Prescription opioid use in multiple sclerosis

INTRODUCTION
Pain can be one of the worst symptoms of multiple sclerosis (MS). \(^1\) Modifiable factors, including depression and anxiety, may influence its severity and impact. \(^2\) Opioids used for chronic non-cancer pain may be prescribed to persons with MS when neuropathic pain therapies are ineffective. Given the potential harms of opioid use and limited data supporting their utility in MS, it is important to understand the extent of opioid prescribing for persons with MS. We estimated incidence, prevalence and patterns of opioid prescription in an MS population and a matched cohort without MS. We assessed whether comorbid mood/anxiety disorders modified the association between MS and prescription opioid use (hereinafter ‘opioid use’).

METHODS
Briefly, this matched retrospective cohort study was conducted in Manitoba, Canada. Online supplemental appendix 1 details methods and references.

We identified Manitobans with MS from 1984 to 2016 using a validated definition relying on health claims; the earliest demyelinating disease claim constituted the index date. A general population cohort was matched 5:1 on sex, year of birth (±5 years) and residence region to the MS cohort, after excluding anyone with diagnosis codes for demyelinating disease or MS disease-modifying therapies. Each control was assigned the index date of their matched case. From these cohorts, we selected incident MS cases and matched controls with an index date ≥1997, excluding individuals with cancer/palliative care. We censored anyone who developed cancer or entered palliative care post index when relevant codes first appeared and censored individuals on death or leaving the province.

Using validated definitions, we updated mood/anxiety disorder status annually (active vs inactive/absent). Individuals with schizophrenia were not excluded.

New (incident) users of opioids were those with no dispensation of ≥1 year before initial dispensation. Prevalent opioid users were individuals with ≥1 opioid dispensation in the year of interest. We measured time from first opioid dispensation to discontinuation. We described use patterns among cohort members with ≥5 years of follow-up post-index. We noted use of non-steroidal anti-inflammatory drugs, cannabinoids, tricyclic antidepressants, serotonin and norepinephrine reuptake inhibitors and anticonvulsants based on ≥1 dispensation.

We estimated the crude annual incidence and prevalence of opioid use, overall and stratified by sex and age. We age and sex standardised the estimates. To assess the association between cohort (MS vs non-MS), mood/anxiety disorders (active vs inactive/absent) and opioid use, we employed multivariable generalised linear models. We tested two-way interactions between cohort and mood/anxiety status. Covariates included sex, age, residence region, socioeconomic status, disease duration, index year, number of physical comorbidities and annual number of classes (types) of prescription medications dispensed, after excluding opioids.

RESULTS
We included 2918 persons with MS and 14,539 persons without MS (online supplemental appendix table e1). In 2016, the crude incidence/1000 persons of opioid use was 1.49-fold higher (rate ratio [RR] 1.49, 95% CI 1.33 to 1.64) in the MS cohort (62.94, 95% CI 58.34 to 67.54) than in the non-MS cohort (43.89, 95% CI 42.39 to 45.40). Temporal trends are shown in online supplemental appendix figure e1. Average annual incidence rate of opioid use did not differ by sex in either cohort (figure 1). Opioid use was higher in the MS than in the non-MS cohorts at all ages; this effect was greatest in those aged ≥65 years (age×cohort interaction, p=0.0081; figure 1). Over the study period, the MS cohort had 1.71-fold higher crude prevalence/1000 persons of opioid use (226.4, 95% CI 220.7 to 232.2) than the non-MS cohort (132.5, 95% CI 130.6 to 134.4).

Time to discontinuation of opioids by 25% of those initiating treatment was 12 days longer in the MS cohort (see online supplemental appendix 1). Among incident opioid users with ≥5 years of follow-up who had MS but no mood/anxiety disorder, 30.0% obtained only one opioid dispensation, and 8.4% used opioids continuously for ≥3 months. In contrast, among individuals with MS and a mood/anxiety disorder, few had only one dispensation (11.4%), and 11.4% used opioids continuously for ≥3 months (11.4%) (online supplemental appendix figure e2).

After adjusting for covariates, the MS cohort had an increased incidence (RR 1.18, 95% CI 1.08 to 1.29) and prevalence of opioid use (RR 1.49, 95% CI 1.41 to 1.57) than the non-MS cohort (online supplemental appendix table e2). Having an active mood/anxiety disorder was associated with an increased prevalence of opioid use (RR 1.22, 95% CI 1.17 to 1.27), but there were no statistically significant interactions between cohort and mood/anxiety disorders on opioid use (all p>0.05).

DISCUSSION
We examined opioid use in people with and without MS over two decades. On average, the annual prevalence of opioid use was 226/1000 persons with MS, but only 132/1000 persons without MS, an adjusted relative increase of 49% in the MS cohort. This higher use of opioids was irrespective of the presence of a mood/

Figure 1 Average annual age-stratified and sex-stratified incidence and prevalence of opioid use in MS and non-MS cohorts. *Error bars indicate 95% CIs. Incidence rate ratios and prevalence ratios comparing MS and non-MS cohorts shown above relevant columns. MS, multiple sclerosis.
anxiety disorder, similar to prior findings for benzodiazepines.\(^3\) Notably, average incidence of opioid use in those with MS aged ≥65 years was quite high, at 83/1000 persons, and prevalent use affected one in four persons. Although incident opioid use was only slightly higher in the MS cohort, higher prevalent use indicated longer duration of use, which was corroborated by our examination of patterns of use. In both cohorts, mood/anxiety disorders were associated with longer duration of opioid use.

One American survey of individuals with MS found that 37.7% currently used opioids.\(^4\) Our finding that approximately 10% of our MS cohort used opioids long-term highlights the need for further pain management research in MS as guidelines state that opioids should not be first-line therapies, given the uncertainty regarding long-term benefits.\(^5\)

Study limitations included inability to assess use of over-the-counter acetaminophen–codeine combinations or to exclude non-MS-related pain syndromes in the MS cohort. We applied validated definitions to identify individuals affected by mood/anxiety disorders, but these only capture individuals receiving care from insured (i.e., physician) providers.

Prescription opioid use is more common in people with MS than those without MS. Both MS and mood/anxiety disorders are associated with longer durations of chronic opioid use. Given the limited evidence supporting opioid use for pain management in MS, the high prevalence of opioid use in persons with MS is concerning and indicates a pressing need for alternative pain management strategies.

### Contributors

Ruth Ann Marrie,\(^1,2\) John D Fisk\(^3\) Randy Waldl,\(^4\) James M Bolton,\(^5\) Jitender Sareen,\(^6\) Scott B Patten,\(^6\) Alexander Singer,\(^1\) Lisa M Lix,\(^7\) Carol A Hitchon,\(^7\) Renée El-Gabalawy,\(^8,9\) Alan Katz,\(^8,9\) James J Marriott,\(^7\) Charles N Bernstein\(^1\)

1Department of Internal Medicine, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
2Department of Community Health Sciences, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
3Psychiatry, Medicine, Psychology, and Neuroscience, Dalhousie University, Halifax, Nova Scotia, Canada
4Manitoba Centre for Health Policy, CAN, Winnipeg, Manitoba, Canada
5Department of Psychiatry, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
6Community Health Sciences, University of Calgary, Calgary, Alberta, Canada
7Department of Family Medicine, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
8Department of Clinical Health Psychology, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
9Department of Anesthesiology, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada

### Correspondence

To Ruth Ann Marrie, Internal Medicine, University of Manitoba College of Medicine, Winnipeg, MB R3A 1R9, Canada; marrie@hsc.mb.ca

### Acknowledgements

The use of Aggregated Diagnosis Groups codes for risk adjustment in regression models was created using The Johns Hopkins Adjusted Clinical Group Case-Mix System V3. The authors acknowledge the Manitoba Centre for Health Policy for provision of the Manitoba Population Health Research Data Repository under project #2014-030 (HIPC #2014-2015-19A). The results and conclusions presented are those of the authors and no official endorsement by the Manitoba Centre for Health Policy, Manitoba Health, or other data providers is intended or should be inferred.

### Funding

RAM: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of the data. JDF: drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of the data. LW: analysis or interpretation of data. MB: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. JL: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. SBP: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. CH: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. AK: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data; data analysis or interpretation of data: CB: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. AS: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data. JMB: drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data.

### Competing interests

RAM received research funding from Canadian Institutes of Health Research, the MS Society of Canada, Roche, Biogen and the Government of Alberta. AS received financial and in-kind support from an IBM/CIMVR Advanced Analytics Grant and Callian Inc. JL received research funds from Canadian Institutes of Health Research, NSERC and the Arthritis Society. CH had research funds for unrelated studies from Pfizer and consulted for Astra-Zeneca Canada. RE-G received research funds from Canadian Institutes of Health Research, University of Manitoba Start-Up Funds. AK received research funding from Idec and Roche. JMB received research funding from the Multiple Sclerosis Society of Canada, Crohn’s and Colitis Canada and Research Nova Scotia, and consultation and distribution royalties from Naapi Research Trust. JIM conducted clinical trials for Biogen Idec and Roche, and received research funding from the MS Society of Canada, the MS Scientific Foundation and Research Manitoba. CNB consulted with Abbvie Canada, Amgen Canada, BMS Canada, JAMP Canada, Janssen Canada, Pfizer Canada, Roche Canada, Sanofi Canada and Takeda Canada, and received unrestricted educational grants from Abbvie Canada, BMS Canada, Janssen Canada, Pfizer Canada and Takeda Canada. He has been on speaker’s bureaus of Abbvie Canada and Shire Canada. SBP holds the Cuthbertson & Fischer Chair in Pediatric Mental Health at the University of Calgary. The sponsors had no role in the design and conduct of the study; collection, management, analysis and interpretation of the data, and preparation, review or approval of the manuscript.

### Ethics approval

This study was funded by the Canadian Institutes of Health Research (THC-135234), Crohn’s and Colitis Canada. RAM is supported in part by the Waugh Family Chair in Multiple Sclerosis. CNB is supported in part by the Bingham Chair in Gastroenterology. AS is supported by CIHR #333252. LML is supported by a tier 1 Canada Research Chair. RE-G is supported by University of Manitoba Start-Up Funding.

### Open Access

This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

---

\(^1\)Department of Internal Medicine, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^2\)Department of Community Health Sciences, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^3\)Department of Psychiatry, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^4\)Community Health Sciences, University of Calgary, Calgary, Alberta, Canada
\(^5\)Department of Family Medicine, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^6\)Department of Clinical Health Psychology, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^7\)Department of Anesthesiology, University of Manitoba Max Rady College of Medicine, Winnipeg, Manitoba, Canada
\(^8\)Manitoba Centre for Health Policy, Canada
Accepted 17 August 2022
J Neurol Neurosurg Psychiatry 2022;0:1–3.
doi:10.1136/jnnp-2022-329508

ORCID iD
Ruth Ann Marrie http://orcid.org/0000-0002-1855-5595

REFERENCES
Supplemental Appendix

METHODS

This matched retrospective cohort study was conducted in Manitoba, a Canadian province with a population of ~1.4 million, and universal health care. Medically necessary services are publicly funded, and the provincial governmental captures health service use by nearly all residents.

Data Sources

We accessed administrative databases held by The Population Research Data Repository at the Manitoba Centre for Health Policy. The databases (and variables used) included the population registry (dates of birth, death and health care coverage; sex; and postal code which provided region of residence), medical services/physician claims (one physician-assigned diagnosis and date of service), the Discharge Abstract Database (DAD; hospitalizations, including admission and separation dates, and diagnoses), and Drug Program Information Network (DPIN; outpatient prescription dispensations, including the date, drug name, and Health Canada drug identification number [DIN]). Physician claims use the International Classification of Diseases (ICD), 9th revision, Clinical Modification (ICD-9-CM) to document diagnoses. Up to 2004, diagnosed in the DAD are also documented using (ICD)-9-CM, and ICD 10th revision, Canadian version (ICD-10-CA) codes are used thereafter. All databases were linked at the individual level using an encrypted unique identifier. We obtained approval to conduct this population-based cohort study from Manitoba’s Health Information Privacy Committee and the University of Manitoba Health Research Ethics Board.

Study populations

We identified all Manitobans with MS over the period 1984 to 2016 by applying a validated case definition that required ≥3 health care encounters for MS, as identified based on diagnostic codes for MS in hospitalizations or physician visits, or the use of MS-specific disease-modifying therapies in any combination. We assigned the index date for each person with MS based on the earliest demyelinating disease claim. Next, we chose a general population cohort matched 5:1 on sex, year of birth (± 5 years), and forward sortation area (first 3 digits of postal code) to the MS cohort. The matched (non-MS) cohort excluded anyone with any ICD-9-CM and ICD-10-CA diagnosis codes for demyelinating disease or use of any MS-specific disease-modifying therapies. The non-MS cohort also excluded individuals with codes
for inflammatory bowel disease and rheumatoid arthritis because we conducted parallel studies for these diseases. The index date for each control was the index date of their matched case. Collectively, these comprised the prevalent cohorts.

From these cohorts, we subsequently selected incident (newly diagnosed) MS cases and matched controls with an index date of 1997 or later. DPIN data began in the fiscal year 1995/96 so this index date coupled with identification of incident MS cases provided a one year run-in period to determine whether opioid use was truly new post-index. Opioids are indicated for the management of acute pain, and cancer pain. Therefore, we also excluded individuals in the MS and non-MS cohorts with cancer (based on ≥1 ICD-9 140-208 or ICD-10-CA C00-C97 code) or in palliative care (based on hospital ICD-9/ICD-10-CA V66.7/Z51.5 or DPIN claims indicating palliative care). To preserve the matching balance, the corresponding matched cases or controls were also excluded. Anyone who developed cancer or entered palliative care following the index date was censored when the relevant diagnostic code first appeared. We also censored individuals on death or leaving the province.

Psychiatric comorbidity

To identify persons with any diagnosed mood/anxiety disorder (including ≥1 of depression, anxiety, or bipolar disorders) we used validated case definitions. We assigned the date of the first claim for each condition as the diagnosis date. Mood/anxiety disorder status was updated annually to account for the relapsing and remitting nature of these disorders. The affected person was deemed to be an ‘active’ case if there were ≥2 physician claims or one hospital claim with a diagnosis code for the mood/anxiety disorder in that year; for hospital claims the mood/anxiety disorder was required to be the most responsible diagnosis. Prescription claims alone were not considered a marker of ‘active’ disease.

Outcomes

The DIN recorded in DPIN can be linked to the World Health Organization’s Anatomical Therapeutic Chemical (ATC) Classification System. Based on DINs and ATC codes we identified opioids (N02AA03, N02AA01, N02AA05, N02AB03, N02AB02) available in Canada. We defined new (incident) users of opioids as those with no dispensation for any opioid for ≥1 year before initial dispensation. Prevalent opioid users were individuals with ≥1 opioid dispensation in the year of interest.

We measured time from the first dispensation of an opioid to discontinuation of therapy (gap ≥ 90 days between dispensations) based on dispensation dates and number of days supplied at dispensation.
also described patterns based on the duration and frequency of use. To ensure similar follow-up, these analyses were restricted to cohort members who had \( \geq 5 \) years of follow-up post-index date. We aimed to describe short-term use (<3 months) and chronic use (\( \geq 3 \) months) within that five year period. A prior systematic review had identified 3 months’ use as the most common definition of long-term opioid use.\(^{10}\) We report the percentage (95% confidence interval [95%CI]) for (i) single dispensation; (ii) continuous use for \( \geq 3 \) months; (iii) cumulative use for \( \geq 3 \) months in any one year period; (iv) continuous use for \( \geq 6 \) months; (v) cumulative use of \( \geq 6 \) months in a one year period; and (vi) intermittent use, defined as prescriptions in two or more years, with a gap of \( \geq 1 \) year between dispensations. Because of the five-year period, discontinuation of opioids could be followed by re-initiation of therapy, and the total percentages could exceed 100%.

To provide additional context for our findings we also report the frequency of use of other classes of medications that may be used for chronic pain management, in the year before the first opioid dispensation. These included non-steroidal anti-inflammatory drugs (NSAIDs), cannabinoids (A04AD11, A04AD10, N02BG10), tricyclic antidepressants (N06AA), serotonin and norepinephrine reuptake inhibitors (SNRIs, N06AB), SSRIs (N06AB) and anticonvulsants (N03AX12, N03AX16, N03AF01, N03AF02, N03AB02), identified based on at least one dispensation.

**Covariates**

Covariates in the analyses included demographic, health service use and clinical characteristics. Sociodemographic covariates included sex (male as reference group), current age (18-44 [reference group], 45-64, \( \geq 65 \)), region of residence (urban, rural [reference]), and socioeconomic status (SES, continuous). We measured SES in the index year by linking postal code to dissemination-area level census data, then calculating the Socioeconomic Factor Index version 2 (SEFI-2) which integrates average household income, high school education rates, unemployment rates and percent of single parent households into a single score.\(^{10}\) Score <0 indicate higher SES. Health service use covariates, to account for general differences in health care use between cohorts, included annual numbers of physician visits, annual number of classes (types) of prescription medications dispensed, at the 4\(^{th}\) level of the ATC system (e.g. by chemical subgroup) after excluding opioids (0-1, 2-3, \( \geq 4 \)). Clinical characteristics included index year (continuous), disease duration from the index date (continuous), and number of physical comorbidities (0 [reference group], 1, \( \geq 2 \)). The number of comorbidities were obtained using the John Hopkins Adjusted Clinical Group System Aggregated Diagnosis Groups (ADGs™), a case-mix system known to predict health care use in Canadian populations.\(^{11,12}\) We used chronic (not...
time-limited) major physical ADGs, for consistency with our prior work. For analyses of incident opioid use we assessed physical comorbidity, number of physician visits, and number of medication classes used in the year before the first dispensation, but we updated these variables annually for the prevalent use analyses.

Analysis
We used descriptive statistics to characterize the MS and non-MS cohorts including frequency (percent), mean (standard deviation [SD]), and median (interquartile range [IQR]). For each year in the study period, we estimated the crude incidence rate (new users) and prevalence of any opioid use, overall as well as stratified by sex, and age (18-44, 45-64, ≥65 years). We also report incidence rates and prevalence estimates age- and sex-standardized to the 2010 Canadian population (from the Statistics Canada census) and 95%CI based on a negative binomial distribution. We report rate ratios and 95%CI comparing incidence rates and prevalence between the MS and non-MS cohorts.

To further assess the association between cohort (MS vs. non-MS), mood/anxiety disorders (active vs. inactive/absent) and use of opioids we employed multivariable generalized linear models. These models used a binomial distribution and the log of person-time as the model offset. We used generalized estimating equations with an exchangeable correlation structure to account for repeated observations in individuals in the prevalence analyses. We also tested for the presence of a two-way interaction between cohort and MAD status for each outcome. Covariates in these models included demographic, health service use and clinical characteristics as delineated above.

Statistical analyses were conducted using SAS V9.4 (SAS Institute Inc., Cary, NC).
RESULTS

Table e1. Characteristics of incident disease cohorts at the time of diagnosis, and matched cohorts at the matched index date.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Matches (n = 14539)</th>
<th>MS (n = 2918)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, n (%)</td>
<td>10232 (70.4)</td>
<td>2051 (70.3)</td>
</tr>
<tr>
<td>Age at diagnosis, mean (SD)</td>
<td>40.30 (12.34)</td>
<td>40.36 (12.38)</td>
</tr>
<tr>
<td>Duration of follow-up from the index date (years), median (IQR)</td>
<td>9.78 (6.09)</td>
<td>9.12 (5.93)</td>
</tr>
<tr>
<td>Urban region of residence, n (%)</td>
<td>9542 (65.6)</td>
<td>1917 (65.7)</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>-0.16 (0.83)</td>
<td>-0.20 (0.84)</td>
</tr>
<tr>
<td>No. physician visits in year pre-index, mean (SD)</td>
<td>4.18 (4.99)</td>
<td>6.54 (6.83)</td>
</tr>
</tbody>
</table>

Cohort sample sizes (%) for ranges of study index years

<table>
<thead>
<tr>
<th>Year Interval</th>
<th>Matches (%)</th>
<th>MS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-2001</td>
<td>4101 (28.2)</td>
<td>823 (28.2)</td>
</tr>
<tr>
<td>2002-2006</td>
<td>3632 (25.0)</td>
<td>729 (25.0)</td>
</tr>
<tr>
<td>2007-2011</td>
<td>3262 (22.4)</td>
<td>655 (22.4)</td>
</tr>
<tr>
<td>2012-2017</td>
<td>3544 (24.4)</td>
<td>711 (24.4)</td>
</tr>
</tbody>
</table>

MS = multiple sclerosis; Socioeconomic status = Socioeconomic Factor Index scores; values less than zero indicate higher socioeconomic status; a- earliest index year was 1997 to allow one year lookback period as of first availability of prescription claims data

Other medications used prior to opioids

In the year before the initial opioid dispensation, of 719 people with MS, 201 (28.1%) had ≥1 prescription dispensation for ≥1 of the following categories of medication: NSAIDS, tricyclic antidepressants, SNRIs, SSRIs, anticonvulsants or cannabinoids; 106 (14.7%) had a dispensation from at least two of those categories. In contrast, among the 3255 people in the non-MS cohort, 669 (20.6%) had received ≥1 prescription dispensation from any of those categories and only 127 (3.9%) had received prescriptions for ≥2 of those categories. Among the MS cohort, NSAIDs were the most commonly used of these medications (20.9%) followed by SSRIs (14.5%) and anticonvulsants (11.5%).
NSAIDs were also the most commonly dispensed medication in the year prior to first opioid use among the non-MS cohort (16.1%), followed by SSRIs (6.7%).

**Figure e1.** Age and sex-standardized annual incidence of opioid use in multiple sclerosis (MS) and non-MS cohorts. After age-standardization, the incidence rate of opioid use declined faster in the MS cohort ($\beta = -4.69$/year) than in the non-MS cohort ($\beta = -2.89$/year) over the study period.

Patterns of opioid use

Time to discontinuation of opioids by 25% of those initiating treatment was 22 days (95%CI: 15-30) in the MS cohort, and 10 days (95%CI: 10-10) in the non-MS cohort. Among incident opioid users with ≥5 years of follow-up who had MS but no mood/anxiety disorder, 30.0% (95%CI: 25.6-35.0%) obtained only one opioid dispensation, 8.4% (95%CI: 6.0-11.8%) used opioids continuously ≥3 months, and 34.9% used them intermittently (95%CI: 30.3-40.1%). Among individuals with MS and a mood/anxiety disorder, a lower proportion obtained only one dispensation (11.4%; 6.2-21.1%), and a higher proportion used opioids continuously ≥3 months (11.4%; 6.2-21.1%). We observed a similar pattern of differences between those with, versus without, mood/anxiety disorders among individuals without MS, although the proportions with single opioid dispensation was higher, and the proportions with continuous use ≥3 months was lower (Figure e2).
**Figure e2.** Patterns of opioid use in multiple sclerosis (MS) and non-MS cohorts stratified by mood/anxiety disorder (MAD) status*

*Error bars indicate 95% confidence intervals.

**Table e2.** Rate Ratios (95% confidence interval) for the association of multiple sclerosis (MS), active mood/anxiety disorder (MAD) and incidence and prevalence of opioid use.

<table>
<thead>
<tr>
<th></th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusted*</td>
</tr>
<tr>
<td>MS vs. not</td>
<td>1.40</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td>(1.29, 1.52)</td>
<td>(1.08, 1.29)</td>
</tr>
<tr>
<td>Active MAD vs. not</td>
<td>1.31</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>(1.19, 1.45)</td>
<td>(1.01, 1.25)</td>
</tr>
</tbody>
</table>

*Adjusted for age (18-44, 45-64, 65+), sex, region, ADG (0, 1, 2+), number of prescription drug classes (0-1, 2-3, 4+), disease duration, index year

**Adjusted for age (18-44, 45-64, 65+), sex, region, ADG (0, 1, 2+), number of prescription drug classes (0-1, 2-3, 4+), number of physician visits (0-3, 4-7, 7+), disease duration, index year
REFERENCES


