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Major Depression Prevalence Increases with Latitude in Canada

La prévalence de la dépression majeure augmente avec la latitude au Canada

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Abstract

Objective: To determine whether there is an association between latitude and annual major depressive episode (MDE) prevalence in Canada.

Methods: Data from 2 national survey programs (the National Population Health Survey and the Canadian Community Health Survey) were used, providing 10 data sets collected between 1996 and 2013, together including 922,260 respondents, of whom 495,739 were assessed for MDE using 1 of 2 versions of the Composite International Diagnostic Interview, a short-form version (8 studies), and a Canadian adaptation of the World Mental Health version (2 studies). Approximate latitude was determined by linkage to postal code data. Data were analyzed using logistic regression and pooled across surveys using individual-level meta-analytic methods.

Results: In models including latitude as a continuous variable, a statistically significant association was observed, with prevalence increasing with increasing latitude. This association persisted after adjustment for a set of known risk factors. The latitude gradient was modest in magnitude, a 1% to 2% increase in the prevalence odds of MDE per degree of latitude was observed. Due to sparse data, this gradient cannot be confidently generalized beyond major population centres, which tend to occur at less than 55° latitude in Canada.

Conclusion: A latitude gradient has not previously been reported. If replicated, the gradient may have implications for the planning of services and generation of aetiological hypotheses. However, this cross-sectional analysis cannot confirm aetiology and could not evaluate the potential contributions of variables such as light exposure, weather patterns, or social determinants.

Abrégé

Objectif : Déterminer s'il y a une association entre la latitude et la prévalence des épisodes de dépression majeure (EDM) au Canada.

Méthodes : Les données de deux programmes d'enquêtes nationales (l'Enquête nationale sur la santé de la population et l'Enquête sur la santé dans les collectivités canadiennes) ont été utilisées, ce qui a procuré 10 ensembles de données recueillies entre 1996 et 2013, comportant ensemble 922 260 répondants dont 495 739 ont été évalués pour l'EDM à l'aide d'une des deux versions de l'Entrevue composite diagnostique internationale, une version abrégée (8 études) et une adaptation canadienne de la version (2 études) de l'Organisation mondiale de la santé. La latitude approximative a été déterminée par un

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couplage à des données de code postal. Les données ont été analysées par régression logistique et totalisées pour les deux enquêtes au moyen de méthodes méta-analytiques au niveau individuel.

Résultats : Dans les modèles incluant la latitude comme variable continue, une association statistiquement significative a été observée, la prévalence augmentant avec la latitude croissante. Cette association persistait après correction pour un ensemble de facteurs de risque connus. Le gradient de latitude avait une magnitude modeste, une augmentation de 1-2 % des probabilités de prévalence de l'EDM par degré de latitude a été observée. En raison de l'insuffisance des données, ce gradient ne peut pas être assurément généralisé au-delà des centres de population majeurs, qui ont tendance à se situer à moins de 55° de latitude au Canada.

Conclusion : Un gradient de latitude n'a pas été étudié précédemment. S'il est répliqué, le gradient peut avoir des implications pour la planification des services et l'émission d'hypothèses étiologiques. Cependant, cette analyse transversale ne peut pas confirmer l'étiologie et n'a pas pu évaluer les contributions potentielles des variables comme l'exposition à la lumière, les modèles météorologiques ou les déterminants sociaux.

Keywords
major depression, major depressive episodes, epidemiology, meta-analysis, cross-sectional studies

Many studies have examined mood seasonality at differing latitudes, usually with negative results,[1,2] but only a few studies have assessed latitude gradients in depression prevalence. An Ontario telephone survey assessed major depressive episodes (MDEs) across 8 degrees of latitude (41.5° to 49.5°) using an ad hoc instrument, finding no significant differences.[3] This investigation had a relatively small sample size ($n = 1605$) and may have lacked power to detect a latitude effect. Two Finnish surveys using modified versions of the Hamilton Depression Rating Scale[4] ($n = 1000$) and Beck Depression Inventory[5] ($n = 8028$) across 10 degrees at Finland's high latitude (60° to 70°) also failed to identify an association. Again, the range of latitudes assessed, the reliance on symptom scales, or a lack of power may have obscured an association.

Nevertheless, there is a suspicion that MDE is more common at more northerly latitudes. If true, explanations may include factors such as light exposure, climate, or social determinants. The goal of the current study was to assess the possible association between latitude and MDE prevalence using data sources providing a larger number of observations.

Methods

This study used data from national surveys conducted by Statistics Canada, including the 1996 National Population Health Survey (NPHS)[6] and 9 iterations of the Canadian Community Health Survey (CCHS). The NPHS was a longitudinal study, so only a single cycle of data collection was included (the largest one from 1996), and respondents would likely not be included more than once. The NPHS included the Composite International Diagnostic Interview–Short Form for Major Depression (CIDI-SFMD),[7] as did 7 of the 9 CCHS surveys. Two mental health–focused surveys (the 2002 CCHS 1.2 Mental Health and Wellbeing and the 2012 CCHS–Mental Health) used a Canadian adaptation of the World Mental Health CIDI.[8] In 2 of the general health surveys and both of the mental health surveys, MDE was assessed in the entire sample. However, MDE was optional content in the remaining surveys such that it was included in the data collection in some, but not all, provinces in each survey.

Analysis was restricted to respondents aged 15+ years for reasons of consistency. Due to very limited coverage and small sample sizes, observations from the northern territories were excluded. Since latitude was modelled as a continuous variable, inclusion of the territories might have produced a misleading extrapolation in the modelling, driven by data from more southerly areas. With the exception of the 2 mental health surveys (which used face-to-face interviews), most of the data were collected by telephone. The samples derived predominantly from an area-based sampling frame, supplemented by a telephone frame and by random-digit dialing in some of the surveys.

Additional details about the data sources are contained in an earlier report [9] and at the Statistics Canada web page.[10] Postal code conversion files (also produced by Statistics Canada)[11] were used to assess latitude.

Adjustments were made for a set of variables that are well-known risk factors for depression and that were measured consistently in the surveys. These variables included age, sex, marital status, employment status, urban residence,[12] being born in Canada (this is associated with an elevated prevalence[12]), and low household income. These variables were assessed using standard field-tested items. Income quartiles adjusted for household size from 1996 were included in the analysis with adjustment for the consumer price index[13] to maintain comparability of the categories in later years.

The analysis employed individual-level meta-analysis, primarily (but not exclusively) using a 1-step approach. In other words, rather than making estimates from each survey (step 1) and then pooling them (step 2), a pooled data set was created and estimates were made directly from it.[14] The 1-step approach was preferable due to variability in the geographical coverage of MDE content in the various surveys, which could affect study-specific estimates. In addition to creating a pooled data set, replicate bootstrap weights provided by Statistics Canada were rescaled for use in the analysis.[15] The combined sample size of the surveys was 922,260, of whom 495,739 could be included because they provided the necessary data (the dominant reason for noninclusion being the noninclusion of MDE as optional content). The number of participants in each survey was divided

by the total sample size, and the replicate bootstrap weights were multiplied by this proportion to produce rescaled values. A conventional weighted logistic regression analysis with bootstrap-derived variance estimation was then performed. A 2-step approach was used to assess robustness of the results in an analysis with restriction to 4 of the 10 surveys that included the MDE as core content. Here, β coefficients for latitude in logistic regression models were estimated from each survey (step 1) and subsequently pooled (step 2) using random-effects meta-analysis. This pooling used the "metan" command in Stata 14.[16]

All analyses were conducted in the Prairie Regional Data Centre in Calgary. Under Canadian ethical guidelines, ethical approval is not required for analyses of this type.[17]

Results

Supplemental Table S1 summarizes sample sizes available for the analyses reported and provincial breakdowns (Suppl. Table S2). In preliminary analyses, no effects of survey year or of survey instrument were identified (data not shown).

In the 1-step pooling, there was a significant slope term for latitude (β coefficient, 0.015; 95% confidence interval [CI], 0.009 to 0.021; $z = 5.11$, $P < 0.001$), corresponding to an odds ratio (OR) of 1.02 and implying a 2% increase in the prevalence odds with each degree of latitude. A model including adjustment for a set of covariates is presented in Table 1. The model shows a slight weakening of the association, but there is continued statistical significance of the latitude term following these adjustments. As expected, MDE prevalence was higher in younger respondents, women, the unmarried, those who were not working, urban dwellers, those born in Canada, and those reporting low household income.

As ORs for continuous variables can be difficult to interpret, the population was divided into 3 latitude strata, each containing a sufficient sample size to support estimation of MDE prevalence. These estimates are reported in Table 2, which also shows results from a 2-step analysis. The 2-step estimates are less precise as only 4 surveys had MDE as core content, but they are consistent with the 1-step results. Notably, heterogeneity as assessed by the I^2 statistic was very high in these analyses, probably due to the very large sample sizes.[18] Consistent with this idea, the τ^2 values reported below (see footnote to Table 2) do not suggest a large degree of between-study variability.

Table 1. Association of Latitude with Major Depressive Episode, with Covariate Adjustments Using Logistic Regression.

Characteristic	Odds Ratio	95% Confidence Interval	*P* Value
Latitude (continuous)	1.01	1.00 to 1.02	0.001
Age (continuous)	0.99	0.99 to 0.99	<0.001
Female sex	2.22	2.00 to 2.47	<0.001
Age-by-sex interaction	0.99	0.99 to 1.00	<0.001
Marital status (referent: legally married)			
Common-law/partner marital status	1.05	0.97 to 1.13	0.202
Single marital status	1.41	1.33 to 1.51	<0.001
Widowed marital status	1.59	1.41 to 1.78	<0.001
Separated marital status	2.83	2.56 to 3.13	<0.001
Divorced marital status	2.08	1.92 to 2.25	<0.001
Employment status (referent: working in past week)			
Has job, absent from work in past week	1.53	1.40 to 1.66	<0.001
No job	1.12	1.07 to 1.19	<0.001
Unable/permanently unable to work	3.36	3.05 to 3.70	<0.001
Urban residence (referent: rural)	1.16	1.10 to 1.21	<0.001
Born in Canada (referent: born outside of Canada)	1.39	1.29 to 1.50	<0.001
Income[a] (inflation adjusted) (referent: highest income)			
Lowest income	1.84	1.71 to 1.99	<0.001
Lower middle income	1.39	1.30 to 1.48	<0.001
Upper middle income	1.20	1.12 to 1.27	<0.001

[a]The Statistics Canada low-income threshold, which is based on total household income adjusted for number of people living in the household, was applied to the 1996 data set and adjusted for consumer price index in subsequent years.

Discussion

The prevalence of MDE has implications for service provision as prevalent disorders are an indicator, albeit an imperfect one,[19] of the need for mental health care in a population. MDE prevalence is associated with a large number of covariates, as documented in Table 1. Generally, these variables appear to be more strongly associated with prevalence than latitude. Table 2 shows an 18% difference between the lowest and highest latitude strata. Representation of more northerly populations in the CCHS is currently limited since these surveys have only recently begun to collect data from the territories. Therefore, the extent to which a pattern of increasing prevalence with increasing latitude can be extrapolated beyond the major population centres (usually below 55° latitude) is unclear. Another issue of extrapolation involves provincial differences. The western provinces do not extend below the 49th parallel, but large populations live below this latitude in eastern Canada. Provincial differences, although these have not been confirmed in Canada, may be confounded with variation in latitude in this analysis. Longitude is also potentially important, but no consistent east-west gradient has yet been reported in Canada.

The ORs from logistic regression suggest a 1% to 2% increase in the prevalence odds of MDE for each degree of latitude. The effect of latitude persisted after adjustment for depression determinants, suggesting that the effect is not merely an artifact of these characteristics. However, latitude is likely to be a marker for many different characteristics, and a causal role cannot be confirmed by cross-sectional survey data. Also, these surveys did not include a fully detailed assessment of MDE determinants, so the association

Table 2. Prevalence of Major Depressive Episode in 3 Latitude Strata.

	1 Step (All Surveys)		2 Steps (4 Surveys: All Provinces)[a]		
Latitude Strata	%	95% Confidence Interval	%	95% Confidence Interval	Examples
42° to 47.9°	5.6	5.5 to 5.8	5.1[b]	3.6 to 6.6	Toronto (44°), Montreal (45°), Halifax (45°)
48° to 52.9°	6.2	6.0 to 6.4	5.6[c]	3.6 to 7.6	Vancouver (49°), Winnipeg (50°), Calgary (51°)
53° to 69.9°	6.6	6.2 to 6.9	6.2[d]	3.9 to 8.4	Edmonton (53°), Fort McMurray (56°)

[a]National Population Health Survey (NPHS) 1996, Canadian Community Health Survey (CCHS) 1.1 (2001), CCHS 1.2 (2002), and CCHS Mental Health (2012).
[b]$I^2 = 98.4\%$, $Q = 183.57$, $df = 3$, $P < 0.001$. τ^2 from the random-effects model: 0.002.
[c]$I^2 = 98.3\%$, $Q = 177.4$, $df = 3$, $P < 0.001$. τ^2 from the random-effects model: 0.0004.
[d]$I^2 = 95.1\%$, $Q = 61.71$, $df = 3$, $P < 0.001$. τ^2 from the random-effects model: 0.0005.

may be due to unmeasured variables related to latitude. For example, hours of light exposure, sunlight intensity, weather and climate, physical activity, diet, drug or alcohol use, chronic disease prevalence, vitamin D status, social factors, aboriginal status, adequacy of health services, and many other factors could all play a role. Irrespective of underlying causal factors, the gradient itself has implications for the population burden of depression and treatment needs.

It would be valuable to replicate this result in other countries with large spans of latitude such as Chile and Argentina. Future research should focus on modifiable variables that may explain the association and whether or not the association can be generalized to the northern territories where extrapolation from these linear model predicts substantially elevated prevalence.

Authors' Note

The estimates reported in this article used data collected by Statistics Canada, but the analysis and results are the sole responsibility of the authors and do not reflect the views of Statistics Canada.

Declaration of Conflicting Interests

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Supplemental Material

Supplementary material is available online with this article.

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