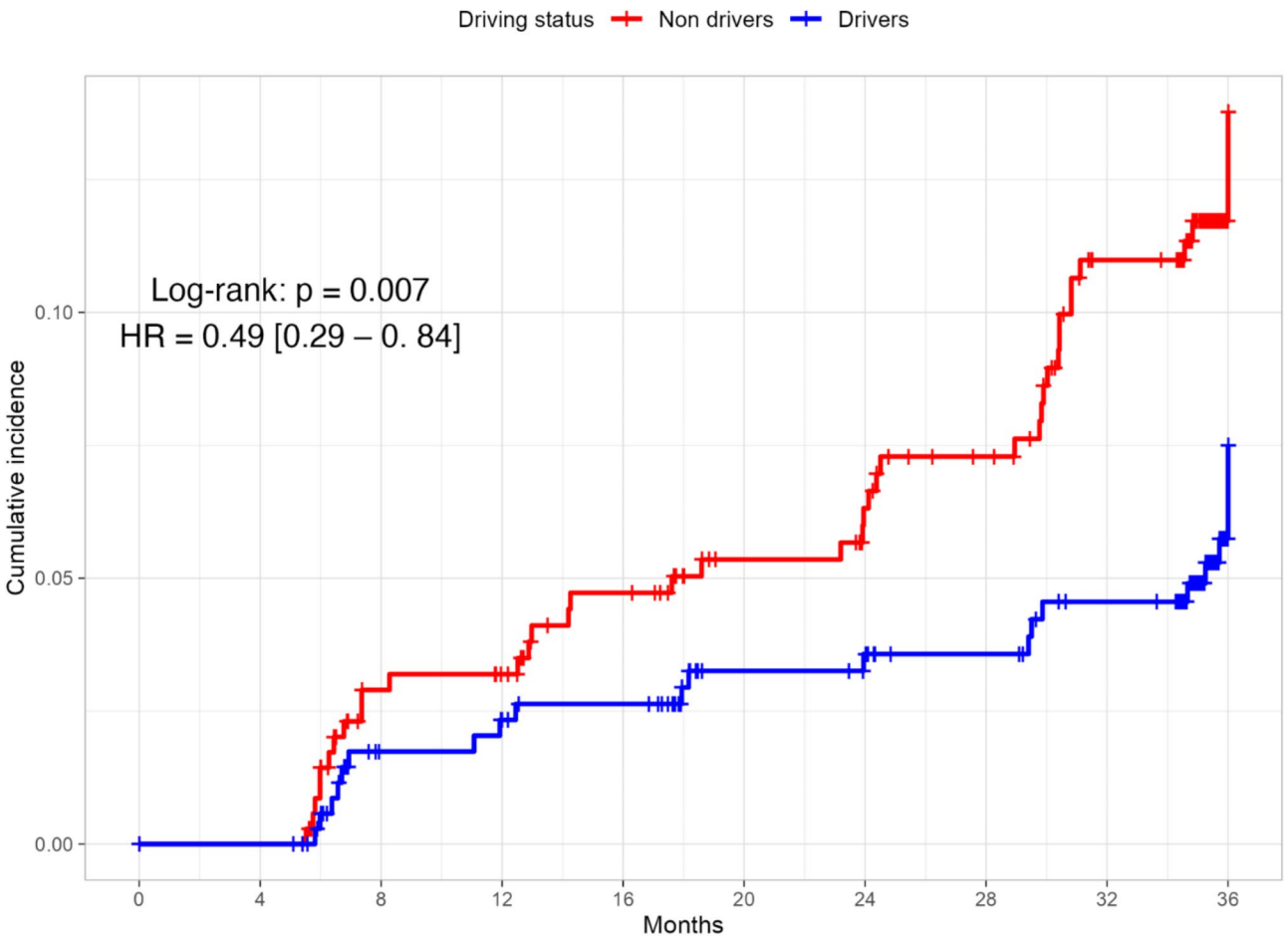

Fig. 2 Time to event analysis comparing drivers vs. non drivers incident risk of antidepressant prescription over 3 years. *Note*: HR: Hazard Ratio

Conclusion and implications

In conclusion, driving was associated with a lower risk of depression and antidepressant prescription in older adults with somatic comorbidities. Although more studies are needed because many factors may contribute to the role of driving, this study provides valuable insight into why driving plays an important part in the overall well-being of older adults.

Abbreviations

ADL	Activities of Daily Living
ANSM	French National Agency for Medicines and Health Products
ATC	Anatomical Therapeutic Chemical
BMI	Body Mass Index
GDS	Geriatric Depression Scale
HR	Hazard Ratio
IADL	Instrumental Activities of Daily Living
MMSE	Mini-Mental State Examination
SD	Standard Deviation

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05826-8.

Supplementary Material 1

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Author contributions

All authors have read and approved of the submission of this manuscript. E.B, R.C, E.D contributed to the study concept and design. L.B and E.C contributed to data acquisition. E.B drafted the manuscript. All authors contributed to critical revisions of the manuscript for important intellectual contents. EB was responsible for statistical analysis. L.B obtained funding. E.C, ED, R.C and L.B provided study supervision.

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Data availability

Qualified researchers may request access to patient level data and related study documents including the clinical study report, study protocol with any amendments, blank case report form, statistical analysis plan, and dataset specifications. Patient level data will be anonymized and study documents will be redacted to protect the privacy of our trial participants. Further details on Sanofi's data sharing criteria, eligible studies, and process for requesting access can be found at: https://www.vivli.org/. This ancillary study was not preregistered.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics committee (Comité de protection des personnes Ile de France XI) on January 15, 2009 (ref 09006) and by the French National Agency for Medicines and Health Products (ANSM) on February 6, 2009 (ref B81333-40). All methods were performed in accordance with the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study Informed consent was obtained for all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Global Burden of Disease. Global Burden of Disease [Internet]. 2019 [cited 2023 Aug 21]. Available from: https://www.healthdata.org/research-analysis/gbd
2. Empana JP, Boutouyrie P, Lemogne C, Jouven X, Van Sloten TT. Microvascular contribution to Late-Onset depression: mechanisms, current evidence, association with other brain diseases, and therapeutic perspectives. Biol Psychiatry. 2021;90(4):214–25.
3. Berk M, Köhler-Forsberg O, Turner M, Penninx BWJH, Wrobel A, Firth J, et al. Comorbidity between major depressive disorder and physical diseases: a comprehensive review of epidemiology, mechanisms and management. World Psychiatry. 2023;22(3):366–87.
4. Rubin R. Exploring the relationship between depression and dementia. JAMA. 2018;320(10):961–2.
5. Zenebe Y, Akele B, W/Selassie M, Necho M. Prevalence and determinants of depression among old age: a systematic review and meta-analysis. Ann Gen Psychiatry. 2021;20(1):55.
6. Lin JH, Huang MW, Wang DW, Chen YM, Lin CS, Tang YJ, et al. Late-life depression and quality of life in a geriatric evaluation and management unit: an exploratory study. BMC Geriatr. 2014;14(1):77.
7. Kok RM, Reynolds CF III. Management of depression in older adults: A review. JAMA. 2017;317(20):2114–22.
8. French Road Safety Observatory. Household car fleet| French road safety observatory [Internet]. [cited 2025 Jan 17]. Available from: https://www.onisr.securite-routiere.gouv.fr/en/knowledge-centre/vehicles/vehicle-fleet/household-car-fleet
9. Nishihori Y, Higuchi K, Ando R, Kawasumi N. Effect of car driving on quality of life for aged people. In: 2015 IEEE First International Smart Cities Conference (ISC2) [Internet]. 2015 [cited 2024 Mar 18]. pp. 1–6. Available from: https://ieeexplore.ieee.org/abstract/document/7366149?casa_token=vnWM-3ArCTgAAAAA:4ub-g8yxhuY5asX1GxfzlA3eF8x3L6ESKKXrPbLOozlRCbk25PpsB8lfftoLBVWp49kPhhMM
10. Wu TY, Chie WC, Liu JP, Liaw CK, Netuveli G, Blane D. Association of quality of life with laboratory measurements and lifestyle factors in community dwelling older people in Taiwan. Aging Ment Health. 2015;19(6):548–59.
11. Navarro J, Reynaud E, Osiurak F. Neuroergonomics of car driving: A critical meta-analysis of neuroimaging data on the human brain behind the wheel. Neurosci Biobehav Rev. 2018;95:464–79.
12. Rebok GW, Jones VC. Giving up driving: does social engagement buffer declines in mental health after driving cessation in older women? Int Psychogeriatr. 2016;28(8):1235–6.
13. Chihuri S, Mielenz TJ, DiMaggio CJ, Betz ME, DiGuiseppi C, Jones VC, et al. Driving cessation and health outcomes in older adults. J Am Geriatr Soc. 2016;64(2):332–41.
14. Becquemont L, Benattar-Zibi L, Bertin P, Berrut G, Corruble E, Danchin N, et al. National observatory on the therapeutic management in ambulatory care patients aged 65 and over, with type 2 diabetes, chronic pain or atrial fibrillation. Therapies. 2013;68(4):265–83.
15. Weyerer S, Eifflaender-Gorfer S, Wiese B, Luppa M, Pentzek M, Bickel H, et al. Incidence and predictors of depression in non-demented primary care attenders aged 75 years and older: results from a 3-year follow-up study. Age Ageing. 2013;42(2):173–80.
16. Almeida OP, Almeida SA. Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. Int J Geriatr Psychiatry. 1999;14(10):858–65.
17. Katz S, Akpom CA. A measure of primary Sociobiological functions. Int J Health Serv Plan Adm Eval. 1976;6(3):493–508.
18. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9(3):179–86.
19. D'Ath P, Katona P, Mullan E, Evans S, Katona C. Screening, detection and management of depression in elderly primary care attenders. I: the acceptability and performance of the 15 item geriatric depression scale (GDS15) and the development of short versions. Fam Pract. 1994;11(3):260–6.
20. World Health Organization. Anatomical Therapeutic Chemical (ATC) Classification [Internet]. 2024 [cited 2023 Nov 2]. Available from: https://www.who.int/tools/atc-ddd-toolkit/atc-classification
21. INSEE. Base des unités urbaines 2020| Insee [Internet]. 2024 [cited 2025 Jan 20]. Available from: https://www.insee.fr/fr/information/4802589
22. Trivedi D. Cochrane review summary: Mini-Mental state examination (MMSE) for the detection of dementia in clinically unevaluated people aged 65 and over in community and primary care populations. Prim Health Care Res Dev. 2017;18(6):527–8.
23. Díez-Manglano J, Giménez-López M, Garcés-Horna V, Sevil-Puras M, Castellar-Otín E, González-García P, et al. Excessive polypharmacy and survival in polypathological patients. Eur J Clin Pharmacol. 2015;71(6):733–9.
24. Tamblyn R, Bates DW, Buckeridge DL, Dixon W, Forster AJ, Girard N, et al. Multinational comparison of new antidepressant use in older adults: a cohort study. BMJ Open. 2019;9(5):e027663.
25. Austin PC. Optimal caliper widths for propensity-score matching when estimating differences in means and differences in proportions in observational studies. Pharm Stat. 2011;10(2):150–61.
26. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivar Behav Res. 2011;46(3):399–424.
27. Austin PC. The use of propensity score methods with survival or time-to-event outcomes: reporting measures of effect similar to those used in randomized experiments. Stat Med. 2014;33(7):1242–58.
28. Li G, Andrews HF, Chihuri S, Lang BH, Leu CS, Merle DP, et al. Prevalence of potentially inappropriate medication use in older drivers. BMC Geriatr. 2019;19(1):260.
29. George S, Crotty M, Gelinas I, Devos H. Rehabilitation for improving automobile driving after stroke. Cochrane Database Syst Rev [Internet]. 2014 [cited 2024 Mar 28];(2). Available from: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD008357.pub2/full
30. Park JS, Jung YJ, Lee G. Virtual Reality-Based cognitive–Motor rehabilitation in older adults with mild cognitive impairment: A randomized controlled study on motivation and cognitive function. Healthcare. 2020;8(3):335.
31. Alexopoulos GS, Raue PJ, Kanellopoulos D, Mackin S, Arean PA. Problem solving therapy for the depression-executive dysfunction syndrome of late life. Int J Geriatr Psychiatry. 2008;23(8):782–8.
32. Aizenstein HJ, Butters MA, Wu M, Mazurkewicz LM, Stenger VA, Gianaros PJ, et al. Altered functioning of the executive control circuit in Late-Life depression: episodic and persistent phenomena. Am J Geriatr Psychiatry Off J Am Assoc Geriatr Psychiatry. 2009;17(1):30–42.
33. Sheline YI, Pieper CF, Barch DM, Welsh-Boehmer K, McKinstry RC, MacFall JR, et al. Support for the vascular depression hypothesis in Late-Life depression: results of a 2-Site, prospective, antidepressant treatment trial. Arch Gen Psychiatry. 2010;67(3):277–85.

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