Trends in Oropharyngeal and Oral Cavity Cancer Incidence of Human Papillomavirus (HPV)-Related and HPV-Unrelated Sites in a Multicultural Population

The British Columbia Experience

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BACKGROUND: There is a growing recognition of the involvement of human papilloma virus infection in the etiology of head and neck cancers at some sites, mainly the base of the tongue, tonsils, and other oropharynx (hereafter termed oropharyngeal cancer). Other oral sites (hereafter termed oral cavity cancer [OCC]) show a stronger association with tobacco and alcohol. Little is known about the ethnic variation in incidence for these cancers. This study determined incidence rates of OCC and oropharyngeal cancer among South Asian, Chinese, and the general population in British Columbia, Canada. METHODS: Patients with OCC and oropharyngeal cancer diagnosed from 1980 to 2006 were identified through the British Columbia cancer registry, and surname lists were used to establish ethnicity. Age-adjusted incidence rates were determined for these cancers by sex, topographical site, and ethnicity, and temporal trends were examined. RESULTS: Age-adjusted incidence rates have been decreasing for OCC and increasing for oropharyngeal cancer in the general population for both sexes, with men having higher incidence rates than women. Ethnic differences were found, with the highest age-adjusted incidence rates for OCC for men in South Asians and for women in Chinese, and with the highest age-adjusted incidence rates for oropharyngeal cancer for men in Chinese and for women in the general population. Differences were also found for OCC topographical sites by sex and ethnicity. CONCLUSIONS: The incidence of oropharyngeal cancer has now surpassed OCC in the British Columbia male population. Ethnic minorities are at higher risk than the general population for both OCC and oropharyngeal cancer for men, and for OCC for women. Cancer 2010;116:2635–44. © 2010 American Cancer Society.

KEYWORDS: human papillomavirus infection, oral cavity cancer, oropharyngeal cancer, incidence, ethnicity, South Asians, Chinese.

There is growing recognition that the human papillomavirus (HPV) status of head and neck tumors impacts biology, clinical features, and outcome, and that knowledge of such status could lead to new strategies for prevention and management. In contrast to the clearly defined role of HPV in virtually all cases of cervical cancer, current evidence suggests that the etiology of head and neck cancers is more heterogeneous, with HPV playing an essential role in some tumors and less of a role in others. For example, HPV-related cancers arise mainly from the tonsils, base of tongue, and other oropharynx (hereafter termed oropharyngeal cancer). HPV is less strongly associated with other oral sites, such as the ventrolateral tongue, gingivae, cheek, palate, and floor of mouth (hereafter termed oral cavity cancer [OCC]), where tobacco and alcohol are major etiological factors.
Knowledge generated by examining trends in incidence rates for OCC and oropharyngeal cancer may shed light on the burden of these cancers and differences in etiology in different ethnic populations. However, the breakdown of incidence rates for OCC and oropharyngeal cancer is often lacking. Similarly, there are few such data reported for ethnic groups. Etiological factors are known to vary between and within countries. For example, the highest rates of OCC are in South Asia, which has been associated with betel quid usage, a practice that preferentially targets the gingiva and cheek. Studies of migrants have shown that cancer incidence often reflects that of their home country, as they bring past exposures and lifestyle habits to their adopted country, and may contribute to variations within a country.

British Columbia is ideally situated to investigate ethnic differences in OCC and oropharyngeal cancer incidence, because it is comprised of a largely multicultural population that is growing primarily through immigration, mainly from South Asian and China. In this paper, we used data from the population-based British Columbia cancer registry to report on the temporal trends and incidence patterns for OCC and oropharyngeal cancer between 1980 and 2006. This time period was selected because immigration became more common from India to British Columbia after 1980.

Our ultimate goal is to use this information as baseline data on which a comprehensive oral cancer control plan can be created that includes tailored strategies for diverse population groups.

**MATERIALS AND METHODS**

**Study Cases**

**Case selection**

This study was approved by the research ethics board at the British Columbia Cancer Agency. Cases were identified from the population-based British Columbia cancer registry for the period from 1980 to 2006, selecting for cases with a histological diagnosis of invasive squamous cell carcinoma in the oral cavity or oropharynx, as defined by histology and site codes from the International Classifications of Diseases in Oncology, third edition (ICD-O-3). Histology codes included: 8050 to 8076, 8078, 80713, 80723, 80733, 80743, and 80833; site codes are listed in Table 1.

**Identification of South Asian and Chinese ethnicity**

Because ethnicity and place of birth are not recorded in the British Columbia cancer registry, South Asian and Chinese cases were identified from the 4895 selected cases using previously generated ethnic surname lists.
When surnames of cases were found to match the ethnic surname list, these names were then manually verified by South Asian and Chinese researchers.

**Data Collection and Statistical Analysis**

Age-adjusted incidence rates and age-specific incidence rates, with 95% confidence intervals (CIs), were calculated separately for OCC and oropharyngeal cancer. The age-adjusted incidence rates were standardized to the 1991 British Columbia general population, and age-specific incidence rates for ethnic groups were calculated using ethnic population data for 1991. To examine for temporal trends in incidence, age-adjusted incidence rates were then calculated by year in the general population for the total time period 1980 to 2006, and the annual percent change in incidence rates was calculated for the entire time period from 1980 to 2006, and for the earlier and later time periods (from 1980 to 1993 and 1994 to 2006, respectively). These 2 time periods were selected to avoid any potential bias because of coding misclassification (ICD-O coding changed in the early 1990s, and the registry adopted the change after 1992) and to compare for temporal trends. We calculated annual percent change by fitting a least squares regression line to the natural logarithm of the rates, using the calendar year as the regression variable and rejecting the hypothesis that annual percent change equaled 0 if the P value was <.05. The numbers of cases were too small to examine for temporal trends in the 2 ethnic groups.

**RESULTS**

Of the 4895 cancer cases identified in this study, 85 were from South Asians and 133 from Chinese. A total of 1801 (36.8%) were oropharyngeal cancer, and 3094 (63.2%) were OCC in the general population, compared with 14 (16.5%) and 71 (83.5%) cases in South Asians, respectively, and 37 (27.8%) and 96 (72.2%) cases in Chinese (Table 1).

**Temporal Trends in Age-Adjusted Incidence Rate for Oropharyngeal Cancer and OCC by Sex in the General Population**

The temporal trends in age-adjusted incidence rate for oropharyngeal cancer and OCC in the general population are shown by sex in Figure 1.

For men (Fig. 1A), oropharyngeal cancer showed a significant increase in age-adjusted incidence rate from 1980 to 2006 (annual percent change, 0.84; P < .001). The changes in age-adjusted incidence rate were then compared in earlier (1980-1993) and later (1994-2006)
time periods, and significant increases were found in both periods (annual percent change, 0.61; \( P < .02 \) and annual percent change, 0.87; \( P < .001 \), respectively), with a greater increase in the later period. In contrast, OCC showed a significant decrease in age-adjusted incidence rate from 1980 to 2006 (annual percent change, −0.63; \( P < .001 \)). Initially, age-adjusted incidence rate marginally increased in the earlier time period (annual percent change, 0.25; \( P = .38 \)) but then decreased in the later time period (annual percent change, −0.42; \( P = .14 \)). For most of the period from 1980 to 2006, age-adjusted incidence rate for oropharyngeal cancer were lower than those for OCC; however, differences steadily narrowed and equalized in 2004. Notably, in 2006, the age-adjusted incidence rate for oropharyngeal cancer surpassed OCC, at 4.08 of 100,000 and 3.00 of 100,000, respectively.

For women (Fig. 1B), oropharyngeal cancer showed a significant increase in age-adjusted incidence rate from 1980 to 2006 (annual percent change, 0.58; \( P = .001 \)). The increase was not significant in the earlier time period (annual percent change, 0.46; \( P = .10 \)); however, the increase was significant in the later time period (annual percent change, 0.68; \( P = .01 \)). OCC showed a nonsignificant increase in age-adjusted incidence rate from 1980 to 2006 (annual percent change, 0.04; \( P = .09 \)). The increase was seen only in the earlier time period (annual percent change, 0.37; \( P = .19 \)), which was then followed by a decrease in the later time period (annual percent change, −0.05; \( P = .87 \)).

Men showed higher age-adjusted incidence rates than women for both oropharyngeal cancer and OCC for all time periods examined (Fig. 1C and D).

**Temporal Trends in Age-Adjusted Incidence Rate for Oropharyngeal Cancer and OCC by Topographic Site and Sex in the General Population**

The temporal trends in age-adjusted incidence rate for oropharyngeal cancer and OCC by topographical sites in the general population are shown by sex in Figure 2. In both sexes, the age-adjusted incidence rates for oropharyngeal cancer were highest for tonsils, followed by base of tongue, and finally other oropharynx, whereas age-adjusted incidence rates for OCC were highest for tongue, floor of mouth, and finally cheek and gums.

For oropharyngeal cancer in men (Fig. 2A), the age-adjusted incidence rates for all 3 sites increased significantly from 1980 to 2006: for tonsils (annual percent change, 0.87; \( P < .001 \)), for base of tongue (annual percent change, 0.67; \( P < .001 \)), and for other oropharynx (annual percent change, 0.56; \( P = .002 \)). Both earlier and
later periods showed increases for all 3 sites; however, the increases were significant only in the later period for the tonsils (annual percent change, 0.74; \( P = .002 \)) and base of tongue (annual percent change, 0.85; \( P < .001 \)), but not for other oropharynx (annual percent change, 0.18; \( P = .55 \)). The increases in the earlier period were not significant for any of the sites (all \( P > .05 \)). For OCC in men (Fig. 2B), age-adjusted incidence rates increased significantly from 1980 to 2006 for tongue (annual percent change, 0.47; \( P = .01 \)), but decreased significantly for floor of mouth (annual percent change, −0.56; \( P = .002 \)) and cheek and gums (annual percent change, −0.38; \( P = .05 \)). The rates increased in both earlier (annual percent change, 0.57; \( P = .03 \)) and later periods (annual percent change, 0.37; \( P = .19 \)) for tongue and decreased in both earlier (annual percent change, −0.23; \( P = .44 \)) and later (annual percent change, −0.61; \( P = .02 \)) periods for cheek and gum, whereas it increased in earlier (annual percent change, 0.29; \( P = .31 \)) but decreased in later (annual percent change, −0.43; \( P = .12 \)) periods for floor of mouth.

For oropharyngeal cancer in women (Fig. 2C), age-adjusted incidence rates increased for tonsils (annual percent change, 0.36; \( P = .06 \)) and base of tongue (annual percent change, 0.24; \( P = .23 \)), although not significantly, from 1980 to 2006, whereas the rate was stable for other oropharynx (annual percent change, 0.02; \( P = .91 \)). In the earlier period, there was a nonsignificant increase for tonsils (annual percent change, 0.42; \( P = .12 \)) and decreases for both base of tongue (annual percent change, −0.34; \( P = .21 \)) and other oropharynx (annual percent change, −0.07; \( P = .78 \)). In the later period, the age-adjusted incidence rate showed nonsignificant increases for all 3 sites: tongue (annual percent change, 0.38; \( P = .19 \)), base of tongue (annual percent change, 0.11; \( P = .78 \)), and other oropharynx (annual percent change, 0.55; \( P = .06 \)). For OCC in women (Fig. 2D), age-adjusted incidence rates increased nonsignificantly from 1980 to 2006 for tongue (annual percent change, 0.30; \( P = .12 \)) and cheek and gums (annual percent change, 0.09; \( P = .62 \)), but decreased significantly for floor of mouth (annual percent change, −0.41; \( P = .03 \)). The earlier time period showed nonsignificant increase for 3 sites: tongue (annual percent change, 0.45; \( P = .11 \)), floor of mouth (annual percent change, 0.06; \( P = .82 \)), and cheek and gum (annual percent change, 0.22; \( P = .43 \)). The later time period showed nonsignificant decrease for tongue (annual percent change, −0.15; \( P = .61 \)) and for floor of mouth (annual percent change, −0.13; \( P = .65 \)), but marginal nonsignificant increase for cheek and gums (annual percent change, 0.08; \( P = .78 \)).

### Age-Adjusted Incidence Rate for Oropharyngeal Cancer and OCC by Topographical Site, Sex, and Ethnicity

For oropharyngeal cancer, the age-adjusted incidence rate in men was highest in Chinese, followed by the general population, and lowest in South Asians (Table 2). The highest age-adjusted incidence rates were found in the tonsils for both Chinese and general populations. Age-adjusted incidence rates in women were highest in the general population.

For OCC, the age-adjusted incidence rate in men were highest in South Asians, followed by Chinese, and lowest in the general population. On examining specific OCC topographical sites in men, the highest age-adjusted incidence rates were found in the tongue for both general and Chinese populations. Of note, the highest age-adjusted incidence rate in South Asian men was found in the cheek and gums. The highest age-adjusted incidence rate in women was found in Chinese, followed by South Asians, and last the general population. On examining specific OCC topographical sites in women, the highest age-adjusted incidence rates were found for the tongue in all 3 population groups. Of interest, the age-adjusted incidence rate for cheek and gums was higher in South Asian women than in Chinese women and in the general female population.

### Age-Specific Incidence Rate for Oropharyngeal Cancer and OCC by Topographical Site and Sex in the General Population

Figure 3 shows age-specific incidence rates for oropharyngeal cancer and OCC by topographic site and sex.

For oropharyngeal cancer, the age-specific incidence rates were very low for young people 35 to 44 years of age and younger, and rose with age, reaching the highest age-specific incidence rates between the ages of 55 and 64 years for both men (11.1 of 100,000; 95% CI, 10.0-12.1) and women (3.9 of 100,000; 95% CI, 3.3-4.6). On examining specific oropharyngeal cancer topographical sites in men (Fig. 3A), peak age-specific incidence rates were found for the group aged 65 to 74 years for the base of tongue (4.9 of 100,000; 95% CI, 4.1-5.7) and other oropharynx (1.6 of 100,000; 95% CI, 1.2-2.1), whereas they occurred 1 decade earlier, at 55 to 64 years, for the tonsils (6.0 of 100,000; 95% CI, 5.2-6.8). Similar findings were
noted in women (Fig. 3B); peak age-specific incidence rates were found for the group aged 65 to 74 years for the base of tongue (1.6 of 100,000; 95% CI, 1.2-2.0) and other oropharynx (0.6 of 100,000; 95% CI, 0.3-0.8), and 1 decade earlier, at 55 to 64 years, for the tonsils (2.1 of 100,000; 95% CI, 1.6-2.5).

For OCC, age-specific incidence rates in men steadily increased with age, reaching the highest age-specific incidence rate between the ages of 65 and 74 years and then plateauing (Fig. 3C). On examining specific OCC topographical sites in men, the highest incidence was in the group aged 65 to 74 years for tongue (5.5 of 100,000; 95% CI, 4.7-6.4) and floor of mouth (4.6 of 100,000; 95% CI, 3.8-5.3), whereas for cheek and gums it was at 75 years and above (5.4 of 100,000; 95% CI, 4.4-6.5). The age-specific incidence rates in women continued to increase sharply with increasing age (Fig. 3D). The highest incidence in women by topographical site was in the group aged ≥75 years for tongue (4.6 of 100,000; 95% CI, 3.8-5.5) and for cheek and gums (5.7 of 100,000; 95% CI, 4.8-6.6), whereas it was in 65 to 74 years for floor of mouth (2.0 of 100,000; 95% CI, 1.6-2.5).

For mean age, those with OCC were significantly older than those with oropharyngeal cancer among both men (62.2 ± 12.8 years vs 60.5 ± 10.8 years, respectively) and women (67.3 ± 14.3 years vs 63.3 ± 11.95 years, respectively), both \( P < .001 \).

**Table 2. AAIR for Oropharyngeal Cancers and Oral Cavity Cancers by Topographical Site, Sex, and Ethnicity**

| Cancer                              | General Population | SA Population | Chinese Population |
|------------------------------------|--------------------|---------------|--------------------|
|                                    | No. | AAIR | 95% CI  | No. | AAIR | 95% CI  | No. | AAIR | 95% CI  |
| Oropharyngeal cancers              |      |      |         |      |      |         |      |      |         |
| Sites combined                      |      |      |         |      |      |         |      |      |         |
| **Men**                            |      |      |         |      |      |         |      |      |         |
| Sites combined                      |      |      |         |      |      |         |      |      |         |
| **Women**                          |      |      |         |      |      |         |      |      |         |
| Specific sites                      |      |      |         |      |      |         |      |      |         |
| Tonsils                            |      |      |         |      |      |         |      |      |         |
| **Men**                            |      |      |         |      |      |         |      |      |         |
| Men                                | 450  | 0.1  | 0.0-0.2 | 4   | NA   | NA      | 4   | NA   | NA      |
| Women                              | 281  | 0.6  | 0.4-0.8 | 2   | NA   | NA      | 2   | NA   | NA      |
| **Base of tongue**                 |      |      |         |      |      |         |      |      |         |
| Men                                | 152  | 0.3  | 0.2-0.4 | 1   | NA   | NA      | 1   | NA   | NA      |
| Women                              | 63   | 0.1  | 0.0-0.2 | 0   | NA   | NA      | 0   | NA   | NA      |
| **Other oropharynx**               |      |      |         |      |      |         |      |      |         |
| Men                                | 682  | 1.6  | 1.3-1.8 | 4   | NA   | NA      | 15  | 1.7  | 0-3.4   |
| Women                              | 281  | 0.6  | 0.4-0.8 | 2   | NA   | NA      | 2   | NA   | NA      |
| **Oropharyngeal cancers**          |      |      |         |      |      |         |      |      |         |
| Sites combined                      |      |      |         |      |      |         |      |      |         |
| **Men**                            |      |      |         |      |      |         |      |      |         |
| Men                                | 1886 | 4.3  | 3.8-4.7 | 42  | 4.4  | 1.8-7.8 | 47  | 5.1  | 1.6-8.5 |
| Women                              | 1208 | 2.7  | 2.3-3.0 | 29  | 4.4  | 1.8-7.8 | 39  | 5.3  | 2.0-8.8 |
| **Total**                          |      |      |         |      |      |         |      |      |         |
| **Women**                          |      |      |         |      |      |         |      |      |         |
| Men                                | 1285 | 2.9  | 1.2-4.7 | 8   | 0.9  | 0-2.3   | 31  | 3.6  | 1.3-5.7 |
| Women                              | 516  | 1.2  | 0.1-2.3 | 6   | 0.7  | 0-1.7   | 6   | 0.5  | 0-1.8   |
| **Oral cavity cancers**            |      |      |         |      |      |         |      |      |         |
| Sites combined                      |      |      |         |      |      |         |      |      |         |
| **Men**                            |      |      |         |      |      |         |      |      |         |
| Men                                | 668  | 1.5  | 0.9-1.2 | 18  | 2.3  | 0.2-4.7 | 30  | 2.5  | 0.3-4.7 |
| Women                              | 466  | 1.1  | 0.4-0.8 | 13  | 1.9  | 0.1-4.0 | 29  | 2.9  | 0.5-5.3 |
| **Total**                          |      |      |         |      |      |         |      |      |         |
| **Women**                          |      |      |         |      |      |         |      |      |         |
| Men                                | 501  | 1.2  | 0.8-1.4 | 1   | NA   | NA      | 9   | 1.1  | 0-2.6   |
| Women                              | 245  | 0.6  | 0-0.7   | 2   | NA   | NA      | 4   | NA   | NA      |
| **Total**                          |      |      |         |      |      |         |      |      |         |
| **Cheek and gums**                 |      |      |         |      |      |         |      |      |         |
| **Men**                            |      |      |         |      |      |         |      |      |         |
| Men                                | 404  | 0.9  | 0.7-1.1 | 20  | 2.8  | 0.5-5.5 | 7   | 0.7  | 0-1.6   |
| Women                              | 329  | 0.7  | 0.3-0.9 | 10  | 1.6  | 0.01-3.6| 10  | 1.2  | 0-2.6   |
| **Total**                          |      |      |         |      |      |         |      |      |         |

AAIR indicates age-adjusted incidence rates; SA, South Asian; CI, confidence interval; NA, not available (number of cases was <5).

Age-Specific Incidence Rates for OCC by Ethnicity

Figure 4 shows the age-specific incidence rates for OCC in South Asian, Chinese, and the general population. In both sexes, age-specific incidence rates were similar in all 3 populations up to the group aged 45 years 54 years. For
men, age-specific incidence rates continued to increase, peaking in the group aged 65 to 74 years in all 3 population groups, with the greatest rise in age-specific incidence rate in South Asians (37.7 of 100,000; 95% CI, 19.1-57.1). After age 74 years, age-specific incidence rates slightly decreased in the Chinese and general population, but fell sharply in South Asians. For women, age-specific incidence rates showed a steady increase with increasing age in Chinese and the general population; however, age-specific incidence rates rose sharply to reach a peak in the group aged 65 to 74 years (25.4; 95% CI, 11.0-39.0) in South Asians, followed by a sharp fall. The numbers of cases were too low to examine ethnicity in oropharyngeal cancer or specific topographical sites of OCC.

**DISCUSSION**

Recent epidemiological, pathological, and molecular studies have led to a growing acceptance of the involvement of HPV in the etiology of head and neck tumors and the need to consider such exposures along with conventional risk factors. There is growing evidence of decreasing incidence for OCC and increasing incidence for oropharyngeal cancer that may reflect changes in behaviors: the former associated with changes in tobacco consumption, the latter associated with HPV infection. A recent Surveillance, Epidemiology, and End Results study in the United States showed an increase in incidence for oropharyngeal cancer, with equalization in incidence rates for OCC from 1973 to 2004.1 Our results not only support these findings but also, for the first time, show that the incidence of oropharyngeal cancer has now surpassed OCC in men. A similar less dramatic but increasing trend was also found in women.

Our finding of a decrease in the incidence of OCC reflects decreased tobacco consumption several decades earlier, for the effects of tobacco on cancer incidence can only be observed after a latency period of about 25 years.14 In fact, smoking rates in Canada from 1965 to 1991 (Fig. 5) have shown a sharper decline in men (−52.4%) than women (−21.3%), supporting the observation of a more significant fall in incidence for OCC in men than in women in recent years. Because there has been a further continued decline in smoking rates in British Columbia, we could expect a continued decline in incidence of OCC in the coming years. Of interest, rates are stable or declining for all OCC topographical sites, except tongue, in both sexes.

In contrast, we found an increase in incidence of oropharyngeal cancer. These cancers are primarily caused by HPV infection that may be transmitted through orosexual practices.15 Increasing social acceptance of

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**Figure 3.** Age-specific incidence rates (ASIR) for oropharyngeal cancer and oral cavity cancer and associated sites from 1980 through 2006 are shown for (A and C) men and (B and D) women. Rates are per 100,000 population and are age-adjusted to the 1991 British Columbia general population.
premarital sex, multiple sex partners, and oral sex over the last several decades have likely contributed to increased oral HPV infection. In support of this possibility, a recent US study has reported an association between oral sex and open-mouthed kissing with the development of oral HPV infection. The increase in incidence for oropharyngeal cancer may continue for some time, although the advent of HPV vaccination in women may result in a decline in incidence for oropharyngeal cancer in several decades, at least in women.

Our findings support the importance of including sex in studies of these cancers. Although some studies do not report incidence rates separately for sex, the studies that do report rates separately for sex show that incidence rates for men are increasing, but for women rates are either increasing at a slower pace or stable. In addition, it is important to consider both age and topographical site when examining incidence patterns. Our results show that oropharyngeal cancer was diagnosed at younger ages than OCC in both sexes. This observation has been reported elsewhere.

Because there is wide variation in incidence of oropharyngeal cancer and OCC by topographical site in different geographical regions around the world and because countries like Canada are growing mainly through immigration, it is important to examine for ethnic differences in OCC and oropharyngeal cancer rates to help the development of cancer control programs. British Columbia is ideally situated to investigate such change, because it is comprised of a largely multicultural population that is growing mainly through immigration from South Asian and China. In fact, the population growth rates in Canada for South Asian and Chinese were 37.7% and 18.2%, respectively, between 2001 and 2006. By using ethnic surname listings, we were able to examine incidence rates for oropharyngeal cancer and OCC in South Asian and Chinese. Again, we found ethnic differences in cancer incidence by sex: men were at much higher risk than women for both oropharyngeal cancer and OCC in both ethnic groups, which is consistent with findings reported from most other countries around the world. Increased incidence in men has been largely attributed to heavier indulgence in risk behaviors like smoking, alcohol, and orosexual practices. However, sex differences in the ethnic groups must be interpreted with caution, because this area has received little investigation and the numbers of cases were small in our study, especially for South Asians.

There is a shortage of high-quality data on oral cancer incidence in Asia Pacific regions, including China. This may partially explain the reports of very high smoking rates and yet very low incidence rates of OCC in China. The observed decline in age-adjusted

Figure 4. Age-specific incidence rates for oral cavity cancers from 1980 through 2006 are shown for (A) men and (B) women. Rates are per 100,000 population and are age-adjusted to the 1991 British Columbia ethnic populations.

Figure 5. Percentage of Canadians who smoke (aged ≥15 years on either a daily or occasional basis) is shown based on federal surveys for 1965 through 2007. Data were accessed at http://www.smoke-free.ca/factsheets/pdf/prevalence.pdf.
incidence rate for OCC in the British Columbia general population may not hold true for South Asians and Chinese, because in their countries of origin tobacco consumption rates are not declining but increasing, especially among young adults who may continue their risk behavior even after immigration to Canada. In fact, we found higher age-adjusted incidence rate for OCC in both South Asian and Chinese than the general population in both sexes. The sharp rise in tobacco usage in India and China in recent years may result in a further increase in age-adjusted incidence rate for OCC in the immigrant populations from these countries into Canada in the coming years, in contrast to the declining age-adjusted incidence rate trend in the British Columbia general population.

Another interesting observation in our study was that not only did South Asian men have the highest age-adjusted incidence rate for OCC, but these cancers were most frequently seen in the cheek and gums (rather than the tongue and floor of mouth, as seen in the Chinese and general populations). A predilection for the cheek and gum in OCC was also found for South Asian women. This observation would support the hypothesis that there is a high prevalence of betel quid and smokeless tobacco usage in the South Asian population in British Columbia. Studies from the United Kingdom have also reported higher incidence of these cancers among South Asian immigrants, and a report from the United States suggests that South Asian immigrants continue chewing betel quid after immigration.

The highest age-adjusted incidence rates for oropharyngeal cancer were found in Chinese men, despite some pathological and molecular studies that have shown the absence of HPV in tonsillar cancers of Chinese patients. The lowest age-adjusted incidence rate for oropharyngeal cancer was found in South Asian in both sexes, which may be explained in part by less social acceptance for premarital sex among South Asians, resulting in lower HPV infection.

Our study had several strengths: an established long-term population-based cancer registry, a multicultural province with large South Asian and Chinese populations, and a recently established provincial oral cancer screening program. A limitation reported previously was the possible effect of changes in registry coding classification from ICD-O-01 to ICD-O-02 in the early 1990s, but interestingly rates for oropharyngeal cancer increased in the later time period, when there was no coding difference. However, cancer registry staff assured us that the older classification systems were transferred appropriately to the new coding system. Another limitation was the use of surname listings to identify South Asian and Chinese instead of ethnicity data. The numbers of identified cancer cases might be underestimated because of omission of surnames that are shared between Anglo-Asians and other ethnic groups (eg, British), the omission of Muslims names, inter-racial marriages, and misspellings of surnames in the cancer registry database. However, this methodology has been previously used by us and is widely accepted. A third limitation is the high likelihood that not all cancers cases within the South Asian and possibly Chinese immigrant populations were reported in the provincial cancer registry. Dentists play a major role in detection of oral cancer in British Columbia; however, many elderly Chinese immigrants do not access dental services in Canada, and field observations and interviews among the South Asian population by 1 of us (A.A.) suggest that dental care is often sought for financial reasons back in India, therefore these cancers would not be registered in British Columbia, resulting in an underestimation of cancer cases in these populations. A fourth limitation is that we cannot comment on cancer rates in first or subsequent generations. Country of birth or immigration status is not recorded in the cancer registry. A final limitation is the lack of determination of HPV status at the anatomical site where the cancer developed. A recent study on tonsillar carcinomas from Sweden reported an increasing incidence in oropharyngeal cancer cancers from 1970 to 2007 with molecular analysis showing that a majority of these cancers were associated with HPV infection.

In conclusion, our results have for the first time shown that the incidence of oropharyngeal cancer has now surpassed OCC in the British Columbia male population. Ethnic minorities in British Columbia are at higher risk for both oropharyngeal cancer and OCC among men and OCC among women. There is a need for more targeted culturally appropriate oral cancer prevention and screening initiatives.

CONFLICT OF INTEREST DISCLOSURES
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