ABSTRACT

Background  Anal cancer is a rare disease, constituting 0.5% of new cancer cases in the United States. The most common subtype is squamous cell carcinoma (scc). Studies in several developed nations have reported on an increasing incidence of anal cancer in recent decades, and various risk factors pertaining to the pathogenesis of the disease have been identified, including infection with the human papillomavirus, tobacco use, and immunosuppression. The epidemiology and distribution of anal scc throughout Canada remain poorly understood, however.

Methods  Using 3 population-based cancer registries, a retrospective analysis of demographic data across Canada for 1992–2010 was performed. The incidence and mortality for anal scc was examined at the levels of provinces, cities, and the forward sortation area (FsA) component (first 3 characters) of postal codes.

Results  During 1992–2010, 3720 individuals were diagnosed with anal scc in Canada; 64% were women. The overall national incidence rate was 6.3 cases per million population per year, with an average age at diagnosis of 60.4 years. The incidence increased over time, with significantly higher incidence rates documented in British Columbia and Nova Scotia (9.3 cases per million population each). Closer examination revealed clustering of cases in various urban centres and self-identified LGBTQ communities in Toronto, Montreal, and Vancouver.

Discussion  This study provides, for the first time, a comprehensive analysis of the burden of anal scc in Canada, identifying susceptible populations and shedding light onto novel avenues of research to lower the incidence of anal cancer throughout the country.

Key Words  Anal cancer, anorectal cancer, anorectal adenocarcinoma, anal squamous cell carcinoma, geographic clustering, epidemiology, incidence in Canada

INTRODUCTION

Anal cancer is one of the least common malignancies worldwide, representing only 2.4% of all gastrointestinal cancers. Cancers of the anal canal can be divided into several subtypes, the most common being squamous cell carcinoma (scc), which accounts for 85% of reported cases. The precursor lesion to anal scc is an anal intraepithelial neoplasia, which can be further classified as either a low-grade or a high-grade squamous intraepithelial neoplasm. The most common symptom at presentation of anal cancer is anorectal bleeding. Treatment of anal cancer depends heavily on the grade and stage of the neoplasm; a multimodal approach is frequently required.

Various risk factors are implicated in the pathogenesis of this malignancy, including infection with the human papillomavirus (HPV), tobacco use, advanced age, and immunosuppression (such as in the case of HIV/AIDS or receipt
of a solid organ transplant)\textsuperscript{7,8}. In addition, risk factors related to sexual practices such as anal receptive intercourse and having multiple sexual partners have been linked to a higher incidence of anal SCC\textsuperscript{3}. A history of dysplasia or malignancy of the cervix, vagina, or vulva has also been found to increase the risk\textsuperscript{3}. Current data demonstrate that, in approximately 90% of all cases of anal SCC, positivity for HPV infection is seen, with most of those infections (approximately 79%) being attributed to HPV strains 16 and 18\textsuperscript{3,9}.

Previous epidemiologic analyses of data from the U.S. Surveillance, Epidemiology, and End Results program\textsuperscript{10} found that anal cancer constitutes only 0.5% of new cancer cases in the United States\textsuperscript{10}. The median age of diagnosis is reported to be approximately 60 years\textsuperscript{3}. However, although this cancer is relatively uncommon, several epidemiologic studies have reported an increasing incidence in recent decades, particularly in developed countries such as Australia\textsuperscript{11}, Scotland\textsuperscript{12}, France\textsuperscript{13}, Denmark\textsuperscript{14}, and the United States\textsuperscript{2,15}. In Canada, limited studies have reported rising rates of anal SCC in Quebec and Alberta in recent years\textsuperscript{16,17}. Because of a low anal cancer incidence rate, the epidemiology of this malignancy is generally poorly documented, and studies describing its epidemiologic characteristics are sparse. For the present study, we conducted an extensive epidemiologic analysis of the burden of anal SCC across all provinces and territories in Canada between 1992 and 2010. The geographic distribution of patients in Canada was analyzed with the aim of better understanding the risk factors related to the pathogenesis of this neoplasm and of identifying communities at high risk for anal SCC.

**METHODS**

Our study was conducted in accordance with the CISS-RDC-668035 and 13-SSH-MCG-3749-5001 protocols approved by, respectively, the Social Sciences and Humanities Research Council of Canada and the Québec Inter-University Center for Social Statistics. In accordance with institutional policy, the study also received an exemption from review by the McGill University Research Ethics Board. The data for anal SCC incidence was examined using two distinct population-based cancer databases: the Canadian Cancer Registry and the Registre québécois du cancer for 1992–2010. Codes set out in the *International Classification of Diseases for Oncology*, 3rd edition, were used for 2 subtypes of anal SCC as reported in previous studies by the authors\textsuperscript{18–41}. To assess causes of mortality, we used the Canadian Vital Statistics database, applying topographic codes from the *International Statistical Classification of Diseases and Related Health Problems*, 9th revision (ICD-9) for deaths occurring during 1992–1999 and 10th revision (ICD-10) for deaths occurring during 2000–2010. Because of space limitations, detailed methods are presented in supplementary Appendix 1.

**RESULTS**

**Demographic and Epidemiologic Characteristics of Patients with Anal SCC in Canada**

The subtypes of anal SCC examined using information gathered from the Canadian Cancer Registry and the Registre québécois du cancer included SCC and verrucous carcinoma. Given that approximately 98% of cases in the database corresponded to the SCC histology, a further breakdown of demographic data by subtype was not performed.

Table 1 presents a general overview of epidemiologic characteristics of anal SCC in Canada for the selected time period. Of 3720 total patients diagnosed with anal SCC, most (64%) were women, for a female:male incidence ratio of 1.8:1. The average age at diagnosis was 60.4 ± 1.6 years, with 74% of the patients being more than 50 years of age. Overall, the annual incidence of anal SCC showed a steady upward trend [Figure 1(A)]. In 1992, the incidence rate was 3.7 cases per million population per year; in 2010, it had risen to approximately 9.0 cases, representing an increase of 142% over 18 years. A notable increase in the incidence rate in 2007 corresponded to a rate of 9.7 cases per million population per year. When examining the annual incidence by sex, a general upward trend over the years was noted [Figure 1(B)], with the highest incidence consistently being seen for women.

A relationship between anal SCC incidence rates and socioeconomic status (SES) was evident. The incidence rates were significantly lower in the highest SES quintile compared with the lowest SES quintile (incidence rate ratio for SES Q5 vs. Q1: 0.20; 95% confidence interval: 0.11 to 0.37). With respect to ethnicity, incidence rates were higher in Q5\textsubscript{white} (highest-SES white individuals) than in Q1\textsubscript{white} (lower-SES white individuals), with an incidence rate ratio of 1.16. However, that increase was not statistically significant (95% confidence interval: 0.99 to 1.36).

**Geographic Distribution of Anal SCC Cases in Canada**

The average national incidence rate for anal SCC during 1992–2010 was 6.3 cases per million population per year (Table 1). Figure 2 presents a geographic analysis of trends in anal SCC throughout the country. On the provincial level, Nova Scotia and British Columbia had incidence rates significantly higher than the national average, at 9.31 cases per million population each. In contrast, Manitoba, Saskatchewan, and Newfoundland and Labrador had significantly lower incidence rates of 5.0, 4.4, and 3.9 cases per million respectively. Prince Edward Island, New Brunswick, Quebec, Ontario, and Alberta had incidence rates that matched the national average. Although the frequencies of anal SCC in the 3 Canadian territories were examined, those frequencies were not within a reportable range.

Incidence rates for Canadian cities (Table II) corroborated the foregoing trends. In total, 120 cities with a reportable frequency of anal SCC between 1992 and 2010 were identified. Of those cities, only 10 had incidence rates significantly higher than the national average. Strikingly, 7 of them (70%) were located in British Columbia, 2 (20%) in Ontario, and 1 (10%) in Nova Scotia. Conversely, of the 12 significantly low-incidence cities identified in Canada during the period of interest, 9 (75%) were located in Ontario; the remaining 3 (25%) were in Quebec.

The distribution within cities or rural areas of patients with anal SCC was then analyzed by the forward sortation area (FSA) component (first 3 characters) of postal codes (Table III, Figures 3–5). Of the 56 high-incidence FSAs identified,
TABLE I Epidemiologic characteristics of anal squamous cell carcinoma, Canada, 1992–2010

| Characteristic | Incidence | Mortality |
|---------------|-----------|-----------|
| Total patients (n) | 3720 | 1110 |
| Sex [n (%)] | | |
| Men | 1325 (36) | 475 (43) |
| Women | 2395 (64) | 635 (57) |
| Age group (n) | | |
| <10 Years | 0 | 0 |
| 10–19 Years | 20 | 0 |
| 20–29 Years | 10 | 0 |
| 30–39 Years | 205 | 30 |
| 40–49 Years | 720 | 110 |
| 50–59 Years | 950 | 210 |
| 60–69 Years | 785 | 250 |
| 70–79 Years | 660 | 255 |
| 80–89 Years | 345 | 195 |
| ≥90 Years | 30 | 45 |
| Average age (years) | 60.42±1.58 | 67.37±3.21 |
| Annual cases (n pmp) | | |
| Average | 6.27 | 1.84 |
| 95% CI | 6.07 to 6.48 | 1.74 to 1.96 |

pmp = per million population; CI = confidence interval.

21 (37.5%) were identified in Ontario; 17 (30.4%) in British Columbia; 10 (17.9%) in Quebec; 2 each (3.6%) in Nova Scotia, New Brunswick, and Alberta; and 1 each (1.7%) in Manitoba and Saskatchewan.

A notably high incidence was found for the M4Y FSA, representing the borough of Church and Wellesley in downtown Toronto, Ontario, with a rate of 46.4 cases per million population per year (95% confidence interval: 28.4 to 71.7), an incidence approximately 7.5 times the national average. A cluster of high-incidence FSAs surrounds Church and Wellesley in Toronto [Figure 3(A)], encompassing High Park/The Junction (M6P), Harbourfront/Regent Park (M5A), St. James Town (M4X), East York (M4J), and North York (M3C). Similarly, a cluster of high-incidence FSAs was identified in the city of Montreal [Figure 3(B)], encompassing Montréal-Nord (H1H), Hochelaga (H1W), Saint-Michel (H2A), Centre-Sud (H2K, H2L), Côte-des-Neiges (H3W), Southern Westmount (H3Z), and Verdun (H4G).

Several notable clusters of anal SCC cases were found in the province of British Columbia. The first (Figure 4) covers a significant part of south Vancouver Island (V0R), Duncan (V9L), and Victoria (V9B, V9A, V8T, V8V). The second (Figure 5) encompasses areas of downtown Vancouver such as West Vancouver (V7V), West End and Stanley Park (V6G), Davie Village (V6E), and the Downtown Eastside (V6A).

Table III identifies 3 statistically significant zero-incidence FSAs in Fredericton, New Brunswick (E3G), Stoneham-et-Tewkesbury, Quebec (G3C), and Sturgeon Country, Alberta (T8T). Of the 56 high-incidence FSAs identified, only 10 (18%) were located in rural areas across the country (Table IV).

Analysis of Mortality from Anal Canal Cancer Across Canada

Table I presents a general overview of the epidemiologic characteristics of anal cancer mortality. Overall, 1110 patients died of anal cancer between 1992 and 2010 in Canada. Most were women (57% vs. 43% men), with a female: male incidence ratio of 1.3:1. The average age at death was 67.4 ± 3.2 years.
FIGURE 2  Incidence and mortality of anal squamous cell carcinoma by province and for Canada (cases per million population per year), 1992–2010. (A) Incidence rates. *Statistically significant lower incidence rate ($p < 0.05$) compared with Canada. **Statistically significant higher incidence rate ($p < 0.05$) compared with Canada. (B) Mortality rates. *Statistically significant lower mortality rate ($p < 0.05$) compared with Canada. **Statistically significant higher mortality rate ($p < 0.05$) compared with Canada.

TABLE II  Incidence of anal squamous cell carcinoma relative to incidence for Canada, Canadian cities, 1992–2010

| City             | Province | Frequency $^a$ | Population $^b$ | Annual incidence (pmp) | 95% CL   |
|------------------|----------|---------------|-----------------|-------------------------|----------|
|                  |          |               |                 |                         | Lower    |
|                  |          |               |                 |                         | Upper    |
| Canada overall   |          |               |                 | 6.27                    | 6.07     |
| High-incidence cities |      |               |                 |                         | 6.48     |
| Vancouver        | BC       | 105           | 560,000         | 9.86                    | 8.07     |
|                  |          |               |                 |                         | 11.94    |
| Langley          | BC       | 20            | 91,000          | 11.54                   | 7.04     |
|                  |          |               |                 |                         | 17.82    |
| Saanich          | BC       | 25            | 106,000         | 12.44                   | 8.05     |
|                  |          |               |                 |                         | 18.37    |
| Penticton        | BC       | 10            | 32,000          | 16.61                   | 7.95     |
|                  |          |               |                 |                         | 30.55    |
| New Westminster  | BC       | 20            | 57,000          | 18.43                   | 11.25    |
|                  |          |               |                 |                         | 28.46    |
| North Cowichan   | BC       | 10            | 27,000          | 19.53                   | 9.35     |
|                  |          |               |                 |                         | 35.92    |
| Georgina         | ON       | 15            | 40,000          | 19.75                   | 11.04    |
|                  |          |               |                 |                         | 32.57    |
| East Hants       | NS       | 10            | 21,000          | 25.04                   | 11.99    |
|                  |          |               |                 |                         | 46.05    |
| Victoria         | BC       | 40            | 76,000          | 27.54                   | 19.68    |
|                  |          |               |                 |                         | 37.51    |
| Carleton Place   | ON       | 5             | 9,000           | 28.57                   | 9.21     |
|                  |          |               |                 |                         | 66.68    |
| Low-incidence cities |      |               |                 |                         |          |
| Vaughan          | ON       | 5             | 210,000         | 1.25                    | 0.40     |
|                  |          |               |                 |                         | 2.92     |
| Scarborough      | ON       | 15            | 559,000         | 1.41                    | 0.79     |
|                  |          |               |                 |                         | 2.33     |
| North York       | ON       | 20            | 590,000         | 1.78                    | 1.09     |
|                  |          |               |                 |                         | 2.76     |
| Richmond Hill    | ON       | 5             | 146,000         | 1.81                    | 0.58     |
|                  |          |               |                 |                         | 4.22     |
| Lévis            | QC       | 5             | 134,000         | 1.96                    | 0.63     |
|                  |          |               |                 |                         | 4.57     |
| Etobicoke        | ON       | 15            | 365,000         | 2.16                    | 1.21     |
|                  |          |               |                 |                         | 3.57     |
| Markham          | ON       | 10            | 236,000         | 2.23                    | 1.07     |
|                  |          |               |                 |                         | 4.10     |
| Mississauga      | ON       | 30            | 635,000         | 2.49                    | 1.68     |
|                  |          |               |                 |                         | 3.55     |
| Quebec City      | QC       | 25            | 504,000         | 2.61                    | 1.69     |
|                  |          |               |                 |                         | 3.85     |
| Brampton         | ON       | 20            | 388,000         | 2.71                    | 1.66     |
|                  |          |               |                 |                         | 4.19     |
| Gatineau         | QC       | 15            | 254,000         | 3.11                    | 1.74     |
|                  |          |               |                 |                         | 5.13     |
| Greater Sudbury  | ON       | 10            | 160,000         | 3.30                    | 1.58     |
|                  |          |               |                 |                         | 6.06     |

---

$^a$ Rounded to the nearest 5.

$^b$ Rounded to the nearest thousand.

pmp = per million population; CL = confidence limits.


### TABLE III Populous forward sortation areas (FSAs) with a high or zero incidence of anal squamous cell carcinoma, Canada, 1992–2010

| FSA   | Province        | Frequency | Population | Annual incidence | 95% CL |
|-------|-----------------|-----------|------------|------------------|--------|
|       |                 |           | (pmp)      |                  | Lower  | Upper  |
| High-incidence FSAs |               |           |            |                  |        |        |
| B0K   | NS              | 10        | 38,390     | 13.71            | 6.56   | 25.21  |
| B3A   | NS              | 10        | 20,440     | 25.75            | 12.33  | 47.36  |
| E1C   | NB              | 10        | 29,160     | 18.05            | 8.64   | 33.20  |
| E7M   | NB              | 5         | 9,700      | 27.13            | 8.74   | 63.31  |
| H1H   | QC              | 10        | 34,700     | 15.17            | 7.26   | 27.90  |
| H1W   | QC              | 10        | 28,140     | 18.70            | 8.95   | 34.40  |
| H2A   | QC              | 10        | 18,510     | 28.43            | 13.61  | 52.29  |
| H2K   | QC              | 15        | 27,080     | 29.15            | 16.30  | 48.09  |
| H2L   | QC              | 10        | 22,250     | 23.65            | 11.32  | 43.50  |
| H3W   | QC              | 10        | 31,110     | 16.92            | 8.10   | 31.11  |
| H3Z   | QC              | 5         | 11,680     | 22.53            | 7.26   | 52.58  |
| H4G   | QC              | 10        | 28,700     | 18.34            | 8.78   | 33.73  |
| J2G   | QC              | 10        | 36,570     | 14.39            | 6.89   | 26.47  |
| J4K   | QC              | 10        | 25,480     | 20.66            | 9.89   | 37.99  |
| K0G   | ON (Eastern)    | 10        | 33,410     | 15.75            | 7.54   | 28.97  |
| K0L   | ON (Eastern)    | 15        | 68,320     | 11.56            | 6.46   | 19.06  |
| K3L   | ON (Eastern)    | 10        | 17,310     | 30.41            | 14.56  | 55.92  |
| K8P   | ON (Eastern)    | 10        | 20,490     | 25.69            | 12.30  | 47.24  |
| L0M   | ON (Central)    | 10        | 31,170     | 16.89            | 8.08   | 31.05  |
| L1G   | ON (Central)    | 10        | 41,740     | 12.61            | 6.04   | 23.19  |
| L2R   | ON (Central)    | 10        | 24,670     | 21.33            | 10.21  | 39.24  |
| L4P   | ON (Central)    | 10        | 24,330     | 21.63            | 10.36  | 39.79  |
| L6K   | ON (Central)    | 5         | 12,650     | 20.80            | 6.70   | 48.55  |
| L8K   | ON (Central)    | 10        | 32,510     | 16.19            | 7.75   | 29.77  |
| L8L   | ON (Central)    | 10        | 33,520     | 15.70            | 7.52   | 28.88  |
| M3C   | ON (Toronto)    | 10        | 35,780     | 14.71            | 7.04   | 27.05  |
| M4J   | ON (Toronto)    | 10        | 35,710     | 14.74            | 7.06   | 27.11  |
| M4K   | ON (Toronto)    | 10        | 32,250     | 16.32            | 7.81   | 30.01  |
| M4X   | ON (Toronto)    | 10        | 20,740     | 25.38            | 12.15  | 46.67  |
| M4Y   | ON (Toronto)    | 20        | 22,660     | 46.45            | 28.36  | 71.75  |
| M5A   | ON (Toronto)    | 10        | 32,840     | 16.03            | 7.67   | 29.48  |
| M6P   | ON (Toronto)    | 10        | 37,400     | 14.07            | 6.74   | 25.88  |
| N6C   | ON (Southern)   | 10        | 32,200     | 16.35            | 7.83   | 30.06  |
| N9C   | ON (Southern)   | 5         | 12,810     | 20.54            | 6.62   | 47.94  |
| P0K   | ON (Northern)   | 5         | 12,270     | 21.45            | 6.91   | 50.05  |
| R3B   | MB              | 5         | 11,580     | 22.73            | 7.32   | 53.03  |
| S7K   | SK              | 10        | 39,180     | 13.43            | 6.43   | 24.71  |
| T0E   | AB              | 10        | 40,240     | 13.08            | 6.26   | 24.06  |
| T3B   | AB              | 10        | 34,780     | 15.13            | 7.24   | 27.83  |
| V0B   | BC              | 10        | 32,860     | 16.02            | 7.67   | 29.46  |
| V0H   | BC              | 15        | 50,980     | 15.49            | 8.66   | 25.54  |
| V0R   | BC              | 15        | 64,150     | 12.31            | 6.88   | 20.30  |
| V0X   | BC              | 10        | 19,960     | 26.37            | 12.62  | 48.50  |
| V1R   | BC              | 5         | 9,950      | 26.45            | 8.52   | 61.72  |
| V2A   | BC              | 10        | 35,040     | 15.02            | 7.19   | 27.63  |
TABLE III  Continued

| FSA | Province | Frequency | Population a | Annual incidence (pmp) | 95% CL |
|-----|----------|-----------|--------------|------------------------|--------|
|     |          |           |              |                        | Lower  | Upper  |
|     |          |           |              |                        |        |        |
|     |          |           |              |                        |        |        |

High-incidence FSAs, continued

| FSA | Province | Frequency | Population | Annual incidence (pmp) | 95% CL |
|-----|----------|-----------|------------|------------------------|--------|
|     | BC       | 10        | 18,750     | 30.75                  | 16.14  | 53.60  |
|     | BC       | 15        | 9,800      | 21.76                  | 12.20  | 42.30  |
|     | BC       | 20        | 16,500     | 30.76                  | 17.87  | 55.50  |
|     | BC       | 10        | 34,410     | 15.30                  | 7.32   | 28.13  |
|     | BC       | 10        | 34,870     | 15.09                  | 7.23   | 27.76  |
|     | BC       | 15        | 22,550     | 35.01                  | 19.58  | 57.75  |
|     | BC       | 20        | 24,280     | 43.35                  | 26.47  | 66.96  |
|     | BC       | 10        | 15,000     | 35.09                  | 16.80  | 64.53  |
|     | BC       | 10        | 18,150     | 29.00                  | 13.88  | 53.33  |
|     | BC       | 10        | 23,770     | 44.28                  | 27.04  | 68.40  |
|     | BC       | 15        | 34,760     | 22.71                  | 12.70  | 37.46  |
|     | BC       | 10        | 32,330     | 16.28                  | 7.79   | 29.94  |
|     | BC       | 10        | 31,560     | 16.28                  | 7.98   | 30.67  |

Zero-incidence FSAs

| FSA | Province | Frequency | Population | Annual incidence (pmp) | 95% CL |
|-----|----------|-----------|------------|------------------------|--------|
|     | AB       | 0         | 5,360      | 0                      | 0      | 36.02  |
|     | QC       | 0         | 7,660      | 0                      | 0      | 25.20  |
|     | NB       | 0         | 8,120      | 0                      | 0      | 23.78  |

* Rounded to the nearest 10.
pmp = per million population; CL = confidence limits.

FIGURE 3  Incidence rate trends relative to the national average for anal squamous cell carcinoma (cases per million population per year) by forward sortation area [FSA (first 3 characters of a postal code)]. Based on the Canadian Cancer Registry and the Registre québécois du cancer databases. (A) Ontario: high-incidence FSAs in the Greater Toronto Area, including the highest incidence FSA, M4Y, representing the borough of Church and Wellesley in downtown Toronto. (B) Quebec: high-incidence FSAs in the Greater Montreal Area.

The annual mortality from anal cancer showed an overall upward trend [Figure 1(C)]. In 1992, the mortality rate was 1.2 cases per million population per year; in 2010, that rate had risen to 2.9 cases, representing an increase of 138% over 18 years. The average national mortality rate for anal cancer between 1992 and 2010 was 1.8 cases per million population per year. Tables v and vi and Figure 6 present a geographic analysis of anal cancer mortality.
trends throughout the country. Further analysis of those results can be found in supplementary Appendix 2.1.

**DISCUSSION**

In this report, we present extensive data on the epidemiology of anal SCC throughout Canada during 1992–2010 at the provincial, municipal, and FSA levels. To the best of our knowledge, no previous study has assessed the distribution of anal SCC across the entire country and to this level of detail. At the national level, we report a steadily increasing burden of anal SCC, with a female predominance and an average incidence rate of 6.3 cases per million individuals per year. Similar trends have been observed in several studies conducted in Europe, Australia, and the United States \(^{11,13,15,43,44}\). The results of those studies are further detailed in supplementary Appendix 3.1. Geographic analysis of anal SCC trends throughout the country demonstrated clustering of cases in the 3 largest cities in Canada, located in the provinces of Ontario [Figure 3(A)], Quebec [Figure 3(B)], and British Columbia (Figures 4 and 5). The highest incidence of anal SCC nationwide was located in the borough of Church and Wellesley, an area known as “The Village,” a historic neighborhood for LGBTQ communities \(^{45,46}\). Similarly, significant clusters were found in Montreal’s Gay Village and Vancouver’s Davie Village \(^{47,48}\). The others corresponded to the boroughs predominantly inhabited by low-income or immigrant populations \(^{49–53}\). Those findings are corroborated by our analysis of median income by FSA, which demonstrated a statistically significant relationship between low SES and a high incidence rate of anal SCC. Further details concerning those FSA clusters are provided in supplementary Appendix 3.2.

We report a significantly higher incidence of anal SCC in urban areas, with only 18% of cases found in rural FSAs. The same trend has been noted in Norway and the United States \(^{44,54}\). This predilection of anal SCC for urban centres might reflect an increased concentration of individuals exposed to predisposing risk factors for the disease—namely, changes in sexual practices leading to increased HPV transmission, tobacco use, and HIV infection. Changes in sexual practices throughout the world, such as lower age at first intercourse, higher number of sexual partners, and increased practice of anal receptive intercourse, might be contributing to the increasing incidence of anal SCC \(^{55–57}\). The increased incidence of this disease was observed in...
| FSA     | Province     | Frequency | Population a (pmp) | Annual incidence (pmp) | 95% CL         |
|---------|--------------|-----------|--------------------|------------------------|----------------|
| B3A     | NS           | 10        | 20,440             | 25.75                  | 12.33, 47.36   |
| E1C     | NB           | 10        | 29,160             | 18.05                  | 8.64, 33.20    |
| E7M     | NB           | 5         | 9,700              | 27.13                  | 8.74, 63.31    |
| H1H     | QC           | 10        | 34,700             | 15.17                  | 7.26, 27.90    |
| H1W     | QC           | 10        | 28,140             | 18.70                  | 8.95, 34.40    |
| H2A     | QC           | 10        | 18,510             | 28.43                  | 13.61, 52.29   |
| H2K     | QC           | 15        | 27,080             | 29.35                  | 16.30, 48.09   |
| H2L     | QC           | 10        | 22,250             | 23.65                  | 11.32, 43.50   |
| H3W     | QC           | 10        | 31,110             | 16.92                  | 8.30, 31.11    |
| H3Z     | QC           | 5         | 11,680             | 22.53                  | 7.26, 52.58    |
| H4G     | QC           | 10        | 28,700             | 18.34                  | 8.78, 33.73    |
| J2G     | QC           | 10        | 36,570             | 14.39                  | 6.89, 26.47    |
| J4K     | QC           | 10        | 25,480             | 20.66                  | 9.89, 37.99    |
| K1L     | ON (Eastern) | 10        | 17,310             | 30.41                  | 14.56, 55.92   |
| K8P     | ON (Eastern) | 10        | 20,490             | 25.69                  | 12.30, 47.24   |
| L1G     | ON (Central) | 10        | 41,740             | 12.61                  | 6.04, 23.19    |
| L2R     | ON (Central) | 10        | 24,670             | 21.33                  | 10.21, 39.24   |
| L4P     | ON (Central) | 10        | 24,330             | 21.63                  | 10.36, 39.79   |
| L6K     | ON (Central) | 5         | 12,650             | 20.80                  | 6.70, 48.55    |
| L8K     | ON (Central) | 10        | 32,510             | 16.19                  | 7.75, 29.77    |
| L8L     | ON (Central) | 10        | 33,520             | 15.70                  | 7.52, 28.88    |
| M3C     | ON (Toronto) | 10        | 35,780             | 14.71                  | 7.04, 27.05    |
| M4J     | ON (Toronto) | 10        | 35,710             | 14.74                  | 7.06, 27.11    |
| M4K     | ON (Toronto) | 10        | 32,250             | 16.32                  | 7.81, 30.01    |
| M4X     | ON (Toronto) | 10        | 20,740             | 25.38                  | 12.15, 46.67   |
| M4Y     | ON (Toronto) | 20        | 22,660             | 46.45                  | 28.36, 71.75   |
| M5A     | ON (Toronto) | 10        | 32,840             | 16.63                  | 7.67, 29.48    |
| M6P     | ON (Toronto) | 10        | 37,400             | 14.07                  | 6.74, 25.88    |
| N6C     | ON (Southern)| 10        | 32,200             | 16.35                  | 7.83, 30.06    |
| N9C     | ON (Southern)| 5         | 12,810             | 20.54                  | 6.62, 47.94    |
| R3B     | MB           | 5         | 11,580             | 22.73                  | 7.32, 53.03    |
| S7K     | SK           | 10        | 39,180             | 13.43                  | 6.43, 24.71    |
| T3B     | AB           | 10        | 34,780             | 15.13                  | 7.24, 27.83    |
| V1R     | BC           | 5         | 9,950              | 26.45                  | 8.52, 61.72    |
| V2A     | BC           | 10        | 35,040             | 15.02                  | 7.19, 27.63    |
| V3M     | BC           | 10        | 34,410             | 15.30                  | 7.32, 28.13    |
| V4A     | BC           | 10        | 34,870             | 15.09                  | 7.23, 27.76    |
| V6A     | BC           | 10        | 16,530             | 31.84                  | 15.24, 58.56   |
| V6E     | BC           | 15        | 22,550             | 35.01                  | 19.58, 57.75   |
| V6G     | BC           | 20        | 24,280             | 43.35                  | 26.47, 66.96   |
| V7V     | BC           | 10        | 15,000             | 35.09                  | 16.80, 64.53   |
| V8T     | BC           | 10        | 18,150             | 29.00                  | 13.88, 53.33   |
| V8V     | BC           | 20        | 23,770             | 44.28                  | 27.04, 68.40   |
| V9A     | BC           | 15        | 34,760             | 22.71                  | 12.70, 37.46   |
| V9B     | BC           | 10        | 32,330             | 16.28                  | 7.79, 29.94    |
| V9L     | BC           | 10        | 31,560             | 16.68                  | 7.98, 30.67    |
### TABLE IV  Continued

| FSA | Province | Frequency | Population<sup>a</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|-----|----------|-----------|-------------------------|-------------------------------------|--------|-------|-------|
| Rural |          |           |                         |                                     |        |       |       |

| FSA | Province | Frequency | Population<sup>a</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|-----|----------|-----------|-------------------------|-------------------------------------|--------|-------|-------|
| B0K  | NS       | 10        | 38,390                  | 13.71                               | 6.56   | 25.21 |
| K0G  | ON (Eastern) | 10       | 33,410                  | 15.75                               | 7.54   | 28.97 |
| K0L  | ON (Eastern) | 15       | 68,320                  | 11.56                               | 6.46   | 19.06 |
| L0M  | ON (Central) | 10       | 31,170                  | 16.89                               | 8.08   | 31.05 |
| P0K  | ON (Northern) | 5        | 12,270                  | 21.45                               | 6.91   | 50.05 |
| TOE  | AB       | 10        | 40,240                  | 13.08                               | 6.26   | 24.06 |
| V0B  | BC       | 10        | 32,860                  | 16.02                               | 7.67   | 29.46 |
| V0H  | BC       | 15        | 50,980                  | 15.49                               | 8.66   | 25.54 |
| V0R  | BC       | 15        | 64,150                  | 12.31                               | 6.88   | 20.30 |
| V0X  | BC       | 10        | 19,960                  | 26.37                               | 12.62  | 48.50 |

<sup>a</sup> Rounded to the nearest 10.

<sup>b</sup> pmp = per million population; CL = confidence limits.

### TABLE V  Mortality from anal cancer in high-mortality and low-mortality cities compared with the average mortality rate from anal cancer, Canada, 1992–2010

| City | Province | Frequency<sup>a</sup> | Population<sup>b</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|------|----------|------------------------|-------------------------|-------------------------------------|--------|-------|-------|

| City | Province | Frequency<sup>a</sup> | Population<sup>b</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|------|----------|------------------------|-------------------------|-------------------------------------|--------|-------|-------|
| Canada overall |          |                        |                         |                                     |        |       |       |
| Winnipeg | MB | 35                     | 649,000                  | 2.84                                | 1.98   | 3.95 |
| Montreal  | QC  | 100                    | 1,635,000                | 3.22                                | 2.62   | 3.92 |
| Vancouver | BC  | 40                     | 591,000                  | 3.56                                | 2.54   | 4.85 |
| London    | ON  | 25                     | 359,000                  | 3.67                                | 2.37   | 5.41 |
| Langley   | BC  | 10                     | 99,000                   | 5.32                                | 2.55   | 9.78 |
| Cornwall  | ON  | 5                      | 46,340                   | 5.68                                | 1.84   | 13.25 |
| Victoria  | BC  | 15                     | 79,000                   | 9.99                                | 5.59   | 16.48 |
| Greenfield Park | QC | 5                      | 17,160                   | 15.34                               | 4.98   | 35.79 |

<sup>a</sup> Rounded to the nearest 5.

<sup>b</sup> Rounded to the nearest 1000.

<sup>b</sup> pmp = per million population; CL = confidence limits.

### TABLE VI  Populous forward sortation areas (FSAs) with high anal cancer mortality, Canada, 1992–2010

| FSA | Province | Frequency | Population<sup>a</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|-----|----------|-----------|-------------------------|-------------------------------------|--------|-------|-------|

| FSA | Province | Frequency | Population<sup>a</sup> | Annual incidence<sup>b</sup> (pmp) | 95% CL | Lower | Upper |
|-----|----------|-----------|-------------------------|-------------------------------------|--------|-------|-------|
| V6E | BC       | 5         | 22,550                  | 11.67                               | 3.79   | 27.23 |
| H4L | QC       | 5         | 32,940                  | 7.99                                | 2.59   | 18.64 |
| V0N | BC       | 5         | 77,040                  | 3.42                                | 1.11   | 7.97 |
| J0K | QC       | 5         | 132,200                 | 1.99                                | 0.65   | 4.65 |

<sup>a</sup> Rounded to the nearest 1000.

<sup>b</sup> pmp = per million population; CL = confidence limits.
Western countries. Tobacco use has been cited as a risk factor for anal SCC; however, the rate of tobacco use throughout Canada has been steadily decreasing, and therefore might not be one of the most contributory risk factors in this population. Infection with HIV has also been cited as an important risk factor for the pathogenesis of anal SCC, and its prevalence throughout Canada has been increasing, particularly in men having sex with men (MSM), representing 47% of national cases in 2011. Clustering of HIV cases in MSM has been noted in Ontario, Quebec, and British Columbia, and in fact, we report clustering of anal SCC cases in the FSA that encompass the 3 largest self-identified LGBTQ communities in the country, which are also located in those 3 provinces. Similar trends have been observed worldwide and have been attributed to higher proportions of MSM, leading to an increased prevalence of anal receptive intercourse. Data for the prevalence of HPV-identifying individuals by FSA were not available for our study. However, in parts of the world where that information has been available, similar trends have been observed; they are detailed in supplementary Appendix 3.3.

The incidence of HPV-related cancers is increasing internationally; however, it appears that the frequency of anal SCC is increasing the most dramatically of all—in both sexes and most ethnic groups. Despite those observations, no national anal SCC screening guidelines are in place. Since 2010, widespread HPV vaccination programs have been instituted across Canada, leading to significant declines in the prevalences of HPV, anogenital warts, and cervical cancer in every province. Cervical cancer and anal SCC have both been strongly linked to the same particular strain, HPV 16. Cost–benefit analyses of anal cancer screening in women with cervical cancer and in MSM with and without concomitant HIV infection have shown that vaccine campaigns against HPV 16, regular digital rectal examination, and anal Pap smear screening could be beneficial in reducing morbidity and mortality from the disease. Given the increasing rate of anal SCC and lack of knowledge about this disease in high-risk groups, it might be useful to consider instituting screening or vaccination programs for susceptible populations in the Canadian urban centres with higher incidences.

It is often believed that routine screening for anal cancer could cause physical and psychological discomfort to patients, but a study performed in 2011 in Toronto found that only 15%–32% of 104 regularly screened patients reported negative psychological consequences associated with the screening process. In fact, the largest barrier to care for these high-risk patient groups, both male and female, is the lack of knowledge and awareness about the disease, its risk factors, and the available prevention and screening resources. Through this study, our group has provided data that can be used to target populations within each province affected by a high burden of anal SCC, consequently providing increased opportunities and needs for intervention and outreach. The information we have compiled might help to guide community health ambassadors in developing targeted and culturally appropriate education and promotion campaigns to raise awareness of the risk factors for anal cancer, of screening methods, and of HPV vaccination. Primary health care workers within affected communities can be encouraged to incorporate screening questionnaires, relevant physical exams, and HPV vaccination more readily into their practice, and they in turn can encourage their patients to perform self-directed anal visual inspection regularly at home.

Our results could be further correlated with demographic information (such as education level, income, employment status, location and accessibility of medical specialists in the region) from other Canadian studies, to contribute to health care policy development and resource allocation.

Our study is not without limitations; large retrospective studies that use databases such as those used here present a risk of data omission or misclassification. When conducting our search, different sets of ICD codes had to be used, depending on the year of interest. Data for the Canadian territories were generally sparse, and therefore not sufficiently statistically significant to comment on. Data concerning the prevalence of various sexual orientations and sexual practices by region were not available for our study, but might have strengthened the clustering trends observed. Finally, because of federal confidentiality regulations and the associated mandatory rounding and suppression of data at too-low frequencies, the data obtained could not be presented in their entirety.

CONCLUSIONS

This epidemiology study highlights areas of clustering of anal SCC throughout Canada, localizing it to the 3 main urban centres: Toronto, Montreal, and Vancouver. We provide an overview of risk factors to consider, particularly in susceptible populations in the inner cities and in LGBTQ-predominant communities. Future analyses might confirm the existence of those risk factors in those communities. Our report also provides the basis for highlighting areas of Canada that could benefit from more efforts in education, primary prevention, and screening for the disease, and more focused distribution of health care resources to lower the incidence, morbidity, and mortality relating to anal cancer throughout the country.

ACKNOWLEDGMENTS

This work was supported by a Cole Foundation grant to IVL, Canadian Foundation of Dermatology research grants to DS and IVL, and Fonds de recherche du Québec–Santé (nos. 34753 and 36769) research grants to IVL. No funding body had any role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

CONFLICT OF INTEREST DISCLOSURES

We have read and understood Current Oncology's policy on disclosing conflicts of interest, and we declare that we have none.

AUTHOR AFFILIATIONS

*Department of Medicine, McGill University, Montreal, QC; †Division of Dermatology, University of Ottawa, Ottawa, ON; ‡Division of Dermatology and §Division of Gastroenterology, McGill University, Montreal, QC.

REFERENCES

1. Hoff PM, Coudry R, Moniz CM. Pathology of anal cancer. Surg Oncol Clinics N Am 2017;26:57–71.
2. Nelson RA, Levine AM, Bernstein L, Smith DD, Lai LL.
Changing patterns of anal canal carcinoma in the United States. *J Clinical Oncol* 2013;31:1569–75.

3. Symer MM, Yeo HL. Recent advances in the management of anal cancer. *F1000Res* 2018;7:F1000 Faculty Rev-1572.

4. Darragh TM, Colgan TJ, Cox JT, et al. on behalf of the members of the LAST project work groups. The Lower Anogenital Squamous Terminology standardization project for HPV-associated lesions: background and consensus recommendations from the College of American Pathologists and the American Society for Colposcopy and Cervical Pathology. *Arch Pathol Lab Med* 2012;136:1266–97. [Erratum in: *Arch Pathol Lab Med* 2013;137:738]

5. Shridhar R, Shibata D, Chan E, Thomas CR. Anal cancer: current standards in care and recent changes in practice. *CA Cancer J Clin* 2015;65:139–62.

6. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology: Anal Carcinoma. Ver. 2.2002. Fort Washington, PA: NCCN; 2020. [Current version available online at: https://www.nccn.org/professionals/physician_gls/pdf/anal.pdf (free registration required); cited 16 May 2020]

7. Uronis HE, Bendell JC. Anal cancer: an overview. *Oncologist* 2007;12:524–34.

8. Welton ML, Sharkey FE, Kahlenberg MS. The etiology and epidemiology of anal cancer. *Surg Oncol Clin N Am* 2004;13:263–75.

9. Giuliano AR, Nyitray AG, Kreimer AR, et al. *Eur J Obstet Gynecol Reprod Biol* 2014 roadmap: differences in human papillomavirus infection natural history, transmission and human papillomavirus–related cancer incidence by gender and anatomic site of infection. *Int J Cancer* 2015;136:2752–60.

10. United States, Department of Health and Human Services, National Institutes of Health, National Cancer Institute (NCI). Surveillance, Epidemiology, and End Results program. Cancer Stat Facts: Anal Cancer [Web page]. Bethesda, MD: NCI; 2018. [Available at: https://seer.cancer.gov/statfacts/html/ anus.html; cited 16 May 2020]

11. Soeberg MJ, Rogers K, Currrow DC, Young JM. Trends in incidence and survival for anal cancer in New South Wales, Australia, 1972–2009. *Cancer Epidemiol* 2015;39:842–7.

12. Brewster DH, Bhatti LA. Increasing incidence of squamous cell carcinoma of the anus in Scotland, 1975–2002. *Br J Cancer* 2006;95:87–90.

13. Bouvier AM, Belot A, Manfredi S, et al. on behalf of the French network of cancer registries FRANCIM. Trends of incidence and survival in squamous-cell carcinoma of the anal canal in France: a population-based study. *Eur J Cancer Prev* 2016;25:182–7.

14. Nielsen A, Munk C, Kjær SK. Trends in incidence of anal cancer and high-grade anal intraepithelial neoplasia in Denmark, 1978–2008. *Int J Cancer* 2012;130:1168–73.

15. Shiwes LS, Kreimer AR, Coghill AE, Darragh TM, Devesa SS. Anal cancer incidence in the United States, 1977–2011: distinct patterns by histology and behavior. *Cancer Epidemiol Biomarkers Prev* 2015;24:1548–56.

16. Shack L, Lau HY, Huang L, Doll C, Hao D. Trends in the incidence of human papillomavirus-related noncervical and cervical cancers in Alberta, Canada: a population-based study. *CMAJ Open* 2014;2:E127–32.

17. Louchini R, Goggin P, Steben M. The evolution of HPV-related anogenital cancers reported in Quebec—incidence rates and survival probabilities. *Chron Dis Can* 2008;28:99–106.

18. Amar L, Le M, Ghazawi FM, et al. Prevalence of human T-cell lymphotropic virus 1 infection in Canada. *Curr Oncol* 2019;26:e3–5.

19. Cattelan L, Ghazawi FM, Le M, et al. Epidemiologic trends and geographic distribution of esophageal cancer in Canada: a national population-based study. *Cancer Med* 2020;9:401–17.

20. Darwich R, Ghazawi FM, Rahme E, et al. Retinoblastoma incidence trends in Canada: a national comprehensive population-based study. *J Pediatr Ophthalmol Strabismus* 2019;56:124–30.

21. Darwich R, Ghazawi FM, Rahme E, et al. Epidemiology of ophthalmic lymphoma in Canada during 1992–2010. *Br J Ophthalmol* 2019;61:149–57. [Epub ahead of print].

22. Ghazawi FM, Alghazawi N, Le M, et al. Environmental and other extrinsic risk factors contributing to the pathogenesis of cutaneous T-cell lymphoma (CTCL). *Front Oncol* 2019;9:300.

23. Ghazawi FM, Cyr J, Darwich R, et al. Cutaneous malignant melanoma incidence and mortality trends in Canada: a comprehensive population-based study. *J Am Acad Dermatol* 2019;80:448–59.

24. Ghazawi FM, Darwich R, Le M, et al. Incidence trends of conjunctival malignant melanoma in Canada. *Br J Ophthalmol* 2020;104:23–5.

25. Ghazawi FM, Darwich R, Le M, et al. Uveal melanoma incidence trends in Canada: a national comprehensive population-based study. *Br J Ophthalmol* 2019;103:1872–6.

26. Ghazawi FM, Le M, Alghazawi N, et al. Trends in incidence of cutaneous malignant melanoma in Canada: 1992–2010 versus 2011–2015. *J Am Acad Dermatol* 2019:80:1157–9.

27. Ghazawi FM, Le M, Cyr J, et al. Analysis of acute myeloid leukemia incidence and geographic distribution in Canada from 1992 to 2010 reveals disease clusters in Sarnia and other industrial US border cities in Ontario. *Cancer* 2019;125:1866–97.

28. Ghazawi FM, Le M, Lagace F, et al. Incidence, mortality, and spatiotemporal distribution of cutaneous malignant melanoma cases across Canada. *J Cutan Med Surg* 2019;23:394–412.

29. Ghazawi FM, Litvinov IV. Distribution and clustering of cutaneous T-cell lymphoma (CTCL) cases in Canada: a response to a letter. *J Cutan Med Surg* 2018;22:657–8. [Comment on: Ghazawi FM, Netchiporouk E, Rahme E, et al. Distribution and clustering of cutaneous T-cell lymphoma (CTCL) cases in Canada during 1992 to 2010. *J Cutan Med Surg* 2018;22:154–65]

30. Ghazawi FM, Netchiporouk E, Rahme E, et al. Comprehensive analysis of cutaneous T-cell lymphoma (CTCL) incidence and mortality in Canada reveals changing trends and geographic clustering for this malignancy. *Cancer* 2017;123:3550–67.

31. Ghazawi FM, Netchiporouk E, Rahme E, et al. Distribution and clustering of cutaneous T-cell lymphoma (CTCL) cases in Canada during 1992 to 2010, *J Cutan Med Surg* 2018;22:154–65.

32. Lagace F, Ghazawi FM, Le M, et al. Analysis of incidence, mortality trends, and geographic distribution of breast cancer patients in Canada. *Breast Cancer Res Treat* 2019;178:683–91.

33. Lagace F, Ghazawi FM, Le M, et al. Penile invasive squamous cell carcinoma: analysis of incidence, mortality trends, and geographic distribution in Canada. *J Cutan Med Surg* 2020;24:124–8.

34. Le M, Ghazawi FM, Alakel A, et al. Incidence and mortality trends and geographic patterns of follicular lymphoma in Canada. *Curr Oncol* 2019;26:e473–81.

35. Le M, Ghazawi FM, Rahme E, et al. Identification of significant geographic clustering of polycythemia vera cases in Montreal, Canada. *Cancer* 2019;125:3953–9.

36. Lefrancois P, Tetzlaff MT, Moreau L, et al. *TruSeq*-based gene expression analysis of formalin-fixed paraffin-embedded (FFPE) cutaneous T-cell lymphoma samples: subgroup analysis results and elucidation of biases from FFPE sample processing on the TruSeq platform. *Front Med (Lausanne)* 2017;4:153.

37. Lefrancois P, Xie P, Wang L, et al. Gene expression profiling and immune cell-type deconvolution highlight robust disease progression and survival markers in multiple cohorts of CTCL patients. *Oncoimmunology* 2018;7:e1467856.
38. Litvinov IV, Tetzlaff MT, Rahme E, et al. Identification of geographic clustering and regions spared by cutaneous T-cell lymphoma in Texas using 2 distinct cancer registries. Cancer 2015;121:1993–2003.

39. Litvinov IV, Tetzlaff MT, Rahme E, et al. Demographic patterns of cutaneous T-cell lymphoma incidence in Texas based on two different cancer registries. Cancer Med 2015;4:1440–7.

40. Litvinov IV, Tetzlaff MT, Thibault P, et al. Gene expression analysis in cutaneous T-cell lymphomas (CTCL) highlights disease heterogeneity and potential diagnostic and prognostic indicators. Oncoimmunology 2017;6:e1306618.

41. Tsang M, Le M, Ghazawi FM, et al. Multiple myeloma epidemiology and patient geographic distribution in Canada: a population study. Cancer 2019;125:2435–44.

42. Wellings K, Collumbien M, Slaymaker E, et al. Sexual behaviour in context: a global perspective. Lancet 2006;368:1706–28.

43. Wilkinson JR, Morris EJ, Downing A, et al. Sexual health and HIV in countries: increasing burden of disease. PloS One 2018;13:e0205105.

44. Guren MG, Aagnes B, Nygard M, Dahl O, Moller B. Rising incidence and improved survival of anal squamous cell carcinoma in Norway, 1987–2016. Clin Colorectal Cancer 2019;18:e96–103.

45. Daling JR, Madeleine MM, Johnson LG, et al. Multiple myeloma epidemiology and patient geographic distribution in Canada: a population study. Cancer Causes Control 2015;4:1440–7.

46. Nash CJ. Querening, Neighbourhoods: Politics and Practice in Toronto. St. Catharines, ON: Brock University; 2008.

47. Hinrichs DW. Montreal’s Gay Village: The Story of a Unique Urban Neighborhood Through the Sociological Lens. Bloomington, IN: iUniverse; 2011.

48. Borbridge R. Sexuality and the City: Exploring Gaybourhoods and the Urban Village Form in Vancouver, BC. Winnipeg, MB: University of Manitoba; 2008.

49. August M. Challenging the rhetoric of stigmatization: the benefits of concentrated poverty in Toronto’s Regent Park. Environ Plan A 2014;46:1317–33.

50. Galabuzi GE, Sidhu N, Fumia D on behalf of Poverty and Employment Precarity in Southern Ontario (PEPSO). Case Study #5: Impact of High Levels of Precarity on Urban Neighbourhood Economics and Particular Populations in Toronto [unpublished report]. Toronto, ON: McMaster University, Faculty of Social Sciences, PEPSO, 2014. [Available online at: https://pepso.ca/documents/city-of-toronto-reportjan-2015.pdf; cited 26 May 2020]

51. Lemelin A, Morin R. L’approche locale et communautaire au développement économique des zones défavorisées: le cas de Montréal. Cahiers de géographie du Québec 1991;35:285–306.

52. Apparicio P, Séguin AM. Measuring the accessibility of services and facilities for residents of public housing in Montreal. Urban Studies 2006;43:187–211.

53. Linden IA, Mar MY, Werker GR, Jang K, Krausz M. Research on a vulnerable neighborhood-the Vancouver downtown eastside from 2001 to 2011. J Urban Health 2013;90:599–73.

54. Amirian ES, Fickey PA Jr, Scheurer ME, Chiao EY. Anal cancer incidence and survival: comparing the greater San-Francisco Bay Area to other SEER cancer registries. PloS One 2013;8:e58919.

55. Daling JR, Madeleine MM, Johnson LG, et al. Human papillomavirus, smoking, and sexual practices in the etiology of anal cancer. Cancer 2004;101:270–80.

56. Tseng HF, Morgenstern H, Mack TM, Peters RK. Risk factors for anal cancer: results of a population-based case–control study. Cancer Causes Control 2003;14:837–46.

57. Moscicki AB, Ma Y, Farhat S, et al. Natural history of anal human papillomavirus infection in heterosexual women and risks associated with persistence. Clin Infect Dis 2014;58:804–11.

58. Islami F, Ferlay J, Lortet-Tieulent J, Bray F, Jemal A. International trends in anal cancer incidence rates. Int J Epidemiol 2017;46:924–38.

59. Lam JO, Lim WY, Chow KY, D’Souza G. Incidence, trends and ethnic differences of oropharyngeal, anal and cervical cancers: Singapore, 1968–2012. PloS One 2015;10:e0146185.

60. Daling JR, Sherman KJ, Hislop TG, et al. Cigarette smoking and the risk of anogenital cancer. Am J Epidemiol 1992;135:180–9.

61. Reid JL, Hammond D, Tariq U, Burkhalter R, Rynard VL, Douglas O. Tobacco Use in Canada: Patterns and Trends. Waterloo, ON: University of Waterloo, Propel Centre for Population Health Impact; 2014.

62. Kang YJ, Smith M, Canfell K. Anal cancer in high-income countries: increasing burden of disease. PloS One 2018;13:e0205105.

63. Goldstone SE, Winkler B, Ufford LJ, Alt E, Palefsky JM. High prevalence of anal squamous intraepithelial lesions and squamous-cell carcinoma in men who have sex with men as seen in a surgical practice. Dis Colon Rectum 2001;44:690–8.

64. Kurdgelashvili G, Dores GM, Srouf SA, Chaturvedi AK, Huycke MM, Devesa SS. Incidence of potentially human papillomavirus-related neoplasms in the United States, 1978 to 2007. Cancer 2013;119:2291–9.

65. Bird Y, Obidiyo O, Mahmood R, Nwanwko C, Moraros J. Human papillomavirus vaccination uptake in Canada: a systematic review and meta-analysis. Int J Prev Med 2017;8:71.

66. Shapiro GK, Guichon J, Kelaher M. Canadian school-based HPV vaccine programs and policy considerations. Vaccine 2017;35:5700–7.

67. Stehen M, Tan Thompson M, Rodier C, et al. A review of the impact and effectiveness of the quadrivalent human papillomavirus vaccine: 10 years of clinical experience in Canada. J Obstet Gynaecol Can 2018;40:1635–45.

68. Cogliano V, Baan R, Straif K, Grosse Y, Secretan B, El Ghissassi F on behalf of the WHO International Agency for Research on Cancer. Carcinogenicity of human papillomaviruses. Lancet Oncol 2005;6:204.

69. Melbye M, Sprogel P. Aetiological parallel between anal cancer and cervical cancer. Lancet 1991;338:657–9.

70. Cromwell I, Gaudet M, Peacock SJ, Aquino-Parsons C. Cost-effectiveness analysis of anal cancer screening in women with cervical neoplasia in British Columbia, Canada. BMC Health Serv Res 2016;16:206.

71. Iriharren Diaz M, Ocampo-Hermida A, Gonzalez-Carrerro Fojón J, et al. Preliminary results of a screening program for anal cancer and its precursors for HIV-infected men who have sex with men in Vigo–Spain. Rev Esp Enferm Dig 2017;109:242–9.

72. Ong JJ, Chen M, Grulich A, et al. Exposing the gaps in awareness, knowledge and estimation of risk for anal cancer in men who have sex with men living with HIV: a cross-sectional survey in Australia. J Int AIDS Soc 2015;18:19895.

73. Garbuglia AR, Gentile M, Del Nonno F, et al. An anal cancer screening program for MSM in Italy: prevalence of multiple HPV types and vaccine-targeted infections. J Clin Virol 2015;72:49–54.

74. Schofield AM, Sadler L, Nelson L, et al. A prospective study of anal cancer screening in HIV-positive and negative MSM. AIDS 2016;30:1375–83.

75. Kostan AM, Leblanc N, Rosa-Cunha I. Exploring the perceptions of anal cancer screening and behaviors among gay and bisexual men infected with HIV. Cancer Control 2016;23:52–8.

76. Wells JS, Flowers L, Paul S, Nguyen ML, Sharma A, Holstad M. Knowledge of anal cancer, anal cancer screening, and HPV
in HIV-positive and high-risk HIV-negative women. J Cancer Educ 2019;:[Epub ahead of print].
77. Tinmouth J, Raboud J, Ali M, et al. The psychological impact of being screened for anal cancer in HIV-infected men who have sex with men. Dis Colon Rectum 2011;54:352–9.
78. Pitts MK, Fox C, Willis J, Anderson J. What do gay men know about human papillomavirus? Australian gay men’s knowledge and experience of anal cancer screening and human papillomavirus. Sex Transm Dis 2007;34:170–3.
79. Reed AC, Reiter PL, Smith IS, Palefsky JM, Brewer NT. Gay and bisexual men’s willingness to receive anal Papanicolaou testing. Am J Public Health 2010;100:1123–9.
80. Ferris D, Lambert R, Waller J, et al. Women’s knowledge and attitudes toward anal Pap testing. J Lower Genit Tract Dis 2013;17:463–8.
81. Leeds IL, Fang SH. Anal cancer and intraepithelial neoplasia screening: a review. World J Gastrointest Surg 2016;8:41–51.