Examining the Association Between Neighbourhood Characteristics and Gonorrhea Rates Among Women Aged 15 to 24 Years in Montreal, Canada

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ABSTRACT

Objective: The reported incidence rate of gonorrhea has more than doubled from 2000 to 2010 in Montréal, increasing in both sexes and all age groups; however, the increase was particularly high in females aged 15 to 24 years. As the reasons for this increase among young women are not fully understood, we wanted to determine whether neighbourhood-level population characteristics were associated with incidence rates in this group, to help target intervention strategies.

Methods: Incident gonorrhea cases were female residents of Montréal aged 15 to 24 years who met Québec's gonorrhea surveillance definition, with a notification date from 2002 to 2009. Adjusted incidence rate ratios (IRR) were estimated by negative binomial regression and show the change in the incidence of gonorrhea for each unit increase in neighbourhood-level independent variables, which included material and social deprivation indices (plus the latter's combination and components) and ethnic origin. In the final model, independent variables were normalized to facilitate comparison of their respective IRRs.

Results: A total of 837 cases were reported (cumulative incidence rate 5.6 per 100,000). Higher proportions of persons of African, Aboriginal and Caribbean ethnicity were associated with higher rates of gonorrhea, even after adjustment for deprivation indices.

Conclusion: Customary methods for gonorrhea surveillance consider individual characteristics of cases as risk factors for disease. However, our results show that gonorrhea is clustered in neighbourhoods that have high proportions of three ethnic origin groups. Findings from this ecological approach suggest that although ethnicity may be strongly correlated with socio-economic status, there are factors in ethnicity that transcend poverty.

Key words: Gonorrhea; surveillance; epidemiology

La traduction du résumé se trouve à la fin de l'article.

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Gonorrhea has been nationally notifiable in Canada since 1924 and remains the second most commonly reported sexually transmitted infection (STI) in the country after chlamydia.¹ In Canada, there has been a gradual but steady increase in reported rates of gonorrhea in both sexes since 2000. The reported incidence has increased from 20.1/100,000 in 2000 to 29.6/100,000 in 2010. The incidence rate of gonorrhea for Montréal is higher than that for both Canada (with the exception of 2004) and Québec. From 2000 to 2010, the incidence rate of reported cases in Montréal doubled from 24.5 to 51.5 per 100,000.

The increase in the reported incidence of gonorrhea in Montréal has affected both men and women and all age groups; however, males continue to have higher incidence rates compared to females (2010: 78/100,000 for males and 26/100,000 for females). Although the highest incidence rate of gonorrhea is consistently among men, from 2005 to 2010, the percent increase in the incidence rate was almost five times higher among women (from 8/100,000 to 26/100,000: +225%) than among men (from 53/100,000 to 78/100,000: +47%). In women, the increase was particularly high in the 15-19 year and 20-24 year age groups (see Figure 1).

Because of the greater risk of severe complications in females, the Montreal Health and Social Services Agency has focused their investigations on women under the age of 25 years. However, the reasons for the increase among young women are not fully understood. Therefore, the objective of this study was to determine whether gonorrhea incidence rates among young women were

associated with neighbourhood-level population characteristics, in order to help target intervention strategies.

Numerous studies have identified individual-level risk factors for STIs and as a result, public health typically targets high-risk individuals, focusing on screening, treatment, partner notification and counselling.^{2,3} However, using individual case characteristics is not always sufficient to fully understand surveillance trends or for the control of outbreaks. Individual characteristics do not always adequately describe key groups, making it difficult to design effective interventions to prevent gonorrhea transmission. As a result, there has been increased attention paid to the social determinants of disease and the relationship between gonorrhea rates and population characteristics. These geographic approaches to STI prevention in areas where core groups exist have been suggested as feasible alternatives to case-by-case management and have had success in lowering incidence.⁴ A more thorough understanding of the target population combined with geographic information may help refine current uniformly applied intervention strategies or with the development of new targeted strategies.

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Figure 1. Reported rates of gonorrhea by age group, females, Montréal, 2000-2010

METHODS

Incident gonorrhea cases were defined as female residents of Montréal, aged 15 to 24 years, who met Québec's provincial gonorrhea surveillance definition,⁵ with a notification date from 2002 to 2009. A person may be included multiple times during the study period if repeated infections (as opposed to relapses) were reported.

Neighbourhoods were used as the analysis unit to approximate the concept of community. These 111 non-administrative boundaries were defined in 2007 by the Montreal Health and Social Services Agency in consultation with many local partners. Neighbourhood populations range from 1,975 to 64,100; with an average population of 16,706. To define the neighbourhoods, the Montreal Health and Social Services Agency conducted a review and analysis of all documents and maps developed by the city and other local territories. This included neighbourhood profiles describing in detail the characteristics of the population, documents outlining the history of the neighbourhood, or any other publication reporting a division of the territory. The purpose was to divide the health and social territories in the Montreal area into smaller units that reflect distinct social realities and, in many cases, areas requiring different interventions. Each neighbourhood had to be fully included in a local community service centre. Specifically, the boundaries of neighbourhoods had to be drawn from census dissemination areas and to follow the perimeter of the local community service centre. A neighbourhood therefore would consist of a set of dissemination areas or parts thereof. Consultations were held to obtain consensus on the defined neighbourhoods. Participants included social workers and nurses, and representatives from community organizations, day care centres, schools, the Ministry of Immigration and Cultural Community, the city of Montreal and the Ministry of Families and Seniors.

The smaller units were chosen because the compilation of data by larger geographical boundaries can mask important differences.⁶ Neighbourhood characteristics were obtained from 2006 Canadian Census data.

The dependent variable was the neighbourhood gonorrhea incidence rate for females aged 15 to 24 years. The independent variables included material and social deprivation indices, their

Table 1. Independent Variables

Independent Variables

1. Population aged 15 years and older without a diploma
2. Employment rate for the population aged 15 years or older
3. Average income after taxes
4. Single-parent families among families with children
5. Population living alone
6. Population separated, divorced, widowed
7. Ethnocultural group (French, Caribbean, British Isles, Aboriginal, Other North American, Latin American, Central and South American, Western European, Northern European, Eastern European, Southern European, African, Arab, West Asian, South Asian, East or South East Asian, Oceania, Maghreb)
8. Material deprivation which reflects the deprivation of goods and conveniences of everyday life (% of the population without a diploma; employment rate; average income)¹¹
9. Social deprivation which reflects the fragility of the social network and family to the community (% of the population separated, divorced, widowed; % of single-parent families; % of the population living alone)¹¹
10. Material and social deprivation: Characterizes a state of relative disadvantage of individuals, families or groups with respect to a population to which they belong: a local community, region or nation. Includes the indicators that make up both social and material deprivation^{11,12}

combination and components, and ethnic origin (see Table 1). These variables were selected based on the deprivation index created in Québec as well as on findings from previous research with specific interest in racial/ethnic composition and STI incidence.⁷⁻¹⁰

Adjusted incidence rate ratios (IRR) were estimated by negative binomial regression to reflect the expected changes in the gonorrhea rate associated with changes in the neighbourhood characteristics.

Variables were applied one at a time and as a group (deprivation indices) to determine whether a single variable or all variables combined were associated with disease rates. Variables significant at $p < 0.05$ in the univariate analysis were further examined in the multivariate models. In the final model, independent variables were normalized into z scores to facilitate comparison of their respective IRRs. STATA version 10.1 was used for analyses. This work only used publicly available aggregate data and no ethical review was required.

RESULTS

From 2002 to 2009, 837 gonorrhea cases were reported among females aged 15 to 24 years. Of those cases, 784 (93.7%) could be geographically coded and attributed to a neighbourhood. Twenty neighbourhoods throughout the island of Montréal had cumulative incidence rates of over 130 per 100,000 population (Figure 2). Less than half (8/20: 40%) of these neighbourhoods were among those with greater than 50% of the population who are both materially and socially deprived. Therefore, the remaining 12 neighbourhoods with high incidence rates of gonorrhea were among those with more favourable material and social conditions.

Results from the univariate analyses are shown in Table 2. Gonorrhea incidence was significantly associated with average income after taxes, and the proportion of the population: without high school diploma; in single-parent families; separated, widowed or divorced; materially deprived; socially and materially deprived; or whose origin is Caribbean, Aboriginal, Western European, Northern European, Eastern European, and African (Table 2).

The six independent variables and six ethnic origin groups that were significantly associated with gonorrhea rates were included in the multivariate analysis. The first multivariate model revealed that when the deprivation indices were included with some of their

Figure 2. Cumulative neighbourhood incidence rates of reported cases of gonorrhea, females aged 15-24 years, residents of Montréal, 2002-2009 (n=784)

components, they were no longer associated with the rates of gonorrhea (Material: IRR 1.004, $p=0.290$, CI 0.996-1.012; Material and Social: 1.000, $p=0.984$, CI 0.990-1.009). Only marital status, no diploma and three ethnic origin groups (Aboriginal, Caribbean, and African) remained associated. However, in subsequent multivariate models, “no diploma” and “marital status” (no diploma: IRR 0.99, $p=0.215$, CI 0.97-1.01; Marital Status: IRR 1.011, $p=0.170$, CI 0.99-1.03) ceased to be associated. The final model therefore only included African, Aboriginal and Caribbean ethnic origin groups.

The final analysis, using normalized independent variables, revealed that higher proportions of African, Aboriginal and Caribbean populations were associated with rates of gonorrhea, even after controlling for indices of deprivation (see Table 3). African origin population had the strongest association, with each increase of one standard deviation in the percentage of the population whose origin is African being associated with a 34% increase in the rate of gonorrhea among women aged 15 to 24 years.

Negative binomial regression was chosen instead of Poisson regression because the variance for the independent variable was five times greater than the mean (mean 7.06 and variance 36.8),

meaning that the data were overdispersed and the Poisson regression method therefore was not appropriate.

DISCUSSION

This study demonstrates the application of regression models to examine the association between neighbourhood-level characteristics and reported incidence rates of gonorrhea. Our results imply that each increase of one standard deviation in the proportion of the population whose origin is African, Aboriginal or Caribbean is associated with a 34%, 33% or 18% increase, respectively, in the rate of gonorrhea among women aged 15 to 24 years. These results suggest that the proportions of three ethnic origin groups are either markers for risk factors of gonorrhea or could be themselves risk factors. The reasons for the association between gonorrhea incidence and these ethnic origin groups are difficult to identify. Late seeking of health care services and failure to use condoms do not seem to account for the association.^{7,13} As well, there are no known biological susceptibility differences between ethnic groups.¹⁴

Sexual mixing patterns have been suggested as a possible mechanism for increased transmission. Some have suggested

Table 2. Results From Univariate Negative Binomial Regression: Unadjusted Incidence Rate Ratio (IRR) Associated With a Unit Increase in Each Independent Variable

Independent Variable	IRR	p-value	95% CI
% of the population aged 15 years and older without a high school diploma	1.027	0.000	1.012-1.042
Employment rate for the population aged 15 years or older	0.986	0.231	0.964-1.008
Average income after taxes	0.999	0.000	0.999-0.999
% of single-parent families among families with children	1.033	0.000	1.020-1.047
% of population living alone	1.004	0.608	0.986-1.024
% of population separated, divorced, widowed	0.981	0.020	0.966-0.997
% of population socially deprived	0.997	0.525	0.990-1.004
% of population materially deprived	1.005	0.054	0.999-1.011
% of population socially and materially deprived	1.013	0.000	1.006-1.019
% of population whose origin is French	1.001	0.851	0.986-1.016
% of population whose origin is Caribbean	1.059	0.000	1.028-1.092
% of population whose origin is British Isles	0.987	0.140	0.971-1.004
% of population whose origin is Aboriginal	1.157	0.003	1.049-1.276
% of population whose origin is Other North American	1.004	0.360	0.995-1.012
% of population whose origin is Latin American, Central or South American	1.057	0.114	0.986-1.133
% of population whose origin is Western European	0.927	0.006	0.879-0.978
% of population whose origin is Northern European	0.732	0.021	0.562-0.954
% of population whose origin is Eastern European	0.969	0.017	0.945-0.994
% of population whose origin is Southern European	0.991	0.248	0.977-1.00
% of population whose origin is African	1.190	0.000	1.120-1.260
% of population whose origin is Arab	0.985	0.210	0.964-1.000
% of population whose origin is West Asian	0.967	0.333	0.905-1.030
% of population whose origin is South Asian	1.011	0.462	0.980-1.044
% of population whose origin is East or South East Asian	1.000	0.987	0.974-1.027
% of population whose origin is Oceania	0.572	0.482	0.120-2.717
% of population whose origin is Maghreb	0.941	0.091	0.877-1.009

Bolding in the table represents the independent variables that were significantly associated with gonorrhea rates in the multivariate analysis.

Table 3. Final Model With Normalized Data: Adjusted Incidence Rate Ratio (IRR) Associated With a 1 Standard Deviation Increase in Each Independent Variable

Independent Variable	IRR for an Increase of 1 Standard Deviation IRR (95% CI)	Same IRR, Adjusted for Deprivation IRR (95% CI)
% of the population whose origin is African	1.34 (1.20-1.49)	1.35 (1.21-1.52)
% of the population whose origin is Aboriginal	1.32 (1.19-1.46)	1.36 (1.18-1.57)
% of the population whose origin is Caribbean	1.19 (1.07-1.33)	1.20 (1.08-1.34)
% of the population both materially and socially deprived	—	0.998 (0.990-1.004)

that sexually transmitted infections stay within certain ethnic groups because partner choices are more segregated (assortative mixing) than in other groups.^{15,16} Rothenberg et al. demonstrate that in groups with high STI risk, partner concurrency is higher, even though the number of partners over time may be similar.³

Previous studies have shown that STI rates are highest in areas with lower levels of socio-economic status;^{8,10,17,18} however, our results did not demonstrate that among young women in Montréal an association exists between gonorrhea rates and traditional socio-economic status indicators associated with STIs, such as unemployment or material and social deprivation indicators.

We note limitations in the gonorrhea incidence data that were used. They were obtained from reported cases of infection, which are dependent upon medical practitioners testing for infections and on physicians or laboratories reporting positive results. Variations in STI screening practices among physicians may have influenced the number of reported cases.

By focusing only on neighbourhoods of residence of cases, our analysis ignored spatial effects from contiguous neighbourhoods. This omission may have affected our estimates, but it is difficult to determine the extent of the effect. Spatial smoothing is one method that could have been used; however, consensus on appropriate methods for adjusting STI rates to increase reliability of comparisons has not been reached.^{19,20}

STI control strategies currently focus on individual intervention.²¹⁻²³ In the short term, these strategies may have an impact on

interrupting disease transmission.²⁴ However, it has become increasingly apparent that risk factors for STIs cannot be explained solely by individual behaviour.^{25,26} This study is consistent with current findings that suggest that differences in population characteristics (more specifically, ethnicity) are associated with differences in gonorrhea rates.^{7-10,19,25-30} Although ethnicity may be strongly correlated with socio-economic status, our findings demonstrate that there are factors of ethnicity that transcend poverty.²⁹ Our study adds to the evidence that suggests that in order to achieve and sustain reductions in community-level disparities of STIs, public health organizations must pay greater attention to the population characteristics. Inclusion of population data into existing surveillance systems will facilitate the study of their relationship to disease trends at the community level.

Community interventions are rare in the field of prevention and control of STIs, as traditional control strategies have focused primarily on individual characteristics of cases to determine risk factors. However, this study demonstrates that gonorrhea is clustered in neighbourhoods that have high proportions of African, Aboriginal and Caribbean populations. In small cities, it may be possible for the local public health department to interview and follow up on every case to obtain individual characteristics. However, disease rates in Montréal have become and will remain a problem insurmountable with current approaches. Population-level prevention programs could be a useful addition to the current armamentarium.

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RÉSUMÉ

Objectif : L'incidence signalée de la gonorrhée a plus que doublé entre 2000 et 2010 à Montréal et s'est accrue chez les deux sexes et dans tous les groupes d'âge; toutefois, l'augmentation a été particulièrement élevée chez les femmes de 15 à 24 ans. Comme les raisons de cette augmentation chez les jeunes femmes ne sont pas bien comprises, nous avons voulu déterminer si les caractéristiques de la population au niveau des quartiers sont associées au taux d'incidence dans ce groupe, pour contribuer à cibler les stratégies d'intervention.

Méthode : Les nouveaux cas de gonorrhée étudiés étaient des résidentes de Montréal âgées de 15 à 24 ans qui répondaient à la définition de la gonorrhée utilisée au Québec pour la surveillance de cette maladie, avec une date de déclaration se situant entre 2002 et 2009. Des rapports de taux d'incidence (RTI) ajustés ont été estimés par régression binomiale négative; ils montrent l'évolution de l'incidence de la gonorrhée pour chaque augmentation unitaire des variables indépendantes au niveau du quartier, lesquelles incluent des indices de défavorisation matérielle et sociale (plus la combinaison et les composantes des deux indices) et l'origine ethnique. Dans le modèle final, les variables indépendantes ont été normalisées pour faciliter les comparaisons entre leurs RTI respectifs.

Résultats : En tout, 837 cas ont été déclarés (taux d'incidence cumulative de 5,6 p. 100 000). Des proportions plus élevées de personnes d'origine africaine, autochtone et antillaise ont été associées aux taux de gonorrhée supérieurs, même compte tenu des indices de défavorisation.

Conclusion : Les méthodes habituelles de surveillance de la gonorrhée considèrent les caractéristiques individuelles des cas comme des facteurs de risque de la maladie. Nos résultats montrent toutefois que la gonorrhée est regroupée dans des quartiers qui ont des proportions élevées d'habitants des trois groupes ethniques mentionnés. Les constatations de cette démarche écologique montrent que bien que l'ethnicité puisse être fortement corrélée au statut socioéconomique, il y a des facteurs dans l'ethnicité qui transcendent la pauvreté.

Mots clés : gonorrhée; surveillance; épidémiologie