

# BMJ Open Risk factor modifications and depression incidence: a 4-year longitudinal Canadian cohort of the Montreal Catchment Area Study

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## ABSTRACT

**Objective** Few studies have examined the effect of risk factor modifications on depression incidence. This study was to explore psychosocial risk factors for depression and quantify the effect of risk factor modifications on depression incidence in a large-scale, longitudinal population-based study.

**Methods** Data were from the Montreal Longitudinal Catchment Area study (N=2433). Multivariate modified Poisson regression was used to estimate relative risk (RR). Population attributable fractions were also used to estimate the potential impact of risk factor modifications on depression incidence.

**Results** The cumulative incidence rate of major depressive disorder at the 2-year follow-up was 4.8%, and 6.6% at the 4-year follow-up. Being a younger adult, female, widowed, separated or divorced, Caucasian, poor, occasional drinker, having a family history of mental health problems, having less education and living in areas with higher unemployment rates and higher proportions of visible minorities, more cultural community centres and community organisations, were consistently associated with the increased risk of incident major depressive disorder. Although only 5.1% of the disease incidence was potentially attributable to occasional drinking (vs abstainers) at the 2-year follow-up, the attribution of occasional drinking doubled at the 4-year follow-up. A 10% reduction in the prevalence of occasional drinking in this population could potentially prevent half of incident cases.

**Conclusions** Modifiable risk factors, both individual and societal, could be the targets for public depression prevention programmes. These programmes should also be gender-specific, as different risk factors have been identified for men and women. Public health preventions at individual levels could focus on the better management of occasional drinking, as it explained around 5%~10% of incident major depressive disorders. Neighbourhood characteristics could also be the target for public prevention programmes. However, this could be very challenging. A cost-effectiveness analysis of a variety of prevention efforts is warranted.

The Global Burden of Disease Study 2010 reported depression is a major public health

## Strengths and limitations of this study

- This study used a large longitudinal population-based study to explore risk factors for incident depression.
- The study provides quantitative measures on the potential effects of risk factor modifications on depression incidence.
- The study sample was not representative of the initial survey sample.
- It is difficult to know how much we could achieve on disease reduction when a single risk factor is removed.

problem.<sup>1</sup> The increasing burden of depression tax healthcare systems as they strive to meet the rising needs.<sup>2,3</sup>

Many cross-sectional and longitudinal studies have consistently found the following mostly psychosocial factors are associated with the increased risk of major depressive disorder: the use of alcohol, tobacco and drugs during pregnancy,<sup>4</sup> maternal stress,<sup>5,6</sup> low birth weight,<sup>7</sup> child abuse and adverse childhood experience,<sup>8,9</sup> low income,<sup>10</sup> unemployment,<sup>11</sup> smoking,<sup>12</sup> physical inactivity,<sup>13</sup> unhealthy eating styles,<sup>14</sup> low social support, stressful events and neighbourhood deprivation.

The prevalence and incidence of depression are increasing.<sup>15,16</sup> Although antidepressants, psychotherapy and alternative therapies have been widely used in the clinical practice, their impact is limited by the rising demand for treatment and the limited resources, both personnel and financial, available for mental healthcare services.<sup>17,18</sup>

Depression is preventable. Our previous studies have shown that public health campaigns, which focus on the risk reduction of modifiable risk factors, can significantly prevent the occurrence of

mental disorders.<sup>13 19</sup> Modifiable risk factors can be used as targets for prevention.

To the best of our knowledge, no previous study has systematically investigated the roles of both psychosocial and environmental risk factors in depression using a longitudinal, population-based study. Public prevention campaigns need to find a target to reduce the risk of depression at a societal level. This longitudinal population-based study was to explore psychosocial and environmental risk factors for incident depression and quantify the effect of risk factors modifications on depression incidence.

## METHODS

### Data

The Montreal South-West Longitudinal Catchment Area Study—Zone d'Épidémiologie Psychiatrique du Sud-Ouest de Montréal (ZEPSOM), is a population-based cohort study of a representative community sample of five neighbourhoods in the South-West sector of Montreal, Canada, which have a combined population of 269720. It is based on an ecological model, which makes it unique. The study was approved by the Douglas Mental Health University Institute Ethics Committee. At the baseline (wave I) of the study, a sample consisted of 2 433 individuals randomly selected individuals aged 15–65 years. More details about the study can be found in previous reports.<sup>20 21</sup>

### Study sample

Subjects for this study were restricted to those who were depression-free at the wave I (2006/2007). The study was further restricted to those with the complete survey data at waves II and III. This resulted in data being available for 1357 participants at the 2-year follow-up analysis and for 965 participants at the 4-year follow-up analysis. **Figure 1** shows the detailed criteria applied to the larger study cohort to obtain the sample analysed here. A lifetime diagnosis of major depressive episode at the wave I was used as an exclusion criteria in order to minimise the influence of recurrent depression on our estimates of the incidence of major depression.

### Measures

#### Depression diagnoses

The World Mental Health-Composite International Diagnostic Interview (WMH-CIDI), an internationally recognised diagnostic questionnaire for selected mental disorders was used for data collection in the longitudinal study. In addition, the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) and the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) definitions and criteria were used to assess the presence of major depressive disorder, mania, anxiety, panic disorder, social phobia, agoraphobia, alcohol abuse/dependence and drug abuse/dependence.<sup>22</sup> For this analysis, we had data on major depressive disorder status at baseline, and at

the 2-year and 4-year follow-ups. The period from beginning of the study to the first onset of the major depressive disorder indicated the period for developing the disease.

### Covariates

The covariates included sociodemographic factors (age, sex, marital status, income, education, immigrant status), family history of mental disorders, type of drinker (regular drinker, anyone who consumes one or more drinks per month; occasional drinker, anyone who consumes a drink less than once a month; former drinker, a person has not had a drink in at least the last 12 months and abstainer) and community neighbourhood social and ecological characteristics (total crime rate, prevalence of low income, unemployment rate for the population aged 25 years and older, proportion of visible minority population, number of cultural community centres, number of all community organisations, number of all medical clinics, number of mental health-related services and number of physical activity places) in a 500 m buffer zone for where the survey participants lived.

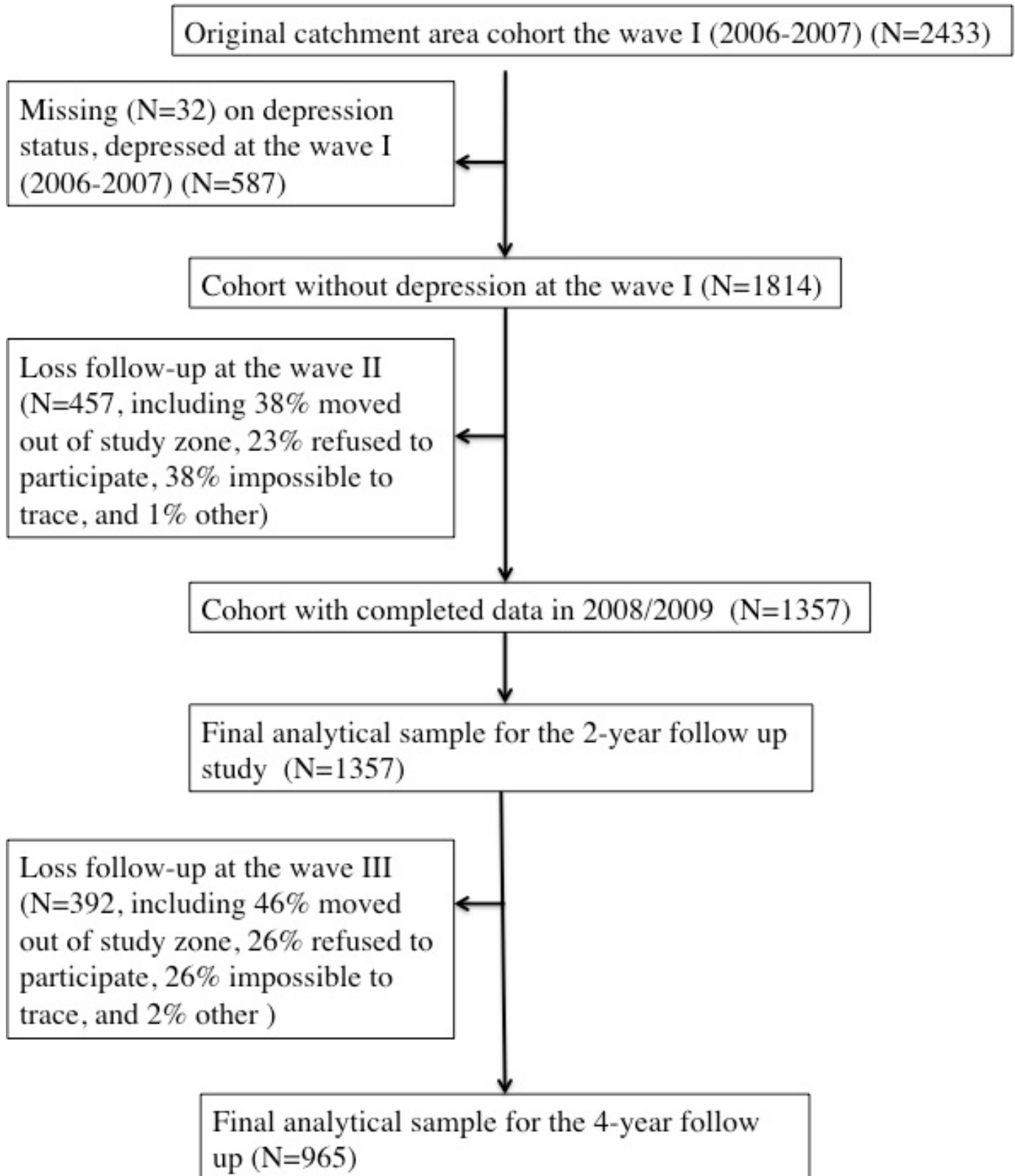
### Statistical analyses

Comparisons were made between participants selected for this analysis and those who were not included to examine the generalisability of the study sample. We used the modified Poisson regression<sup>23</sup> to estimate relative risk (RR) for the association between risk factors and incident mental disorders during the study period. Modified Poisson regression analysis has been consistently used in prospective studies to estimate RR with a robust error variance. Covariates with  $p < 0.20$  in the univariate analyses were initially considered in the multivariate Poisson regression. The goodness-of-fit was tested. To estimate potential influence of individual risk factors on major depressive disorder, population attributable fractions (PAFs) were used. PAFs represent the percentage of all depression cases exposed to different levels of risk factors that would not have occurred if the exposure had not existed. The PAF was calculated by the following formula based on previous literature<sup>24–26</sup>:  $PAF = \frac{p(RR-1)}{p(RR-1)+1}$ , where  $p$  is the population incidence of individual risk factor and RR is the relative risk of major depressive disorder given to an individual risk factor holding other covariates constant. We calculated RR based on multiple Poisson regression methods. Finally, the total number of depression cases attributable to risk factors was estimated by multiplying the PAF and the incident cases during the follow-up. All analyses were run using STATA V.12 (StataCorp, 2011).

## RESULTS

### Comparison between participants selected in this study and unselected ones

In comparison with the unselected participants, the analysis sample for both the 2-year and the 4-year follow-ups, contained more younger adults, males, married people (including common-law), people with higher income



**Figure 1** The selection process of the study sample from the Montreal South-West Longitudinal Catchment Area study.

and higher education, immigrants, abstainers and fewer people with a family history of mental health problems ( $p<0.05$ ). In addition, compared with those not eligible for this study, the analysis sample tend to live in areas having lower rates of: low income, unemployment for

those aged 25 years and older, visible minorities and fewer numbers of cultural community centres, community organisations, medical clinics, mental health-related services and physical activity places ( $p<0.05$ ).

### Characteristics of the study population

For the 2-year follow-up group, the sex ratio was 1:1 (males: 50.3% vs females: 49.7%). In comparison to males, females tend to be older, more likely to be widowed, separated or divorced, poor, more educated, more likely to be occasional/abstainer/former drinkers and have fewer individuals with a family history of mental health problems (see online supplementary appendix 1). With respect to community characteristics, males were more likely to live in the places with higher rates of crime, low income, unemployment for those aged 25 years and older, higher proportions of visible minorities and more cultural community centres, but fewer community organisations, medical clinics, mental health-related services and physical activity places ( $p < 0.05$ ).

For the 4-year follow-up group, there were slightly more females than males (52.2% vs 47.8%). No statistical difference was found between males and females in terms of the crime rate in their neighbourhoods ( $p > 0.05$ ). The rest of characteristics remained the same as what were found in the 2-year follow-up group.

### Characteristics associated with depression incidence during the 2-year follow-up

Multivariate modified Poisson regression was applied to explore the determinants of incident major depressive disorder. The goodness-of-fit was tested for the final model. Table 1 presents characteristics associated with incident major depressive disorder. For those remaining in the cohort after the 2-year period, individual depression risk factors were being younger, female, Caucasian, widowed, separated or divorced, having a family history of mental health problems, being an occasional drinker (vs abstainer) and having less education, were associated with an increased incidence of major depressive disorder. Community/contextual factors significantly associated with incident major depressive disorder included living in the areas with higher unemployment rates, higher proportions of visible minorities, more cultural community centres or community organisations. Those who lived in areas with more physical activity places, more medical clinics, higher rates of low income and crime reported lower rates of incident major depressive disorder during the 2-year follow-up.

We ran different regression models for males and females. Factors including younger age, having a family history of mental health problems, having less education and living in an area with a lower crime rate, lower proportions of people with low income and higher unemployment rate for those aged 25 years and older were consistently related to a higher risk of major depressive disorder. For *males*, being widowed, separated, divorced, with less education and living in the area with a higher proportion of visible minorities, or more cultural community centres, or mental health-related services, were more likely to develop major depressive disorder. Conversely, *females*, being an occasional drinker, having a low income, living in the area with more community organisations,

were associated with an increased risk of developing major depressive disorder. Table 2 shows the characteristics associated with major depressive disorder for both males and females, separately. Notably, *males* who lived in areas with more community organisations, medical clinics and physical activity places reported a lower incidence of major depressive disorder. *Females*, living in areas with higher proportions of visible minorities, more cultural community centres and mental health-related services, were less likely to develop major depressive disorder.

### Characteristics associated with the incidence of major depressive disorder during the 4-year follow-up

The same methods were used to analyse the data for the 4-year follow-up. Table 3 presents characteristics associated with incident major depressive disorder at the 4-year follow-up. For those remaining in the selected sample at the 4-year follow-up, factors significantly associated with an increased risk of developing major depressive disorder including being younger, Caucasian, widowed, separated or divorced, having a family history of mental health problems, being an occasional drinker (vs abstainer), having less education. Also, living in areas with a higher unemployment rate, a lower crime rate, a lower level of income, a higher proportion of visible minorities, more cultural community centres or mental health-related services were associated with an increased incidence of major depressive disorder.

We then explored risk profiles for males and females, separately. Table 4 presents characteristics associated with incident major depressive disorder for both males and females. Individual risk factors included being younger, widowed, separated or divorced, an occasional drinker (vs abstainer) and having less education. For both males and females, community neighbourhood characteristics associated with an increased risk of incident major depressive disorder were living in areas with higher unemployment for those aged 25 years and older, and fewer medical clinics. Males were at higher risk of major depressive disorder if they lived in an area with higher proportions of visible minorities, more cultural community centres or more mental health-related services. Whereas, *females* had greater risks of major depressive disorder if they were Canadian born, lived in the area with more physical activity places and more community organisations. Notably, *females* living in areas with more mental health-related services reported a lower incidence of major depressive disorder. For *males*, living in areas with more physical activity places reduced the risk of developing major depressive disorder.

### Number of population potentially influenced by personal modifiable risk factors

Although we found a number of risk factors including both personal characteristics (modifiable factors, eg, drinking habit, and non-modifiable factors, e.g., family history of mental health problems) and community



**Table 1** Characteristics associated with incident major depressive disorder during the 2-year follow-up (wave II)

Characteristics	People with complete cases n=1212	
	RR, 95% CI	p Value
Age	0.996 (0.994 to 0.998)	<0.001
Gender		
Males	1	
Females	1.176 (1.107 to 1.249)	<0.001
Immigrant status		
Immigrant	1	
Canadian born	3.250 (2.939 to 3.595)	<0.001
Marital status		
Married/common law	1	
Single	0.602 (0.538 to 0.673)	<0.001
Widowed/separated/divorced	1.153 (1.078 to 1.234)	<0.001
Family history of mental health problems		
No	1	
Yes	1.772 (1.668 to 1.882)	<0.001
Type of drinker		
Abstainer	1	
Former	0.148 (0.117 to 0.186)	<0.001
Occasional	1.277 (1.124 to 1.452)	<0.001
Regular	0.505 (0.443 to 0.575)	<0.001
Education		
Postsecondary degree	1	
Some postsecondary	1.190 (1.065 to 1.330)	0.002
Postsecondary	1.111 (1.017 to 1.215)	0.020
Less secondary	0.974 (0.894 to 1.062)	0.553
GIS measures in 500 m buffer zone		
Crime rate	0.996 (0.994 to 0.998)	<0.001
Low income rate	0.979 (0.973 to 0.985)	<0.001
Unemployment rate for population aged 25 years and older	1.110 (1.097 to 1.124)	<0.001
Proportion of visible minorities	1.005 (1.002 to 1.008)	0.002
No. of cultural community centres	1.017 (1.004 to 1.031)	0.013
No. of community organisations	1.120 (1.062 to 1.181)	<0.001
No. of medical clinics	0.908 (0.861 to 0.958)	<0.001
No. of physical activity places	0.768 (0.734 to 0.803)	<0.001

characteristics (number of mental health-related services, etc.), we focus here on modifiable risk factors at the individual level. Drinking habit is the only modifiable risk factor for major depressive disorder consistently evident in the current study.

The cumulative incidence rate of major depressive disorder during the 2-year follow-up was 4.8% (4.2% for males and 5.4% for females), which represented 5318 individuals in the catchment area developed incident major depressive disorder during the 2-year period. We then calculated that 5.1% (273) of depression cases were potentially attributable to occasional drinking. If the

prevalence of occasional drinking could be reduced by 10%, about 50% (137) of cases were prevented.

The cumulative incidence rate of major depressive disorder during the 4-year follow-up was 6.6% (5.9% for males and 7.3% for females), which represented 5193 individuals in the catchment area developed incident major depressive disorder during the 4-year period. A total of 532 (10.2%) cases were potentially attributable to occasional drinking, and 474 (21.5%) cases of depression were potentially attributable to occasional drinking among males, and 4.18% (125) cases for females. If the

**Table 2** Characteristics associated with incident major depressive disorder during the 2-year follow-up (wave II) by gender

Characteristics	Males n=441		Females n=646	
	RR, 95% CI	p Value	RR, 95% CI	p Value
Age	0.995 (0.992 to 0.999)	0.015	0.991 (0.988 to 0.994)	<0.001
Low income				
No	1		1	
Yes	0.950 (0.794 to 1.136)	0.574	1.228 (1.101 to 1.369)	<0.001
Immigrant status				
Immigrant	1		1	
Canadian born	N/A		1.271 (1.136 to 1.423)	<0.001
Marital status				
Married/common law	1		1	
Single	N/A		0.981 (0.867 to 1.111)	0.767
Widowed/separated/divorced	2.034 (1.822 to 2.271)	<0.001	0.859 (0.778 to 0.950)	0.003
Family history of mental health problems				
No	1		1	
Yes	1.723 (1.551 to 1.914)	<0.001	1.526 (1.402 to 1.660)	<0.001
Type of drinker				
Abstainer	N/A		1	
Former			0.106 (0.074 to 0.153)	<0.001
Occasional			1.487 (1.249 to 1.770)	<0.001
Regular			0.746 (0.625 to 0.891)	0.001
Education				
Postsecondary degree	1		1	
Some postsecondary	1.408 (1.189 to 1.667)	<0.001	0.510 (0.404 to 0.643)	<0.001
Postsecondary	2.359 (2.063 to 2.697)	<0.001	0.821 (0.729 to 0.949)	0.008
Less secondary	1.172 (1.005 to 1.367)	0.043	1.491 (1.323 to 1.681)	<0.001
GIS measures in 500 m buffer zone				
Crime rate	0.983 (0.978 to 0.988)	<0.001	0.978 (0.974 to 0.982)	<0.001
Low income rate	0.985 (0.976 to 0.994)	0.001	0.986 (0.978 to 0.994)	0.001
Unemployment rate for population aged 25 years and older	1.164 (1.141 to 1.188)	<0.001	1.112 (1.092 to 1.132)	<0.001
Proportion of visible minorities	1.038 (1.034 to 1.043)	<0.001	0.991 (0.987 to 0.996)	<0.001
No. of cultural community centres	1.075 (1.053 to 1.097)	<0.001	0.961 (0.942 to 0.980)	<0.001
No. of community organisations	0.638 (0.574 to 0.708)	<0.001	1.605 (1.471 to 1.752)	<0.001
No. of mental health-related services	1.291 (1.229 to 1.355)	<0.001	0.926 (0.886 to 0.967)	0.001
No. of medical clinics	0.531 (0.463 to 0.608)	<0.001	1.011 (0.892 to 1.147)	0.859
No. of physical activity places	0.559 (0.515 to 0.607)	<0.001	0.952 (0.897 to 1.011)	0.112

prevalence of occasional drinking could be reduced by 10%, 47% (249) of depression cases would be prevented.

## DISCUSSION

This is a unique study of depression incidence in a longitudinal community cohort, for which both individual and ecological community characteristics were available. We found that the cumulative incidence rate of depression during the 2-year follow-up was 4.8%, and 6.6% for the

4-year follow-up. Being a younger adult, female, widowed, separated or divorced, Caucasian, poor, occasional drinker (vs abstainer), having a family history of mental health problems, having less education and living in areas with a higher unemployment rate, more visible minorities, more cultural community centres and community organisations, were consistently associated with the increased risk of incident major depressive disorder. Although only 5.1% of depression incidence was potentially attributable

**Table 3** Characteristics associated with incident major depressive disorder during the 4-year follow-up (wave III)

Characteristics	Data with complete case n=877	
	RR, 95% CI	p Value
Age	0.992 (0.990 to 0.994)	<0.001
Immigrant status		
Immigrant	1	
Canadian born	3.117 (2.845 to 3.415)	<0.001
Marital status		
Married/common law	1	
Single	0.550 (0.499 to 0.608)	<0.001
Widowed/separated/divorced	1.277 (1.204 to 1.354)	<0.001
Family history of mental health problems		
No	1	
Yes	1.915(1.820 to 2.015)	<0.001
Type of drinker		
Abstainer	1	
Former	0.276 (0.232 to 0.328)	<0.001
Occasional	1.564 (1.399 to 1.748)	<0.001
Regular	0.683 (0.611 to 0.763)	<0.001
Education		
Postsecondary degree	1	
Some postsecondary	1.697 (1.558 to 1.848)	<0.001
Postsecondary	1.115 (1.028 to 1.208)	0.008
Less secondary	1.449 (1.352 to 1.554)	<0.001
GIS measures in 500 m buffer zone		
Crime rate	0.993 (0.991 to 0.994)	<0.001
Low income rate	0.983 (0.978 to 0.988)	<0.001
Unemployment rate for population aged 25 years and more	1.080 (1.068 to 1.091)	<0.001
Proportion of visible minorities	1.007 (1.004 to 1.009)	<0.001
No. of cultural community centres	1.043 (1.031 to 1.055)	<0.001
No. of mental health-related services	1.051 (1.024 to 1.079)	<0.001
No. of community organisations	0.865 (0.817 to 0.915)	<0.001
No. of medical clinics	0.796 (0.739 to 0.859)	<0.001
No. of physical activity places	0.897 (0.864 to 0.932)	<0.001

to occasional drinking at the 2-year follow-up, the attribution of occasional drinking increased to 10.2% at the 4-year follow-up. Furthermore, a 10% reduction in the prevalence of occasional drinking among this population could potentially prevent half of incident depression cases.

There is a lack of information on the cumulative incidence of major depressive disorder. Comparisons of the cumulative incidence are also restricted by different scales or questionnaires used to identify major depressive disorder. A previous study in a national Canadian longitudinal sample reported a 16-year incidence of major depressive disorder was 12.1%.<sup>19</sup> In this current analysis, we found the 2-year cumulative incidence of major

depressive disorder was 4.8%, and 6.6% at the 4-year follow-up, indicating that major depressive disorder is a critical public mental health problem. It is not surprising that the risk of major depressive disorder increases as the observational time lengthens. A straightforward explanation is that the longer observational time increases the possibility of having more risk exposures (ie, stressful life events, occurrence of other comorbidities, etc), which contribute to develop of the disease.

People who are younger, female, having a lower income and having a family history of mental health problems, have been consistently found to be at an increased risk of having major depressive disorder.<sup>1 19 27</sup> We also found immigrants (compared with Canadian born) had a lower

**Table 4** Characteristics associated with incident major depressive disorder during the 4-year follow-up (wave III) for those with complete cases

Characteristics	Males n=327	p Value	Females n=550	p Value
	RR, 95% CI		RR, 95% CI	
Age	0.985 (0.982 to 0.988)	<0.001	0.992 (0.989 to 0.995)	<0.001
Immigrant status				
Immigrant			1	
Canadian born	N/A		1.274 (1.156 to 1.404)	<0.001
Marital status				
Married/common law	1		1	
Single	N/A		0.893 (0.802 to 0.994)	0.038
Widowed/separated/divorced	1.469 (1.338 to 1.612)	<0.001	1.166 (1.075 to 1.265)	<0.001
Family history of mental health problems				
No	1		1	
Yes	2.774 (2.556 to 3.011)	<0.001	1.530 (1.424 to 1.644)	<0.001
Type of drinker				
Abstainer	1		1	
Former	0.255 (0.178 to 0.365)	<0.001	0.213 (0.169 to 0.269)	<0.001
Occasional	2.618 (1.929 to 3.555)	<0.001	1.187 (1.045 to 1.349)	0.008
Regular	0.452 (0.332 to 0.615)	<0.001	0.747 (0.657 to 0.849)	<0.001
Education				
Postsecondary degree	1		1	
Some postsecondary	1.747 (1.548 to 1.971)	<0.001	1.436 (1.256 to 1.643)	<0.001
Postsecondary	1.407 (1.243 to 1.591)	<0.001	1.079 (0.961 to 1.210)	0.198
Less secondary	1.040 (0.930 to 1.165)	0.490	1.629 (1.478 to 1.796)	<0.001
GIS measures in 500 m buffer zone				
Crime rate	0.993 (0.990 to 0.996)	<0.001	0.987 (0.984 to 0.991)	<0.001
Prevalence of low income	0.976 (0.968 to 0.985)	<0.001	0.998 (0.991 to 1.005)	0.574
Unemployment rate for population aged 25 years and more	1.141 (1.121 to 1.162)	<0.001	1.054 (1.038 to 1.071)	<0.001
Proportion of visible minority population	1.054 (1.050 to 1.059)	<0.001	0.984 (0.980 to 0.988)	<0.001
No. of cultural community centres	1.077 (1.058 to 1.097)	<0.001	1.006 (0.991 to 1.022)	0.414
No. of mental health-related services	1.303 (1.249 to 1.360)	<0.001	0.876 (0.843 to 0.910)	<0.001
No. of community organisations	0.447 (0.408 to 0.490)	<0.001	1.408 (1.301 to 1.524)	<0.001
No. of medical clinics	0.508 (0.453 to 0.570)	<0.001	0.944 (0.844 to 1.055)	<0.001
No. of physical activity places	0.743 (0.694 to 0.795)	<0.001	1.081 (1.030 to 1.135)	<0.001

risk of having depression.<sup>28 29</sup> In Canada, the pre-entry medical examination policy may be one of the reasons for this phenomenon. In addition, we identified several neighbourhood (contextual) characteristics associated with major depressive disorder. Researchers have investigated the role of neighbourhood in mental health. Although it is not completely consistent, a number of studies have found that neighbourhoods with poor-quality housing, poverty and higher unemployment rates are associated with higher risk of major depressive disorder.<sup>30 31</sup> Stress plays a role in the relationships between neighbourhood characteristics and depression. Researchers hypothesised

that the role of neighbourhood characteristics in incident major depressive disorder by (1) increasing the level of daily stress, (2) influencing on the vulnerability to depression and (3) interfering with the formation of bonds among people.<sup>32</sup> We found people living areas with higher unemployment were more likely to develop incident major depressive disorder. This is consistent with the theoretical explanations of neighbourhood's role in major depressive disorder. We also found that those living in an area with higher proportion of visible minorities, more cultural community centres and more mental health-related services reported a higher incidence of



major depressive disorder. This seems counterfactual with what other studies have shown about more resources in the neighbourhood decrease the risk of major depressive disorder. One explanation of this finding is that people from different ethnic groups have different vulnerability for the disease, and discrimination due to minority status could also increase risk.<sup>33</sup> Alternatively, the increase in mental health-related community services might reflect a greater need, or perceived need, in these areas. The availability of mental health service is critical to help identify and treat people suffering from major depressive disorder. Areas with more mental health services are associated with better education and knowledge of mental health problems among people who live in these areas. Those cases may be more likely to be identified in these areas. The measurements and operationalisation of definitions of geospatial community characteristics may also differ between studies. There is a need to consider these differences in making comparisons.

The literature reports significant differences in the determinants associated with major depressive disorder between males and females.<sup>34</sup> We found the same phenomenon. Males living in areas with more physical activity places reported a lower rate of major depressive disorder, but this finding does not apply for females. Although the mechanism of the discrepancy is difficult to understand due to many domains involved, including biological, psychological and sociocultural influences, our finding reinforces the importance of recognising the gender difference in major depressive disorder, and warrants gender-specific prevention programmes for major depressive disorder.

Inconsistent findings regarding the relationship between alcohol consumption and major depressive disorder have been reported in the literature,<sup>35,36</sup> partially due to the measurements of alcohol consumption (frequency of drinking behaviour and/or quantity per occasion) and major depressive disorder. One study on *quantity per occasion* suggested that major depressive disorder was primarily related to drinking large quantities per occasion, and this effect was stronger for females than for males.<sup>35</sup> Since we did not have measures on quantity per occasion, direct comparison to this findings was not possible.

In terms of *drinking frequency* and depression, one study suggested the U-shape relationships of alcohol consumption and major depressive disorder, because abstainers or heavy drinkers were associated with many disadvantaged factors, including low-status occupations, less education, current financial hardship, poor social support and many of these characteristics are related to major depressive disorder.<sup>37</sup> However, in this study after adjusting other covariates, we found 'occasional drinkers' had higher rates of incident major depressive disorders compared with abstainers.

Occasional drinking (compared with non-drinking) was the only modifiable risk factor at an individual level. It explained around 5%~10% of incident major

depressive disorders. From public health perspectives, occasional drinking could be a target for public prevention programmes. We also identified few neighbourhood characteristics associated with depression. However, it can be more challenging to modify these neighbourhood characteristics. A cost-effectiveness analysis of prevention efforts is also advised.

### Strengths and limitations

The primary strength of our study is we used relatively large longitudinal population-based study to quantify the potential effects of risk factor modifications on the incidence of major depressive disorder. We examined the effect of individual risk factors as well as neighbourhood characteristics. The risk and contextual factors were analysed in multivariate models. While we have strove to deliver reliable results, there are several limitations to this study: (1) only individuals who completed all the three waves of data collection were included in the analysis. Compared with those without complete data, our sample had statistically different characteristics, which were also associated with major depressive disorder. The generalisability of our findings is restricted; (2) our sample was not representative for the whole survey sample. There was a significant attrition.<sup>38,39</sup> Those survey participants, who did not complete all the follow-up assessments, had an increased risk of major depressive disorder compared with our sample. The cumulative incidence rates reported in this study may be underestimated; (3) this is an secondary analysis of data already collected, therefore we are limited in the variables and interactions we could explore, for example, the variable 'type of drinker' only codes for regular drinker, occasional drinker, former drinker and abstainer. There are more useful ways to characterise drinking behaviour. However, because data were already recorded, we are restricted in terms of defining variables; (4) the cause of major depression is complex. It is difficult to know how much we could achieve on the disease reduction, when a single risk factor is removed or reduced in prevalence.

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**Data sharing statement** The Zone d'Épidémiologie Psychiatrique du Sud-Ouest de Montréal (ZEPSOM) study is currently continuing in survey data and biological sample data collection, consequently, for now only members of the ZEPSOM study team have access the data.

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