Rheumatol Int (2016) 36:1275–1279
DOI 10.1007/s00296-016-3540-1

Rheumatology INTERNATIONAL

PUBLIC HEALTH

Health-selective migration among patients with rheumatoid arthritis in Québec: a cohort study using administrative data

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Received: 14 March 2016 / Accepted: 21 July 2016 / Published online: 26 July 2016
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Abstract Little is known about how rheumatoid arthritis (RA) affects an individual's ability to relocate. The current literature suggests the relationship between health and migration is often disease-specific. We sought to estimate the impact of RA diagnosis on migration within a Canadian province, comparing migration rates in residents before and after RA diagnosis. We identified a cohort of 81,181 individuals diagnosed with RA between 1998 and 2009 using Québec administrative databases. A migration was defined as a change in the first three characters of the postal code. We categorized migrations as urban or rural depending upon an individual's origin and destination. We estimated the association between RA diagnosis and migration by fitting marginal models using a generalized estimating equations approach, adjusting for age, sex, and population level socioeconomic status indicators. The vast majority of moves after RA diagnosis were within urban areas. RA diagnosis was associated with increased migration except for people around age 50 moving within urban areas. Although RA was associated with increased inter-urban migration in many demographic groups, the net result did not translate to higher rates of rural-to-urban migration after RA diagnosis. Our results suggest fairly complex associations between RA diagnosis and migration. Both age and location (urban or rural) modify this effect. Overall, we did not see a greater movement from rural-to-urban areas after RA diagnosis. This is of interest for studies of regional environmental effects on chronic disease patterns.

Keywords Rheumatoid arthritis · Migration · Administrative data · Longitudinal studies

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Introduction

People living with chronic illnesses, such as rheumatoid arthritis (RA), might move away from their initial residence, for several health-related reasons: to live closer to supportive family members, to obtain specialized care, or if the current residence poses difficulties, such as a two-floor home for someone with difficulty climbing stairs. Alternately, severe illnesses may restrict an individual's ability to relocate. Several authors term this differential propensity for migration either as health-related mobility or health-selective migration [1, 2]. Studies of health-selective migration have used different measures of health ranging from general concepts such as self-rated health [3], to more specific measures including personal disabilities [4] and chronic illnesses [5]. A greater knowledge of the migration behaviors of patients may illuminate the factors driving regional differences in disease prevalence [6]. For example, health-selective migration may explain the higher prevalence of RA in urban areas in Québec for some age groups [7]. Although several studies suggest that healthier individuals are more likely to migrate, there is also evidence to the contrary. This may be due to variations in health-related mobility according to age, urban versus rural residence, and type of illness. It is clear that further examination of health-selective migration across a range of settings is required.

Rheumatoid arthritis is a chronic autoimmune disorder causing inflammation of the joints [8] that affects almost

1 % of adults in the developed world. To date, we are aware of only one study that has examined health-selective migration among those with rheumatic diseases. Moorin et al. [9] suggested that individuals with connective tissue diseases and rheumatoid disorders migrated from urban areas less frequently than the general population. However, potentially important analytic considerations, such as age and urban versus rural residence, were not fully explored.

The objective of this cohort study was to estimate within-province health-selective migration in RA patients identified in Québec administrative databases by comparing migration rates before and after RA diagnosis in urban and rural areas. Understanding migratory patterns in RA patients is important for two reasons. The first is to determine whether migration patterns in RA patients may explain all or part of the associations previous studies have identified between air pollution sources and RA incidence or prevalence [7, 10, 11]. Understanding migration rates in RA patients is also important because it could indicate the presence of unmet needs. For example, increased migration may indicate a need to be closer to care or the necessity to move to a residence that better accommodates the limited mobility of RA patients. Decreased migration may indicate that RA may be limiting patients' physical ability to change residences.

Materials and methods

We identified study subjects using provincial medical billing and hospitalization databases managed by the Régie de l'Assurance Maladie du Québec (RAMQ). In the province of Québec, all provincially reimbursed medical services are recorded in a single physician billing database. The RAMQ administrative database provides physician billing code information for all patients who had visited a physician, while the MED-ÉCHO hospital database (Maintenance et exploitation des données pour l'étude de la clientèle hospitalière) provides records for inpatient physician services and up to 15 discharge diagnoses per patient.

Only Québec residents diagnosed with RA between 1999 and 2009 were included in the analysis. The definition of RA consisted of two or more RA diagnoses (ICD-9 code 714.X) by any physician occurring at least 8 weeks apart but within a 2 year period; at least one RA diagnosis-related billing by a rheumatologist; or at least one hospital discharge diagnosis of RA. For patients with multiple RA-related records, calculation of the diagnosis date was based on the first related ICD code.

Each subject's forward sortation area (FSA; first three letters of the postal code) was available as of July 1 of each year they had a medical encounter. Due to confidentiality restrictions, we did not have access to a more precise residential address. If the FSA changed from 1 year to the next, a migration event was said to have occurred in the second year. Using these data, we constructed a dataset where, for each year between 1998 and 2009, we recorded each person's RA status, whether or not they migrated in the previous year as well as a number of covariates. In accordance with the current Canada Post classification scheme, all FSAs where the second digit was zero were considered as rural areas [12]. This dataset allowed us to compare the annual migration rate before and after RA diagnosis. Although the date of first recorded RA diagnosis was known precisely, only the year in which a migration took place was available, making it difficult, in some cases, to identify the timing of a migration event relative to RA diagnosis. We assumed that a migration occurring in the same year as an RA diagnosis happened after the diagnosis. Individuals who relocated outside of Québec no longer appeared in the RAMQ databases making it impossible to track their migration. This analysis is therefore limited to within-province migration.

FSA-level variables measuring socioeconomic status were obtained from the 2001 Census of Canada, as a limited number of subject-level socioeconomic status (SES) measures were available for inclusion as covariates. These variables included average family income, prevalence of renting, employment rate, and a composite education variable calculated as the proportion of people without a high school degree subtracted from the proportion of people with any post-secondary education. We used physician practice data collected in 2010 to generate a binary indicator of rheumatologist availability in a subject's FSA [13]. All these variables were considered as potential confounders or effect modifiers.

Log-binomial regression was used to model the annual risk of migration. Four different types of migration events were modeled: migration from a rural FSA to an urban FSA, migration from an urban FSA to a rural FSA, migration from an urban FSA to another urban FSA, and migration from a rural FSA to another rural FSA. We included a product term between age and RA status to estimate effect measure modification by age of the association between RA and migration. We fit marginal models to our longitudinal data using generalized estimating equations (GEE) [14] clustering at the level of the individual. Stata was used for all analyses [15], except for GEE diagnostics, which we performed in SAS 9.2 (SAS Institute, Cary, NC, USA). We used empirical standard errors for statistical inferences from marginal models, and evaluated working correlation structures by comparing empirical and model-based standard errors while also examining quasi-likelihood information criterion and correlation information criterion values [16, 17].

We controlled for a number of potential confounders. Given that children and adolescents are generally unable

Table 1 Number of moves and rate (moves per person-year) by type of move and RA status

Type of move	Pre-RA diagnosis		Post-RA diagnosis	
	Number	Rate	Number	Rate
Total	16,386	0.058	28,694	0.056
Rural to urban	1749	0.017	2693	0.015
Urban to rural	1732	0.010	2874	0.008
Rural to rural	2681	0.027	4447	0.025
Urban to urban	10,224	0.057	18,680	0.056

to move independently of their parents, and as those of university age move frequently for reasons unrelated to their health, we excluded those younger than 25 years of age. As the prevalence of RA is higher in women than men, and also increases with age [18], we adjusted for both sex and age, since these factors may also affect migration. Age was included as a continuous variable, mean-centered at 50 years, with a quadratic age term to accommodate the nonlinear relationship between age and migration [19]. Age was centered to reduce collinearity between main effects, interaction terms and quadratic terms in the model [20]. We also included FSA-level SES covariates. If removing a covariate resulted in at least a 10 % change in the estimates of interest, we retained it in the model [21].

Results

After merging RAMQ and MED-ÉCHO data sources, the initial dataset included 895,405 person-years collected from 82,562 subjects with a diagnosis of RA between 1998 and 2008. Due to missing data on FSA or other covariates, we omitted 96,597 person-years. An extensive examination of the distribution of covariates within the set of excluded observations suggested no obvious similarities between these records that might reveal a pattern to the missingness. Our analysis is based upon 798,808 observations collected from a final study population of 81,181 subjects.

Sixty-nine percent of study subjects were female. The mean age at first observation within our data was 57.0 years [standard deviation (SD) = 15.5], and the mean age at RA diagnosis was 60.7 years (SD = 15.0). Between 1998 and 2008, 14,183 deaths were recorded. The mean number of observations per subject was 9.8 (SD = 2.4). A total of 1077 subjects had only 1 year of observation, and 58,037 subjects had complete data for the entire eleven-year period of observation.

We identified 45,080 migrations among 396 Québec FSAs over the course of the study. Table 1 shows the number of migration rate by type of move and RA status. The annual migration rates by age were roughly equivalent to provincial statistics [19]. The crude risk ratio between RA and migration was 0.96 (95 % confidence interval: 0.94, 0.98). One or more migrations were observed for 34.3 % of subjects between 1998 and 2008. Only 20.1 % of the observed migrations occurred among subjects moving from rural-to-urban FSAs or from urban-to-rural FSAs; that is, most moves by rural residents were to rural areas and most moves by urban residents were to urban areas. Rural-to-urban moves were slightly more frequent than urban-to-rural moves.

As the effect of RA on migration changed qualitatively with age, we retained an interaction term between RA and age in all subsequent models. Removal of the FSA-level SES variables changed the estimate by, at most, 1 % and were therefore not used in the final models. A review of diagnostic plots did not suggest any outliers that were likely to substantially influence fit of the marginal models [22]. The first-order autoregressive correlation structure provided the smallest QIC and CIC values and was also supported by review of a logit plot and lorelogram [23]. As a result, it was our chosen working correlation structure for all marginal models.

As can be seen in Table 2, the effect of RA on migration varied qualitatively with age and migration type. At age 30, RA was associated with increased migration regardless of the type of migration. In this age group, the association was largest among those moving from an urban-to-rural FSA and smallest among those moving within an urban area. At age 50, the association differed by migration type. RA was associated with increased urban-to-rural or rural-to-urban migration but with decreased urban-to-urban or rural-to-rural migrations. At age 70, RA was once again associated with increased migration among all types of migration. The models also suggested that in regions with greater

Table 2 Risk ratios (95 % confidence interval) for probability of migration between Forward Sortation Areas by Québec residents before and after RA diagnosis

Predictor	Urban to rural	Rural to urban	Urban to urban	Rural to rural
Female	0.89 (0.82, 0.96)	1.03 (0.96, 1.12)	0.99 (0.96, 1.02)	1.00 (0.94, 1.07)
RA × age				
30 years	2.18 (1.84, 2.75)	1.08 (0.89, 1.32)	1.05 (0.99, 1.10)	1.12 (0.98, 1.28)
50 years	1.18 (1.07, 1.30)	1.12 (1.01, 1.24)	0.94 (0.90, 0.98)	0.93 (0.86, 1.01)
70 years	1.38 (1.21, 1.56)	1.14 (1.02, 1.26)	1.17 (1.12, 1.21)	1.08 (1.00, 1.17)

proportions of renters, or where there was greater employment, there was greater migration.

Discussion

The results of these analyses suggest that the association between RA and migration varies according to age and migration origin and destination. In most demographic groups, people with RA were more likely to migrate (including changes in urban/rural status) following their RA diagnosis. RA was associated with increased migration within urban or rural areas, although people with RA around age 50 had decreased migration within urban or rural areas.

Our study was intended, in part, to explore the theory that people are more likely to move from a rural-to-urban area once they are diagnosed with RA. This theory has been offered as one potential explanation as to why prevalence estimates for RA and similar rheumatic diseases are higher in urban versus rural areas [7]. It is important to note that we did not see a greater movement from rural-to-urban areas after RA diagnosis. The vast majority of moves after an RA diagnosis were within urban areas. This is of interest for studies of regional effects (including environmental exposures such as pollution) on chronic disease patterns using administrative data, particularly because it is generally difficult to separate incident from prevalent patients. Thus, it may be that very strong regional risk factors for a given disease are apparent even if the population studied is not comprised solely of recently diagnosed cases. Our results do not permit strong conclusions in this regard.

In prior studies involving the general population, several analyses have reported heterogeneity in health-selective migration by age. Halliday and Kimmitt [3] determined that patient self-reports of poor health in the USA were associated with reduced migration among men younger than 60, with an inverse relationship among men over age 60. Other research also suggests heterogeneity in migratory behaviors by age and limiting long-term illness, a different pattern from the relationship we identified among subjects in Québec [24, 25]. It is plausible that the relationship is country dependent. A previous Australian study found a relationship between poor health and increased migration from rural-to-urban areas [26]. A subsequent study of Australians with rheumatic disorders determined that individuals were less likely to move from an urban area to a rural area [9].

We restricted our analyses to individuals eventually diagnosed with RA, which allowed us to compare migration before and after RA diagnosis. However, individuals who develop RA are possibly less healthy than the general population even before diagnosis. Therefore, the association between RA and migration would likely have been larger had we used the general population as the control group. It is also possible that RA symptoms manifest themselves prior to RA diagnosis, which would mean that RA influences migration patterns before diagnosis as well. This would also cause our estimates to be conservative.

To our knowledge, this is the first published assessment of health-selective migration among patients with RA. Our study's longitudinal design and the study population of over 80,000 RA patients are strengths of this analysis. However, the use of administrative databases poses challenges. Medical claims data are intended for billing and hospital administrative purposes. We attempted to address this limitation by using previously validated criteria for identifying cases of rheumatoid arthritis [7], and also similar to definitions used by the Public Health Agency of Canada. However, there is no perfect definition for any chronic disease using administrative data [27, 28]. Any misclassification of RA in our analysis would lead to an underestimate of the association between migration and RA. Therefore, the estimates presented are likely conservative estimates. Our analysis was also limited by confidentiality restrictions; we specified FSA-level rather than individual-level predictors for educational level, income, and employment status.

In summary, although we found an important association between RA and migration, we did not see a greater movement from rural-to-urban areas after RA diagnosis. The vast majority of moves after an RA diagnosis were within urban areas. This is of interest for studies of regional effects, such as pollution, on chronic disease patterns using administrative data, particularly because it is generally not trivial to separate incident from prevalent patients. Differences in migration rates before and after RA diagnosis may reflect many possible consequences of RA. On one hand reduced physical mobility or the desire to be close to a specialist may favor migration; conversely other reasons (need to stay close to existing networks, restricted income) may lessen the tendency to migrate. Further work is necessary to identify factors contributing to increased migration among those with RA.

Acknowledgments We would like to thank Dr. Charles Heilig and Dr. Jason Thomas for helpful comments on an earlier version of our manuscript, and Dr. Jay Kaufman and Dr. Sam Harper for feedback on our analysis design.

Funding This study was funded by a Graduate Student Training Award by The Arthritis Society.

Compliance with ethical standards

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest The authors declares that they have no conflict of interest.

References

1. Fox A, Goldblatt P, Adelstein A (1982) Selection and mortality differentials. J Epidemiol Community Health 36:69–79. doi:10.1136/jech.36.2.69
2. Cox M, Boyle PJ, Davey P, Morris A (2007) Does health-selective migration following diagnosis strengthen the relationship between Type 2 diabetes and deprivation? Soc Sci Med 65(1):32–42. doi:10.1016/j.socscimed.2007.02.045
3. Halliday TJ, Kimmitt MC (2008) Selective migration and health in the USA, 1984–1993. Popul Stud 62(3):321–334. doi:10.1080/00324720802339806
4. Speare A, Avery R, Lawton L (1991) Disability, residential-mobility, and changes in living arrangements. J Gerontol 46(3):S133–S142. doi:10.1093/geronj/46.3.S133
5. Yiannakoulias N, Schopflocher DR, Warren SA, Svenson LW (2007) Parkinson's disease, multiple sclerosis and changes of residence in Alberta. Can J Neurol Sci 34(3):343–348. doi:10.1017/S0317167100006806
6. Polissar L (1980) The effect of migration on comparison of disease rates in geographic studies in the United States. Am J Epidemiol 111(2):175–182
7. Bernatsky S, Dekis A, Hudson M, Pineau CA, Boire G, Fortin PR et al (2014) Rheumatoid arthritis prevalence in Quebec. BMC Res Notes 7:937. doi:10.1186/1756-0500-7-937
8. Silman AJ, Hochberg MC (2001) Epidemiology of rheumatic diseases, 2nd edn. Oxford University Press, New York
9. Moorin RE, Holman CDJ, Garfield C, Brameld KJ (2006) Health related migration: evidence of reduced "urban-drift". Health Place 12(2):131–140. doi:10.1016/j.healthplace.2004.10.013
10. De Roos AJ, Koehoor M, Tamburic L, Davis HW, Brauer M (2014) Proximity to traffic, ambient air pollution, and community noise in relation to incident rheumatoid arthritis. Environ Health Perspect 122(10):1075–1080. doi:10.1289/ehp.1307413
11. Hart JE, Laden F, Puett RC, Costenbader KH, Karlson EW (2009) Exposure to traffic pollution and increased risk of rheumatoid arthritis. Environ Health Perspect 117(7):1065–1069. doi:10.1289/ehp.0800503
12. Canada Post (2016) Addressing guidelines. https://www.canadapost.ca/tools/pg/manual/PGaddress-e.asp?ecid=murl10006450. Accessed 27 June 2016
13. Association des médecins rhumatologues du Québec (2011) Trouver un rhumatologue. http://www.rhumatologie.org. Accessed 19 May 2011
14. Zeger SL, Liang K-Y (1986) Longitudinal data analysis for discrete and continuous outcomes. Biometrics 42(1):121–130. doi:10.2307/2531248
15. StataCorp (2013) Stata Statistical Software: Release 13. StataCorp LP, College Station
16. Pan W (2001) Akaike's information criterion in generalized estimating equations. Biometrics 57(1):120–125. doi:10.1111/j.0006-341X.2001.00120.x
17. Hin LY, Wang YG (2008) Working correlation structure identification in generalized estimating equations. Stat Med 28:642–658. doi:10.1002/sim.3489
18. Helmick CG, Felson DT, Lawrence RC, Gabriel S, Hirsch R, Kwoh CK et al (2008) Estimates of the prevalence of arthritis and other rheumatic conditions in the United States Part I. Arthritis Rheum 58(1):15–25. doi:10.1002/art.23177
19. Institut de la statistique Quebec (2012) Migrations et population immigrante. http://www.stat.gouv.qc.ca/statistiques/population-demographie/migration/internes/migir_nombre_et_taux_age.htm. Accessed 15 June 2011
20. Gelman A, Hill J (2007) Data analysis using regression and multilevel/hierarchical models. Cambridge University Press, New York
21. Mickey RM, Greenland S (1989) The impact of confounder selection criteria on effect estimation. Am J Epidemiol 129(1):125–137
22. Preisser JS, Qaqish BF (1996) Deletion diagnostics for generalised estimating equations. Biometrika 83(3):551–562. doi:10.1093/biomet/83.3.551
23. Heagerty PJ, Zeger SL (1998) Lorelogram: a regression approach to exploring dependence in longitudinal categorical responses. JASA 93(441):150–162. doi:10.1080/01621459.1998.10474097
24. Bentham G (1988) Migration and morbidity: implications for geographical studies of disease. Soc Sci Med 26(1):49–54. doi:10.1016/0277-9536(88)90044-5
25. Boyle PL, Norman P, Rees P (2002) Does migration exaggerate the relationship between deprivation and limiting long-term illness? A Scottish analysis. Soc Sci Med 55(1):21–31. doi:10.1016/S0277-9536(01)00217-9
26. Larson A, Bell M, Young AF (2004) Clarifying the relationships between health and residential mobility. Soc Sci Med 59(10):2149–2160. doi:10.1016/j.socscimed.2004.03.015
27. Bernatsky S, Lix L, O'Donnell S, Lacaille D, the CANRAD Network (2013) Consensus statements for the use of administrative health data in rheumatic disease research and surveillance. J Rheumatol 40(1):66–73. doi:10.3899/jrheum.120835
28. Widdifield J, Labrecque J, Lix L, Paterson JM, Bernatsky S, Tu K et al (2013) Systematic review and critical appraisal of validation studies to identify rheumatic diseases in health administrative databases. Arthritis Care Res 65(9):1490–1503. doi:10.1002/acr.21993