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Migraine Headaches are Associated with Motor Vehicle Crashes and Driving Habits among Older Drivers: Prospective Cohort Study

Short Running Title: Migraine, Motor Vehicle Crashes and Driving

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Key Points:

- Older adult drivers who reported having had migraine headache at any time in the past were not at increased risk of motor vehicle crashes in the subsequent two years, although they did have more hard braking events (a proxy for less safe driving) compared to older adult drivers who never had migraine.
- Older adult drivers with new onset of migraine headache were more than three times as likely to have a motor vehicle crash in the year after onset compared to older adult drivers who had never had a migraine.
- Use of medications commonly prescribed for acute migraine treatment or chronic migraine prophylaxis did not influence these relationships.

Why does this matter?

In the US, migraine headache affects 7% of adults ages 60 and older. Migraine symptoms, such as somnolence, impaired concentration, pain, or dizziness have the potential to adversely affect driving safety. Older adult patients newly diagnosed with migraine may benefit from counseling about reducing or avoiding driving during initial stabilization and management of migraine, holistic clinical assessment of driving risk factors and counseling to reduce other crash risks (e.g., avoiding alcohol, cannabis, and distraction).

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Abstract

Background: Migraine headache is common in older adults, often causing symptoms that may affect driving safety. This study examined associations of migraine with motor vehicle crashes (MVCs) and driving habits in older drivers and assessed modification of associations by medication use.

Methods: In a multi-site, prospective cohort study of active drivers aged 65-79 (53% female), we assessed prevalent migraine (i.e., ever had migraine, reported at enrollment), incident migraine (diagnosis first reported at a follow-up visit) and medications typically used for migraine prophylaxis and treatment. During two-year follow-up, we recorded self-reported MVCs and measured driving habits using in-vehicle GPS devices. Associations of prevalent migraine with driving outcomes were estimated in multivariable mixed models. Using a matched design, associations of incident migraine with MVCs in the subsequent year were estimated with conditional logistic regression. Interactions between migraine and medications were tested in all models.

Results: Of 2589 drivers, 324 (12.5%) reported prevalent migraine and 34 (1.3%) incident migraine. Interactions between migraine and medications were not statistically significant in any models. Prevalent migraine was not associated with MVCs in the subsequent two years (adjusted OR [aOR]=0.98; 95%CI: 0.72, 1.35), whereas incident migraine significantly increased the odds of having an MVC within one year (aOR=3.27; 1.21, 8.82). Prevalent migraine was associated with small reductions in driving days and trips per month and increases in hard braking events in adjusted models.

Conclusion: Our results suggest substantially increased likelihood of MVCs in the year after newly diagnosed migraine, indicating a potential need for driving safety interventions in these patients. We found little evidence for MVC risk or substantial changes in driving habits associated with prevalent migraine. Future research should examine timing, frequency and severity of migraine diagnosis and symptoms, and use of medications specifically prescribed for migraine, in relation to driving outcomes.

Key Words: Migraine, Motor Vehicle Crashes, Driving Habits, Driving Safety, Migraine Medications

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INTRODUCTION

Migraine is the second greatest cause of years of life lived with disability and affects over 1 billion people worldwide,[1] based on data from the Global Burden of Diseases, Injuries and Risk Factors 2016 study.[2] In the US, migraine affects 7% of adults ages 60 and older.[3] Symptoms, which can occur before, during and after a migraine attack, may include fatigue, somnolence, mood changes, impaired concentration, photophobia, neck stiffness, head and neck pain, dizziness or vertigo and, sometimes, temporary neurologic deficits.[4]

Migraine symptoms have the potential to adversely affect driving safety.[5] Prospective studies in New Zealand and Canada reported significantly increased risks of motor vehicle crash (MVC) injuries in people with prevalent (i.e., ever diagnosed or treated) migraine, while a smaller retrospective study in male military drivers found migraine diagnosis associated with police-reported MVCs.[6-8] Migraines could also reduce crash risk if symptoms lead to reductions in driving. In a survey of 5485 licensed drivers with migraine diagnosis, greater headache pain and frequency and migraine-related disability caused patients to drive less or avoid driving altogether.[9]

Medications to prevent or treat migraine, including triptans, opioids, barbiturates and antiemetics for acute attacks, or β-blockers, antidepressants, or antiepileptics used as preventive treatments, may reduce driving safety.[5] However, by decreasing migraine symptoms, such medications might also reduce impaired driving and promote safety. Vingilis et al. (2012) simultaneously examined migraines and pain medications (not necessarily prescribed specifically for migraine) and found that the increased odds of MVC injuries in those with prevalent migraine persisted after adjustment for use of pain relievers such as Tylenol[8]; however, odds were smaller and no longer significant when adjusted for codeine, pethidine, or morphine use. Other medications were not examined.

More evidence on whether the condition itself or its treatment is the etiologically relevant factor for MVCs and driving changes may improve driving safety decision-making for older adults with

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migraine. We examined the relationship between prevalent migraine and subsequent MVCs, driving habits and driving safety, explored the association of incident migraine with subsequent MVCs, and assessed the influence of medications typically prescribed for migraine on these relationships, in a US cohort of older drivers.

METHODS

Study Design

The AAA Longitudinal Research on Aging Drivers (LongROAD) study was a prospective cohort study designed to examine factors associated with safe driving in older adults. Recruitment and enrollment occurred between July 2015 and March 2017 at five sites (Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; San Diego, CA). The study collected data on health, functioning, MVCs and driving habits. After a baseline (Y0) in-person visit, participants were followed annually, with telephone follow-up at year one (Y1) and three (Y3) and in-person follow-up at year two (Y2). The study design and sample have been detailed previously.[10] The study was approved by each site's institutional review board. Enrolled participants provided written informed consent and received $100 at baseline and Y2 visits and $50 at telephone follow-ups as compensation for time and travel costs.

For examination of prevalent migraine, we analyzed data from baseline and the first two annual follow-ups. For the exploratory analysis of incident migraine, we used a matched design nested within the cohort, matching participants with incident migraine identified at Y1 or Y2 to six participants never diagnosed with migraine during the study on age group at enrollment (65-69, 70-74, 75-79 years), gender, enrollment site, and visit year when incident migraine was reported.

Participants

At enrollment, participants were aged 65-79, had a valid driver's license, drove on average at least once a week, drove one car (1996 or newer with accessible OBDII port) at least 80% of the time, spoke English, had no significant cognitive impairment (e.g., Alzheimer's disease) based on medical

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record review and a Six-Item Screener score of four or more (sensitivity 67.5% and specificity 96.1% for clinically diagnosed dementia),[11] and resided in the catchment area at least 10 months a year with no plans to move away within five years.[10] Using electronic medical records from healthcare systems affiliated with study sites, study staff identified potentially eligible patients, sent recruitment letters followed by telephone calls for eligibility screening, and scheduled eligible, interested people for a baseline study visit. Of 40,806 individuals sent recruitment letters, 7.3% (n=2990) enrolled[10]; the remainder could not be contacted (19.0%), declined eligibility screening (29.7%), were ineligible (19.0%) or declined participation (25.0%).

The analysis cohort for prevalent migraine and driving outcomes included participants who provided information on migraine headaches at baseline, had driving data available, and drove at least 10 of 12 months in both Y1 and Y2 (Figure 1). Participants reporting a new migraine diagnosis after baseline were excluded. The MVC outcome (any MVC reported at Y1 or Y2) was analyzed for those that reported crash data at both Y1 and Y2 follow-up.

The analysis cohort for incident migraine and driving outcomes included participants who provided information on migraine headaches at baseline and follow-up visits, did not report migraine headache at baseline, had driving data available, drove at least 10 of 12 months in the year before migraine diagnosis (or matched visit year for the comparison group), and reported crash data at the follow-up after migraine diagnosis (or matched visit year). Participants who first reported a migraine diagnosis at Y3 (n=11) were excluded.

Variables

Exposures

Prevalent migraine was defined as "Yes" to the following question asked at baseline: "Have you ever had, or have you ever been told by a doctor or other health professional that you have, the following? Migraine headaches." At each subsequent visit, participants were asked, "In the past 12

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months, have you been told by a doctor or other health professional that you have the following? Migraine headaches." Incident migraine was defined as a "Yes" answer to this question at the Y1 or Y2 visit in participants who had not reported migraine headache at any preceding visit. Unexposed participants were those answering "No" to these questions at baseline and follow-up.

Data on current medications were collected using a "brownbag review" method at the baseline and Y2 in-person assessments.[12] During telephone follow-ups, participants were asked if they were still taking each of the medications reported at the prior visit, if they were currently taking any other medications, and if so, which ones. Indication for medications was not collected. Prescribed medications were categorized according to the American Hospital Formulary System (AHFS) classification, as described in Hill et al. (2020).[13] For this analysis, we examined medications commonly used for acute migraine treatment and chronic migraine prophylaxis. For acute treatment, we assessed ergotamine preparations, serotonin 1b/1d agonists, and selective serotonin 1F receptor agonists. For prophylaxis, we focused on typical first-line medications (i.e., beta-adrenergic blocking agents, e.g., propranolol, timolol and metoprolol, and anticonvulsants, e.g., topiramate), recognizing that these medications are commonly used for other indications and that other medications not considered here may also be used for migraine prophylaxis. Medication use was defined as current use reported at baseline for prevalent migraine analyses, and current use reported at the diagnosis or matched visit year for incident migraine analyses.

Outcomes

Self-reported crashes were collected annually using the "crashes and citations" domain from the Driving Habits Questionnaire (DHQ),[14] which asks "How many accidents have you been involved in over the past year when you were the driver?" and a follow-up question asking the number where police were called to the scene. For the prevalent migraine analysis, total number of past-year accidents reported at Y1 and Y2 visits were combined and categorized as any MVC during two-year follow-up

versus none. For the incident migraine analysis, the outcome was any self-reported MVC vs. no MVC during the 12 months after diagnosis or matched visit year (based on data collected at the visit one year after diagnosis), using the same self-report measure.

Driving habit measures are defined in Table 1. We measured driving habits through the OBDII DataLogger (Danlaw, Inc., Novi, MI, USA), a recording device installed in the study participant's primary vehicle at enrollment,[10] which collected data when the vehicle was turned on. The device determined if the participant was the driver using a Bluetooth receiver to detect participant codes and signal strengths transmitted by Bluetooth beacons carried by the participant. Driving habit measures were based on previous work,[15] conceptualized from three components of the DHQ: driving space, driving exposure, and avoidance of driving in challenging conditions (Table 1). Reduced driving in challenging conditions indicates greater avoidance of such conditions. Rapid deceleration ("hard braking") and speeding events served as proxies for unsafe driving.[16-18] We derived monthly means and standard deviations for each measure.

Other Variables

Baseline demographic characteristics included age group, gender, education, marital status, annual household income, employment, and race/ethnicity, categorized as shown in Table 2.

Statistical Analysis

Baseline characteristics by migraine status were summarized with frequencies and percentages. Differences between groups were tested with Fisher's exact tests. Driving habits were summarized with means and standard deviations.

The association of prevalent migraine compared to never having migraine was estimated for each driving outcome in a mixed model with a random intercept for site and a binomial or normal distribution for the outcome, as appropriate. If needed, continuous driving habits outcomes were log-transformed to meet model assumptions. Age and gender were included in all models. Other potential

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covariates were identified by association with both migraine diagnosis and outcome at $p < 0.20$. Analyses were based on complete cases (Table 2 enumerates missing covariate data). Unadjusted estimates (i.e., betas or odds ratios) were compared to estimates adjusted for each potential covariate separately and combined; if covariate inclusion affected the magnitude of the estimate by more than 10%, the covariate was included in the final model. For all models, interactions between migraine and medication use (categorized as: any acute treatment, any prophylaxis, beta-blockers, anticonvulsants, or any acute treatment or prophylaxis) were tested on a multiplicative scale. Since none were significant at $p<0.05$, the models were fit without any interaction terms to examine main effects of migraine and medication use.

To test the association of incident migraine compared to never having migraine with reporting an MVC at the subsequent annual visit, the same demographics comparisons, covariate selection, modeling procedures, and testing of interactions between incident migraine and medication use were conducted. Conditional logistic regression was used to model the association between migraine status and MVCs to account for matching. No interactions were statistically significant. We tested a composite variable for migraine and medication use to assist in model convergence.

Statistical analyses were performed in R version 4.2.0.[19]

RESULTS

Of 2990 participants enrolled in the LongROAD study, 2589 (86.6%) were included in the analytic cohort for driving habits, of whom 324 (12.5%) reported ever having migraine headache at baseline (Figure 1). Table 2 summarizes demographics and medication data by prevalent migraine status. The analytic cohort for MVC outcomes included 2420 (80.9%) participants; distributions of characteristics were similar to those shown in Table 2.

Prevalent Migraine and MVCs

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Having at least one MVC in the two years after the baseline visit was reported by 51 (16.5%) participants with prevalent migraine and 352 (16.7%) participants who never had migraine. Police-involved MVCs were reported by 16 (5.2%) participants with and 138 (6.5%) without prevalent migraine. Prevalent migraine was not associated with reporting an MVC in adjusted analyses (Figure 2). There were no significant interactions between prevalent migraine status and baseline use of either beta-blockers or anticonvulsants. The model examining interaction with acute migraine medication failed to converge. Use of acute migraine medication, beta-blockers, or anticonvulsants, alone or in combination, did not materially change the estimated association of prevalent migraine with subsequent MVCs in adjusted analyses (Figure 2).

Baseline use of beta-blockers was associated with a significantly reduced odds of reporting a subsequent MVC, while baseline use of anticonvulsants was associated with increased odds of reporting an MVC (Figure 2). Acute migraine medication use was not associated with subsequent MVC in any analyses, although power for these analyses was low. Analyses examining combined prophylaxis treatments, with or without acute migraine medication, showed no association with MVC.

Prevalent Migraine and Driving Habits

After accounting for potential confounding variables, participants with prevalent migraine had significantly less driving exposure, on average driving about one less day and making about nine fewer driving trips per month, than participants without migraine (Table 3). Those with prevalent migraine made a smaller proportion of trips during morning rush hour but a greater proportion during evening rush hour. The two groups did not otherwise differ significantly in their driving habits.

There were no statistically significant interactions between prevalent migraine status and baseline medication use for any driving habits. There were few associations between medication use and driving habits in unadjusted models, which were primarily related to driving exposure and avoidance (see Supplemental Material). In adjusted analyses, baseline use of acute migraine medication

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was not associated with any driving habits (Supplemental Material, Table 1). Associations of anticonvulsant use with a slightly greater right to left turn ratio, and of beta blocker use with a smaller proportion of trips at night, persisted in adjusted models, but neither medication was otherwise associated with driving habits (Supplemental Material, Tables 2 and 3). Adjusted models that included baseline medication use demonstrated associations between prevalent migraine and driving habits that were similar to those reported in analyses that did not include medications, for measures of both driving exposure and driving avoidance. However, prevalent migraine was associated with small statistically significant increases in hard braking events per 1000 miles in adjusted models that included acute migraine medications, anticonvulsants, or beta-blockers, respectively. In absolute terms, the increases ranged from 0.21 to 0.23 hard braking events per 1000 miles driven.

Incident Migraine and MVCs

After excluding 324 participants with prevalent migraine, 34 (1.3%) of 2627 participants first reported having been diagnosed with migraine headache at either their Y1 or Y2 visit. Of these, 30 (N=18 at Y1 and N=12 at Y2) met inclusion and exclusion criteria for driving and crash data. Each of these participants was matched on baseline age group, gender, site and visit year to six participants never diagnosed with migraine (N=108 matched at Y1 and N=72 matched at Y2), who similarly met inclusion and exclusion criteria.

Seven (23.3%) drivers with incident migraine reported at least one crash in the year after their diagnosis versus 15 (8.3%) matched drivers without migraines; police-involved MVCs were reported by two (6.7%) participants with and six without (3.3%) incident migraine. The odds of having at least one crash were more than three times as high among those with incident migraine compared to matched drivers without migraines (OR=3.27, 95%CI: 1.21, 8.82; p=0.019). No participants with incident migraine reported taking acute migraine medication. There were no significant interactions between incident migraine and use of either beta-blockers or anticonvulsants or both at the matched visit. Neither use of

beta-blockers nor anticonvulsants, alone or in combination, confounded the association of incident migraine with subsequent MVC.

DISCUSSION

In this longitudinal study of older drivers, those who had ever had migraine headache drove slightly less often on average than did older drivers who had never had migraine headache. However, those with and without prevalent migraine did not otherwise differ in their driving habits nor were they at increased odds of MVC. Use of commonly prescribed migraine medications did not influence these associations, except that after accounting for acute migraine medications, anticonvulsants, or beta-blockers, respectively, prevalent migraine was associated with modest increases in hard braking events. In contrast, incident migraines were associated with substantially increased odds of having at least one crash compared to matched drivers who did not have migraines, independent of medication use.

Migraine symptoms such as somnolence, impaired concentration and pain have the potential to adversely affect driving safety and prior studies have identified increased risk of MVC injuries with history of migraine.[5,7,8] However, we found no difference in the odds of MVC between those with and without a history of ever having migraine headache. Our measure of migraine headache, like the measures used in prior studies of crash risk,[7,8] reflected self-report of ever having had this condition. Some persons with migraine may have complete or partial remission[4,20,21]; hence, participants may no longer have had symptoms at the time of our assessment. The prevalence of self-reported migraine headache declines markedly with age,[3,20] suggesting substantial remission may occur over the lifespan. On the other hand, migraine symptom frequency and presence of aura have been shown to increase with age among those with persistent migraine,[3] potentially resulting in greater effects on driving performance among those still affected. We did not assess current migraine symptom type, frequency, or severity, but note that less than 10% of participants reporting a history of migraine were currently using acute migraine medication. If participants had experienced remission or if current migraine

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symptoms were infrequent or mild, this could explain the lack of association with crash risk observed in our study. It is also possible that any increased risk resulting from migraine symptoms was counterbalanced by reductions in miles driven and trips made, reducing potential exposure to crash risk. We also found greater avoidance of early morning rush hour and less avoidance of evening rush hour. Several studies have reported that most migraine attacks begin in the early morning,[22-24] which could explain our findings if individuals with migraine are therefore less likely to drive in the morning.

We did not find evidence that either acute or preventive migraine medications interacted with or substantially influenced the relationship between prevalent migraine and crash outcomes. The acute migraine medications we assessed are prescribed specifically for migraine headaches, but few participants used them. For migraine prophylaxis, we focused on typical first-line medications that are also commonly used for other indications. Participants may have been using these medications for reasons other than migraine headache. Vingilis et al (2012) similarly found no association of migraine with motor vehicle-related injuries after adjusting for pain medications (as in our study, these were not necessarily prescribed or used specifically for migraine).[8] We also found no evidence that migraine medications interacted with or influenced the relationship between prevalent migraine and driving habits, except that after adjustment for medication use, we observed statistically significant, albeit modest increases in hard braking events. The observed increases ranged from 0.21 to 0.23 events per 1000 miles driven. Given that US drivers ages ≥70 drive on average about 7,400 miles annually,[25] this translates to about one to two more hard braking events per older driver per year. Such events may serve as proxies for unsafe driving,[16-18] but whether this small increase translates into meaningful differences in crash risk is uncertain.

In contrast to prevalent migraine, an exploratory analysis revealed that the odds of having at least one MVC within one year after a new report of migraine headache diagnosis were more than three times as high as for those without migraines. This suggests that as much as 19% more drivers with

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newly reported migraine diagnosis will experience at least one crash within the next year relative to those without migraines. Participants with incident migraine were presumably experiencing migraine symptoms currently (leading to their new diagnosis), which might not yet be adequately managed with abortive medications nor controlled through lifestyle changes or preventive medications, or they may be self-medicating with potentially inappropriate medications, all of which may have adversely affected their driving. In contrast, those with prevalent migraine may have had few or no current symptoms influencing their driving. We observed that use of chronic prophylactic medications did not modify the association between incident migraine and crashes, however our power to examine interactions with medications was limited.

These results have potentially important clinical implications for the management of older patients with newly diagnosed migraine who drive. Such patients may benefit from counseling about reducing or avoiding driving during initial stabilization and management of migraine, holistic clinical assessment of driving risk factors such as the assessments recommended by the Clinician's Guide to Older Driver Safety,[26] referral for driving rehabilitation programs, and counseling to reduce other crash risks (e.g., avoiding alcohol, cannabis, and distraction). Confirmation of our findings in larger samples that assess current symptoms and migraine-specific medication use, as well as studies to assess how long increased crash risk may persist after diagnosis, are needed.

In addition to limitations noted above, this study examined self-reported migraine and MVCs. If some with migraine did not report it or some without migraine did report it (e.g., confusing it with other headache diagnoses), such misclassification may have biased our results toward the null. Accurate reporting may be more likely for incident migraine, since participants were reporting diagnoses received within the past year. The MVC outcome was based on a question from the DHQ, which has been shown to have good test-retest reliability in community-dwelling older drivers,[27] but its validity is unconfirmed. The DHQ does not define "accident," hence the type or severity of accidents respondents chose to

report may vary. If drivers with and without migraine reported accidents differently, this could have biased our results. However, proportions with MVCs in which police were called, which may be less variably reported, were distributed similarly to overall MVCs. Our data were collected from a sample of generally affluent, well-educated, White, non-Hispanic older drivers, among whom the relationship between migraine headache and study outcomes may differ from that of the general population. These same characteristics may also reduce the generalizability of our findings to other more diverse populations. Providing compensation could theoretically have affected external validity, but the modest amount to offset travel and parking costs was likely not enough to influence our results and may have improved external validity by enabling people with less income to participate. Among the study's strengths are its large sample of older drivers from geographically varied sites, the examination of multiple types of medications commonly used for migraine treatment or prevention, the objective assessment of driving habits, and the use of longitudinal data to assess both driving habits and crash outcomes.

CONCLUSIONS

Older drivers who have ever been diagnosed with migraine headache drive somewhat less and, after accounting for medication use, have slightly less safe driving, but do not otherwise differ in driving habits nor occurrence of MVCs from those who never had migraine. These results suggest stable, long-standing, or past history of migraine has relatively little impact on driving safety. However, odds of crashes were significantly increased in the year following newly reported migraine, indicating a potential need for driving safety intervention and improved clinical management in this population. Further research is needed to examine timing, frequency and severity of migraine diagnosis and symptoms, as well as use of medications explicitly prescribed for migraine, in relation to driving outcomes.

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Description of Supplemental Materials: Tables 1-3 show associations of baseline use of acute migraine, anticonvulsant and beta-blocker medications, respectively, vs. no use, and prevalent migraine (ever having been diagnosed with migraine) vs. no migraine diagnosis, with driving habits during two-year follow-up.

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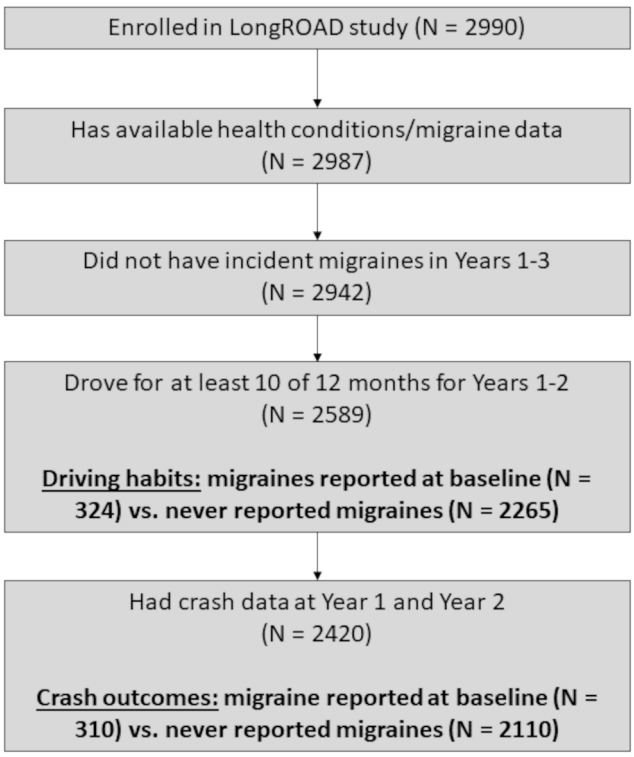
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Figure 1. Study flow for the cohort comparing prevalent migraine diagnosis to no migraine diagnosis reported in the study.

Figure 2. Association of prevalent migraine (ever having been diagnosed with migraine) vs. no migraine diagnosis, and migraine medication use vs. no use, with self-reported motor vehicle crash during two-year follow-up.

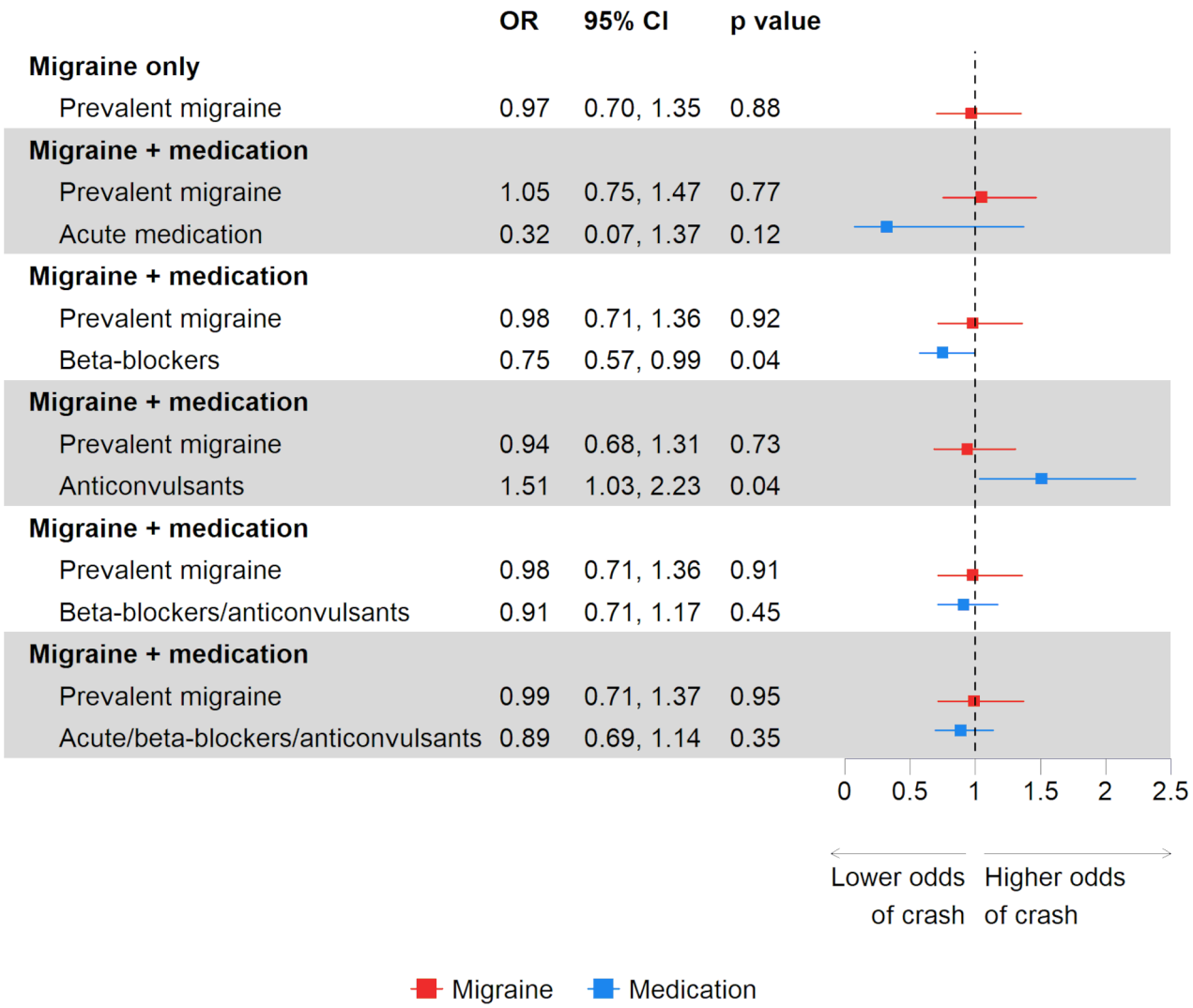
Footnote: All models are adjusted for age group and gender as fixed effects and include a random effect for site. Abbreviations: CI = Confidence Interval; OR = Odds Ratio.

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LongROAD_Migraine_Figure1_300dpi_86mmWidth.png

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LongROAD_Migraine_Figure2_300dpi_42picaWidth v2.png

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Table 1. Measures of driving habits

Averaged monthly driving habits variable, mean (SD)	**Definition for the Monthly Variable**	**Category**	**Overall Mean (SD)** (N = 2589)
Average % of trips* within 15 miles of home	Percent of trips in month traveled within 15 miles of home	Driving space	64.2 (21.9)
Average number of miles	Total number of miles driven in month	Driving exposure	764.2 (419.4)
Average number of days driving	Total number of days in month with at least one trip	Driving exposure	21.9 (4.7)
Average number of trips	Total number of trips in month	Driving exposure	115.0 (50.7)
Average % of trips at night	Percent of trips in month during which at least 80% of the trip was during nighttime, with nighttime defined as end of evening civil twilight to beginning of morning civil twilight or a solar angle greater than 96 degrees	Driving avoidance	6.8 (5.1)
Average % of trips on high-speed roads	Percent of trips in month during which at least 20% of distance travelled was at a speed of 60 MPH or greater	Driving avoidance	12.8 (10.6)
Average % trips in AM peak	Percent of all trips taken in month during 7:00-9:00 AM on weekdays	Driving avoidance	7.1 (4.7)
Average % trips in PM peak	Percent of all trips taken in month during 4:00-6:00 PM on weekdays	Driving avoidance	9.5 (4.2)
Right to left turn ratio	Ratio of all right-hand to left-hand turning events identified in month	Driving avoidance	0.93 (0.13)
Average speeding events/1000 miles	Number of speeding events (speed > 80 MPH sustained for at least 8 seconds) per 1000 miles driven in month	Unsafe driving	6.5 (13.9)
Average rapid deceleration events/1000 miles	Number of events with deceleration greater than or equal to 0.4g (hard braking, near crash, crash) per 1000 miles driven in month	Unsafe driving	1.4 (4.4)

Abbreviations: AM – ante meridiem; g – acceleration/deceleration of gravity; MPH – miles per hour; PM – post meridiem; SD – standard deviation

*Trip is defined as ignition on to ignition off

Table 2. Demographics and medication data by prevalent migraine status (ever having migraine headache as reported at baseline vs. never having migraine headache at baseline or during study follow-up)

	Never had migraine (N = 2265)	**Ever had migraine** (N = 324)	**p value***
Demographic variables			
Age Group (years)			0.091
65-69	942 (41.6%)	155 (47.8%)	
70-74	774 (34.2%)	103 (31.8%)	
75-79	549 (24.2%)	66 (20.4%)	
Gender			<0.001
Male	1125 (49.7%)	94 (29.0%)	
Female	1140 (50.3%)	230 (71.0%)	
Highest level of education attained			0.492
High school degree or less	248 (11.0%)	32 (9.9%)	
Some college/vocational/tech/associate's	530 (23.5%)	88 (27.2%)	
Bachelor's degree	536 (23.7%)	70 (21.6%)	
Master's/professional degree	943 (41.8%)	134 (41.4%)	
Missing	N = 8	N = 0	
Marital status			0.005
Single/divorced/widowed	702 (31.3%)	126 (39.3%)	
Married/living with partner	1539 (68.7%)	195 (60.7%)	
Missing	N = 24	N = 3	
Income			0.003
<$80,000	1087 (49.6%)	185 (59.9%)	
$80,000-$100,000	344 (15.7%)	36 (11.7%)	
$100,000 or more	761 (34.7%)	88 (28.5%)	
Missing	N = 73	N = 15	
Employment			0.246
Not working	1560 (68.9%)	234 (72.2%)	
Worked for pay in last month	703 (31.1%)	90 (27.8%)	
Missing	N = 2	N = 0	
Race/ethnicity			0.031
White, Non-Hispanic	1943 (85.9%)	294 (90.7%)	
Black, Non-Hispanic	162 (7.2%)	12 (3.7%)	
Other race/ethnicity†	158 (7.0%)	18 (5.6%)	
Missing	N = 2	N = 0	
Medication Use			
Taking acute migraine medication	1 (0.0%)	32 (9.9%)	<0.001
Taking beta-blocker	503 (22.2%)	79 (24.4%)	0.393
Taking anticonvulsant	141 (6.2%)	42 (13.0%)	<0.001

*Differences between groups are tested with Fisher's exact tests due to some small cell sizes.
†Includes "American Indian," "Asian," "Alaska Native, Native Hawaiian, Pacific Islander," "Other, Non-Hispanic," and "Hispanic."

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Table 3. Mean and standard deviation for driving habits variables by prevalent migraine status, and unadjusted and adjusted associations (with 95% confidence intervals and p-values) between migraine status and each driving habit variable.

Averaged monthly driving habits variable	Prevalent migraine: Mean (SD)[a] (N = 324)	Never migraine Mean (SD) (N = 2265)	Unadjusted Model: Beta Estimate (95% CI)	p value	Adjusted[b] Model: Beta Estimate (95% CI)	p value
Average % of trips within 15 miles of home	62.9 (22.8)	64.4 (21.7)	-1.5 (-4.1, 1.1)	0.257	-1.1 (-3.5, 1.3)[c]	0.376
Average number of miles	721.9 (384.7)	770.3 (423.9)	-49.5 (-99.7, 0.7)	0.053	-42.2 (-90.5, 6.1)[d]	0.087
Average number of days driving	21.4 (4.7)	22.0 (4.7)	-0.6 (-1.1, -0.04)	0.035	-0.6 (-1.2, -0.1)	0.029
Average number of trips	106.8 (41.0)	116.2 (51.8)	-9.4 (-15.3, -3.5)	0.002	-8.8 (-14.7, -2.9)	0.003
Log average % of trips at night	6.6 (5.1)	6.8 (5.1)	-0.0 (-0.1, 0.1)	0.451	0.0 (-0.1, 0.1)	0.896
Log average % of trips on high-speed roads	12.4 (10.0)	12.9 (10.7)	-0.0 (-0.2, 0.1)	0.609	-0.0 (-0.2, 0.1)[e]	0.765
Average % trips in AM peak	6.2 (4.6)	7.3 (4.7)	-1.1 (-1.6, -0.6)	<0.001	-1.1 (-1.6, -0.5)	<0.001
Average % trips in PM peak	10.0 (4.6)	9.4 (4.1)	0.6 (0.2, 1.1)	0.009	0.6 (0.2, 1.1)	0.009
Right to left turn ratio	0.9 (0.1)	0.9 (0.1)	0.0 (-0.02, 0.01)	0.659	0.0 (-0.01, 0.02)	0.641
Any speeding events	6.3 (12.6)	6.5 (14.1)	0.9 (0.7, 1.2)	0.500	1.0 (0.7, 1.4)	0.969
Log average rapid deceleration events/1000 miles	1.5 (2.1)	1.4 (4.7)	0.1 (-0.1, 0.2)	0.246	0.1 (-0.02, 0.3)	0.082

Abbreviations: AM – ante meridiem; PM – post meridiem; SD – standard deviation

[a] For log-transformed variables, means and SDs are reported on the raw scale.

[b] All adjusted models include age group, gender, and a random effect for site.

[c] Adjusted in addition for marital status, annual household income and race/ethnicity.

[d] Adjusted in addition for annual household income.

[e] Adjusted in addition for race/ethnicity.

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