CANCER CLUSTER DETECTION IN BRITISH COLUMBIA SCHOOL DISTRICTS 1983–1989

by

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Abstract

A disease cluster is an aggregation of occurrences of a disease. The observation of a perceived excess number of similar illnesses is termed disease clustering. Statistical tests for disease clustering investigate if the observed pattern of cases in at least one geographical area could possibly have happened by chance alone. This pattern may be spatial, temporal, or both. Investigating possible cancer clusters in British Columbia for the period of 1983–1989 inclusive is the objective of this thesis. Whether or not cancer clustering appears near pulp and paper mills within the province is of specific interest. The geographical units upon which our investigation will be based are the B.C. school districts. The variation in size and population demographics among districts requires a cluster detection method which is considerate of the underlying population distribution within the study region. School district population size diversity requires a modification to the Besag and Newell (1991) method. This modification is implemented with B.C. school district data and several possible clusters are detected for various types of cancer.

Contents

List of Tables

List of Figures

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1 Introduction

Health authorities are often alerted to suspected cancer clusters by members of the public. A cluster is an aggregation of cases of a disease. The aggregation may be in space or time or both. In space, cases may occur physically close to each other while in time, cases may occur temporally close. These local reports may be made by observant clinicians who notice a perceived increase in the number of people afflicted with a specific disease or by individual citizens who have anecdotal observations about an illness afflicting their neighbourhood, family, or friends. Health authorities then need to respond to inquiries about areas of seemingly excess disease in a timely fashion, either to assure the public the numbers of cases observed do not indicate clustering or to inform the public and initiate further investigation if strong evidence of clustering is found.

Generally speaking, the majority of these local reports are false alarms. Because thorough investigations of these reports would require extensive resources and involve much time, detailed studies on all local reports of clustering are impractical. On the other hand, there probably are real cancer clusters which are caused by some specific risk factors which may not be reflected by coincidental observations. This situation may persist for several years and as a direct result many more individuals will be exposed to the risk factors.

To overcome these potential problems to a certain extent, health departments need objective and standardized approaches to detect possible clusters with or without local reports. One such method is to use statistical techniques for disease cluster detection in conjunction with available databases such as cancer registries. Statistical tests for disease clustering investigate if the observed pattern of cases in administrative areas could possibly have happened by chance alone. The main advantages of this approach are that it is cost effective and it allows for timely cluster detection because these databases for populations of the administrative areas and their associated cancer cases

are generally available.

A surveillance system, where administrative regions are monitored for high disease rates, identifies areas requiring further study and has the potential to target resources for the most plausible clusters. Such a system allows for responses to lay reports of excess cases which are easier, timelier, and less expensive than individual thorough investigations. The detection of clusters may also lead to etiological findings or suggest possible causes.

Identifying possible cancer clusters in British Columbia for the period 1983–89 is the objective of this thesis. Whether or not cancer clustering appears near pulp and paper mills within the province is of specific interest.

Particular information is required for a cancer cluster detection method to operate. Both disease data and population data must be known for the administrative zones under investigation. The administrative unit upon which our investigation will be based is the B.C. school district. Data about cancer cases in B.C. during 1983 to 1989 is provided by the British Columbia Cancer Agency (BCCA). For each patient, the year of cancer diagnosis, sex, type of cancer, and age at time of diagnosis are contained in the database. The patient's age is categorized into an age group. Information about the patient's residence at the time of diagnosis is also recorded, including address, postal code and school district. During the study period 74 school districts existed and 22 pulpmills were located within 17 of the school districts. Population data is known for each school district, age group, sex, and year.

British Columbia school districts have a variety of shapes and sizes. The population within each district can range from below $10,000$ to above $100,000$. The cluster detection method used should allow for the differences in population size among the school districts. Of the choices available, a procedure proposed by Besag and Newell [1] appears to be appropriate to deal with our clustering questions.

The Besag and Newell method requires the identification of the nearest neighbours of each school district. The spatial relationship between school districts is based on their cell centroids. Cancer cases which have complete postal code information are used to estimate the location of each school district's population-based centroid. An estimate of a cancer patient's location of residence is calculated using its postal code and a software conversion package called the Postal Code Conversion File [12].

The Besag and Newell method was designed for very small administrative zones with similar population sizes. The dissimilarity of population sizes in B.C. school districts requires a modification to their method. This modification is used in yearly and combined year analyses for each sex and cancer type.

The sections which follow give a detailed account of the analysis. Section 2 provides a summary of the statistical cluster detection methods which are found in the literature. The data sources and centroid determination are detailed in Section 3. Section 4 describes the analysis based on the Besag and Newell method and the proposed modifications to the approach. A discussion of the individual results obtained from the modified approach follow in Section 5 with concluding remarks in Section 6. Tables of results are found in the Appendix.

2 Literature Review

Many methods have been proposed in an attempt to provide detection plans which allow for timely responses, with or without a local report of a suspected cluster. To detect spatial clustering, general tests and focused tests are two varieties which emerge. General tests are designed to detect clusters within the overall pattern of disease in the complete region. The null hypothesis is defined as complete randomness, i.e. each individual in the population is assumed to have an equal chance of developing the disease. As the terms general and focused, introduced by Besag and Newell [1] suggest, the general test is used when one has no particular alternative in mind and the focused test is used when one has a particular alternative hypothesis that incidence rates will be higher near sources of contamination. The general and focused tests to be described in this section include those developed by Whittemore et al. [13], Openshaw et al. [6], Turnbull et al. [9], Besag and Newell [1], Stone [8], and Waller et al. [10], [11]. Generally speaking, these tests allow for the underlying populations of the administrative regions to be different, which is necessary.

Other cluster detection techniques, such as those proposed by Pinke and Nefzger [7], Knox [4], and Mantel [5], will not be discussed. Generally speaking, these methodologies and many others have been proposed over the years where unrealistic assumptions about the underlying population at risk within the study region are made. It is usually assumed that the administrative areas within the region have approximately the same population and age distribution. These techniques are unsuited for comparing disease rates between dense and sparse regions. For example, a retirement community may be identified as a cluster for a disease that affects only elderly people when age distribution is assumed to be uniform over the study region or a city may be identified as a cluster because of its high numbers of cases due to dense population. Such methods are unsuitable for our situation and will not be discussed.

2.1 General Tests

We now describe several test procedures which could be classified as general tests, along with their advantages and disadvantages. The common null and alternative hypotheses in these test procedures are:

H_0: Every person is equally likely to contract the disease independently of other cases, and the location of their residence,

H_1: Not H_0.

Suppose that the region of interest is divided into I cells. These cells may be administrative areas of interest such as health units, school districts, political ridings, census divisions/sub-divisions, or enumeration areas. The population residing in cell i is denoted by n_i, $i = 1, \ldots, I$. For cell i, the number of incident cases of the disease is denoted by a random variable C_i with observed value c_i, $i = 1, \ldots, I$. The total number of cases in the entire study region is $C_\cdot = \sum_{i=1}^{I} C_i$. The total population and the total number of observed cases are denoted by $n_\cdot = \sum_{i=1}^{I} n_i$ and $c_\cdot = \sum_{i=1}^{I} c_i$, respectively. For a rare disease, the number of incident cases within a particular cell may be modeled as a Poisson random variable. The hypothesis above is equivalent to

H_0: The C_i, $i = 1, \ldots, I$, are independent Poisson random variables with $E(C_i) = n_i\theta$,

where θ denotes the individual baseline risk of contracting the disease. With this formulation, the baseline risk of the disease multiplied by the population of a cell yields the expected number of diseased individuals for that cell. This model assumes that the disease investigated is not hereditary or contagious. The model could accommodate such diseases if more features were added.

The underlying population must be available for most of the methods detailed below. The number of cases per cell is also necessary. Several procedures require the centroid

of the cell, if not the actual location of each case.

2.1.1 The Whittemore et al. Test

Whittemore et al. [13] developed a method for detecting spatial clusters for chronic diseases. Their rationale for examining only spatial clustering is that chronic diseases caused by a pollution source tend to be diagnosed long after exposure. Cases may be close in space but not in time due to the fact that the disease development is long and will vary from patient to patient. Their proposed test statistic is based on the mean distance between all pairs of cases. Cell centroids may be used if precise locations of the cases are not available. The degree of clustering within the entire study region is related to the mean distance between all pairs of cases. The smaller this mean, the closer the cases are together and the more clustering is indicated.

Specifically, the population of an administrative area is partitioned into S subgroups called strata. For example, the strata could be defined by sex, age group, or race. Each stratum is assumed to have a different disease incidence rate, θ_s. The numbers of observed cases and population in cell i for stratum s are denoted by c_{is} and n_{is}, respectively, $i = 1, \ldots, I$, $s = 1, \ldots, S$. The random variable C_{is} represents the number of cases in cell i and stratum s. The C_{is}'s are assumed to be mutually independent Poisson random variables under the following null hypothesis,

$$H_0\text{: } E(C_{is}) = \theta_s n_{is}, \qquad i = 1, \ldots, I,\ s = 1, \ldots, S.$$

Under this hypothesis the vector of strata-specific total disease numbers is a sufficient statistic for the unknown parameters $\theta_1, \ldots, \theta_S$. Given its value $c = (c_{\cdot 1}, \ldots, c_{\cdot S})$, the cell frequencies $(c_{1s}, \ldots, c_{Is})$ are mutually independent multinomials with size $c_{\cdot s}$ and estimated probability vector

$$p_s{}^T = (n_{1s}, \ldots, n_{Is})/n_{\cdot s}, \qquad s = 1, \ldots S. \tag{1}$$

The mean distance between all pairs of cases, regardless of their strata membership, is considered as the test statistic. Let $\rho(q_1, q_2)$ be the distance between the $q_1{}^{th}$ and the $q_2{}^{th}$ case. The test statistic is given by,

$$W = \binom{c_{..}}{2}^{-1} \sum_{q_1 < q_2} \rho(q_1, q_2). \tag{2}$$

To calculate the distribution of W under the null hypothesis, the cases are assumed to be located at the centroid of the cell. The distance between cases within a cell will be zero by this assumption. The total distance between all pairs of cases will be the sum over all cell pairs of the product of the number of cases contained in the pair of cells with the distance between the pair's cell centroids. This total distance can be written as $1/2 c_{..}{}^2 r^T D r$, where $r = c_{..}^{-1} \sum_{s=1}^{S} (c_{1s}, \ldots, c_{Is})^T$ is the vector of relative cell frequencies and D is an $I \times I$ matrix whose (k,l)th entry is the distance between cells k and l. Equation (2) can then be written as

$$W = \frac{c_{..}}{c_{..} - 1} r^T D r. \tag{3}$$

Since r is the mean of the S multinomial vectors $(c_{1s}, \ldots, c_{Is})$, for $s = 1, \ldots, S$, its expected value is equal to $E(R) = \pi = c_{..}{}^{-1} \sum_{s=1}^{S} c_{.s} p_s$. Let $U_s = diag(p_s) - p_s p_s{}^T$, $s = 1, \ldots, S$. Then $U = c_{..}{}^{-1} \sum_{s=1}^{S} c_{.s} U_s$ is the mean of the multinomial covariance matrices $c_{.s} U_s$ and the covariance matrix of r is $c_{..}{}^{-1} U$. Whittemore et al. show that W is asymptotically normally distributed under H_0. Assuming that $\lim_{c_{..} \to \infty} (c_{.s}/c_{..}) > 0$ for $s = 1, \ldots, S$, then under H_0, as $c_{..} \to \infty$,

$$\frac{1}{2} \sqrt{c_{..}} \frac{W - \pi^T D \pi}{\sqrt{\pi^T D U D \pi}} \xrightarrow{\mathcal{D}} \mathcal{N}(0,1). \tag{4}$$

Whittemore et al. used their statistic to examine clustering of 63 cases of anal and rectal squamous cell carcinoma in San Francisco during $1973 - 1981$. There were three age groups, two races and the two sexes yielding $S = 3 \times 2 \times 2 = 12$ strata, for that study. With the stratification, the results indicated statistically significant evidence for clustering.

This Whittemore et al. method allows incorporation of the underlying facets of the population. When administrative areas are not homogeneous, the population distribution within each area must be considered. Methods may produce clusters because of population variation. If the population within the stratifications at high risk varies from area to area, a method assuming homogeneous areas may produce spurious clusters. The method proposed by Whittemore et al. alleviates any possibility of clusters being detected because of nonuniformity of subgroups at different disease risk over the study region. Previous cluster detection tests, such as those proposed by Pinke and Nefzger [7], Knox [4], and Mantel [5] were designed to detect cases clustered in space and time simultaneously, without taking the population into account. The Whittemore et al. method addresses the problem of spatial clustering alone. Spatial clustering may be more informative than space-time clustering when disease development varies greatly from patient to patient.

The procedure has some shortcomings. The location of significant clusters, if one or more exist, is not indicated. The statistic only reflects the degree of clustering in the overall study region. Since the test statistic is based on the pairwise distances between cases, a small observed value of W could arise in two different situations. Where population density is high, such as in metropolitan areas, there may be an apparent cluster because the distance between people, and thus cases, is small. In rural areas, the same value of W could represent a true cluster since rural individuals generally live farther apart than urban individuals do. The method cannot distinguish these two types of close cases when only the distance between cases is considered and not the population density. Clusters detected may arise either because of high population density or a genuinely elevated disease incidence rate. If clusters occur in several cells, the test statistic has poor power. The power will also be poor when the cells with the highest rates vary among the strata.

2.1.2 The Geographical Analysis Machine

The Geographical Analysis Machine (GAM), proposed by Openshaw et al. [6], is a graphical attempt to identify disease clusters. Openshaw et al. originally carried out the method on 1968–85 childhood leukemia data from northern England. The procedure analyzes a large number of circles of fixed radius r to identify regions of particularly high incidence rates. A square lattice is laid on a map of the study region with grid points evenly spaced at intervals $r/5$ apart. Each grid point is considered in turn. For grid point ω, compute the number of cases in a circle of radius r centered at that grid point and call this number C_ω. A circle is drawn at grid point ω if the observed valued of C_ω is at least two and exceeds the 99.8 percentile of a Poisson distribution with mean $\mu = P_{\omega r}c./n..$ Here, $P_{\omega r}$ is the population contained in the circle centered at the ω^{th} grid point. The procedure is repeated with different values of r. The procedure begins with r equal to 1 km. After each iteration, r is incremented by 1 km and the procedure is terminated once r is greater than 25 km.

The GAM method has some drawbacks. The procedure is computationally intensive and does not offer a quantitative assessment of an observed pattern's significance. The population at risk within these circles of varying radii is difficult to determine. When one circle is drawn, many neighbouring circles are drawn because of the large number of circles considered and the amount of overlap. High correlation between overlapping circles will produce some apparent clusters even under the null hypothesis. The original version of GAM was unable to handle stratification. Diseases, such as cancer, with different forms afflicting different age groups and sex categories could not be analyzed properly with this methodology.

There seem to be multiple testing problems as well. Each individual significance test is correct, but an adjustment for multiple testing has not been offered. The problem is manifested globally and locally. With tests on a sufficiently large region, chance alone

will yield some apparent clusters. The local problem is more severe. The use of different radii and shifts of location are an attempt to identify an optimal circle for any set of cases. The area contained in the optimal circle is considered the most likely cluster. However, the significance level calculations do not incorporate the varying radii and location shifts. Perhaps the low significance level (0.002) was meant to compensate for these multiple testing problems.

The procedure provides an excellent descriptive method for finding areas of high incidence rates that are free of geographical boundaries. Some of the above deficiencies have been rectified. The GAM method is a good descriptive tool, however, any supposed areas of clustering may have happened by chance.

2.1.3 Cluster Evaluation Permutation Procedure

Where the GAM procedure analyzes circles of constant area, Turnbull et al. [9] consider regions of constant population, called "balls". The distance between cells is again defined as the distance between their respective cell centroids. For each cell, a two-dimensional ball of adjacent cells is formed so that the population is equal to some fixed number of people, R. Each cell's population is examined in turn. For cell i, $i = 1, \ldots, I$, if n_i is less than R, the cell with the closest centroid is examined. Suppose the nearest cell to cell i is cell j. If the combined population of cells i and j, $n_i + n_j$, equals R, then the cells i and j form the ball for cell i. If the combined population exceeds R, the ball for cell i is formed with a portion of cell j. This portion is the population required from cell j to attain R people within the ball for cell i. If $n_i + n_j < R$, both cells become part of the ball for cell i and the next nearest neighbour to cell i is examined. To ensure each ball contains at least one cell, R is chosen to exceed each cell's population. Altogether, there will be a collection of I balls.

The number of cases within the ball for cell i is C_{iR}. When a proportion of a cell

is combined to a ball to attain the population size required, the same proportion of the cases in that cell will be added to the ball's cases. For example, if the ball for cell i is formed by combining cell i and 1/8th of cell j, C_{iR} is equal to $c_i + \frac{1}{8}c_j$. The C_{iR} values are considered identically distributed random variables under the null hypothesis. These variables are dependent though, due to the procedure's combining scheme. Since the balls have equal populations at risk under the null hypothesis, the expected number of cases per ball is directly proportional to the disease rate. Therefore, the ball with the most cases, and thus the highest disease rate, is of concern to health authorities. The maximum rate statistic, $M_R = max(C_{1R}, C_{2R}, \ldots, C_{IR})/R$ becomes a natural choice for a test statistic. If M_R is greater than some cutoff value determined by the null distribution of M_R and the significance level, the null hypothesis is rejected. The cell whose ball has the highest rate is noted as the most likely cluster. The second and third highest rates may also be investigated in a analogous fashion. Null distributions for these statistics can be found similarly.

The randomization test ideas of Fisher [3], can be used to evaluate the null distribution of M_R. The distribution is the group of M_R values achieved by considering all ways of assigning $c.$ cases to $n.$ individuals in the population. Each assignment is equally likely. The number of such permutations, $n.!/(c.!(n. - c.)!)$, is typically too large to compute the null distribution exactly. A Monte Carlo sample of the permutations can be used to estimate the distribution under H_0.

The Turnbull et al. method does not have the multiplicity problems of the GAM method. This method also provides a quantitative assessment of the statistical significance of a supposed cluster, which the GAM procedure is unable to accomplish, and is less computationally intensive. Stratified analyses can also be accommodated with this procedure. Turnbull et al. have not addressed what effect the underlying population has on their test statistic. If population density within a cell is uniform, then taking

the proportion of cases corresponding to the proportion of population required may be suitable. However, if the population is not uniformly distributed within a cell, the amalgamation of fractions of other cell populations may not represent the true population within the ball.

Turnbull et al. also require that the cells have quite similar population sizes. If, for example, one cell has much more population than the others, the population of the ball, R, has to be greater than the largest cell's population. Many small cells will have to be combined to form a ball with population R and smaller clusters may be undetectable.

2.1.4 Besag and Newell Statistic

Besag and Newell [1] chose to examine regions with the same number of cases rather than areas of fixed population. The method requires a minimal amount of information including the number of cases, the population at risk, and the centroid of each district. Their method is best used for an extensive area that is divided into relatively small administrative districts for which census information is known.

Each cell is considered separately. All cases within a cell are considered to be located at the cell's centroid. The distance between cells is defined as the distance between their respective centroids. For cell i, the remaining districts are ordered in increasing distance from cell i. An integer k is selected to represent cluster size. The number of cells, L, which must be added to cell i to include the nearest k cases is the test statistic. To illustrate, cell i's closest neighbours may be cells $i_1, i_2, \ldots$ with cell i_p being the p^{th} farthest cell centroid from cell i. If $c_i \geq k$ then the observed value of the test statistic, ℓ, is equal to zero. If $c_i < k$ but $c_i + c_{i_1} \geq k$ then ℓ is one and so on. Small observed values of L indicate that k cases are nearby and reflect the degree of clustering.

Under the null hypothesis, the significance level of each suspected cluster can be evaluated. Let m_{iL} represent the total population in cell i and in its L nearest neigh-

bours. Note that $L > \ell$ if and only if less than k persons among the $m_{i\ell}$ have the disease. For a rare disease, the hypergeometric probability that exactly x individuals among $m_{i\ell}$ persons have the disease can be very closely approximated by a Poisson term under H_0. This Poisson term is given by

$$exp(-\lambda_{i\ell})\lambda_{i\ell}{}^x/x!, \tag{5}$$

where $\lambda_{i\ell} = m_{i\ell}c./n..$ Therefore, equation (6) below determines the significance level for cell i with respect to the k nearest cases,

$$P(L \leq \ell) = 1 - \sum_{x=0}^{k-1} exp(-\lambda_{i\ell})\lambda_{i\ell}{}^x/x!. \tag{6}$$

Cells which attain some nominal significance level, $\alpha = 0.05$ say, are recorded. All cells which achieve significance at the 5% level can be plotted on a map of the region as a useful diagnostic tool. The cell with the lowest p-value shows the strongest evidence of clustering for cluster size k. If there are S strata, the Poisson formulation is adapted slightly. The method proceeds in the same manner as if stratification was not present with one exception: the Poisson distribution has a mean which incorporates the stratification. The total number of cases and individuals in stratum s are denoted by $c._s$ and $n._s$, respectively. The mean of the Poisson term in equation (5) would be replaced by $\lambda_{i\ell} = \sum_{s=1}^{S} m_{is\ell}c._s/n._s$, where $m_{is\ell}$ is the number of cases in stratum s in cell i and its ℓ closest neighbours.

By chance, however, some cells are expected to be nominally significant at the 5% level. A rough approximation for the expected number of cells significant at 100α% would be αI. Let R be the total number of cells that are significant at the nominal level α. An overall test for R can be pursued. The true significance level for cell i is

$$\alpha_i = P(L \leq \ell_i{}^* - 1), \tag{7}$$

where $\ell_i{}^*$ is the smallest value of ℓ such that $P(L \leq \ell) > \alpha$. The exact null expectation

of R is given by

$$E(R) = \sum_{i=1}^{I} \alpha_i. \tag{8}$$

If the observed values of R exceed $E(R)$, a Monte Carlo simulation can be used to assess statistical significance. Samples are generated by distributing the $c.$ cases among the $n.$ individuals randomly. A particular case has a probability of being placed in cell i equal to $n_i/n.$, $i = 1, \ldots, I$. If different strata are incorporated, each stratum is considered separately with cases allocated to cells with probabilities proportional to the applicable numbers at risk. This simulation may provide some information about number of clusters detected, however, Besag and Newell stress that lack of overall statistical significance should not preclude investigation of clusters that appear to exist.

The Besag and Newell procedure also has multiple testing problems. Each cell is considered in turn with the obtained significance recorded. With the combination of cells, each test is not independent. An overall test of clustering is offered as an attempt to assess the overall significance in the multiple testing environment when many cells appear significant. The Besag and Newell approach accommodates the underlying population distribution, and can easily incorporate different strata. Different population densities are assumed among the cells, however, the population within each cell is considered to be uniformly distributed. In sparsely populated regions, this uniformity assumption probably would not apply.

This method looks specifically for clusters of size k. Besag and Newell chose 2, 4, 6 and 8 as their values for k in an analysis of Northern England leukemia data. The choice of k is not an obvious one. Since the significance level depends k, the value of k to be employed (hereafter referred to as the "cluster size") is an important issue. If the cluster size investigated is too small, larger clusters cannot be detected. With large k, a spurious cluster may be produced because the significance level is based on the sum of k terms. If k is large enough and the mean is appropriate, the sum of these k terms

will be close to 1 and the p-value will be close to zero.

2.2 Focused Tests

Focused tests are intended to determine if disease cases are clustered around suspected sources of exposure. Such sources are called foci. The detection of a cluster near a focus need not indicate that the source is the cause of the cluster. However, it would suggest that further investigations be considered to establish any causality.

For the validity of the focused test, several issues need to be carefully considered. When looking at foci, the sources should be chosen for reasons other than suspected high incidence rates. A nonarbitrary choice of cell boundaries and risk categories is important. With a focused test, boundaries can be chosen deliberately to achieve the most extreme value of a test statistic. For example, investigators wishing to prove that a specific chemical causes a disease may alter their cell borders to give their desired result. Investigators must ensure knowledge of a potential source does not bias their test statistic. An additional problem may arise when results from a particular site are not robust to small changes in the definition of the population at risk. The choice of subgroups and geographical borders are critical considerations for any inferences made about a possible cluster.

The general test null hypothesis and notation apply to the focused tests as well. However, a different alternative is specified for these tests. The alternative hypothesis is that disease rates are elevated in the vicinity of sources of environmental exposure. That is, regions in the proximity of the source will have higher incidence rates.

2.2.1 Besag and Newell Focused Test

Besag and Newell [1] proposed a slight alteration of their general test to examine clustering about a focus. Instead of looking at each cell, only each focus is examined. The

location of a focus is considered a separate cell which does not contain population or cases. For focus f, the I cells are ordered in increasing distance from the focus. A cluster size k is chosen as it was in the general test. The test statistic, L is the number of cells which must be added to the focus to include the nearest k cases. The probability that L is greater than ℓ, as defined for the general test, determines the unadjusted p-value.

The focused version of the Besag and Newell test has the same problems and advantages as its general parent. Multiple tests are still performed and the choice of cluster size to investigate is still an issue. This focused test does, however, allow an analysis without requiring exposure data. The test examines if a focus and some of its close neighbours have statistically significant excess numbers of cases. Intuitively, if a source emits some contaminant which increases an individual's risk for a disease, many cases should be found in close proximity to that source. This intuition does not necessitate the use of exposure data which is generally unavailable.

2.2.2 Stone Statistic

Stone [8] developed a method to test clustering about a single focus. Cells are ordered according to increasing distance to the focus. The distance here is determined by the distance between the cell's centroid and the focus. The cell whose centroid is closest to the focus is labeled cell 1, and the farthest cell is called cell I. The expected number of cases in cell i under the null hypothesis is $E_i = n_i c_\cdot / n_\cdot$. The Stone test statistic is defined as

$$T_{Stone} = \max_{1 \le y \le I} \frac{\sum_{i=1}^{y} C_i}{\sum_{i=1}^{y} E_i}. \tag{9}$$

Intuitively, this statistic is the maximum value of the estimated relative risks among successively larger geographic areas about the source. These areas are composed of the y cells closest over the values of $y = 1, \ldots, I$. Let y^* be the value of y which maximizes T_{Stone}. The estimated relative risk is maximized in the y^* closest cells to the focus.

This test statistic identifies both the cells which are most likely to be a cluster and the number of cases in the presumed cluster.

Consideration of a two-dimensional random walk is required for the distribution of T_{Stone} under H_0. Let the plane be defined by the cumulative observed and cumulative expected numbers of cases and let A be the line through the origin with slope equal to T_{Stone}. The probability of a random walk beginning at the origin and traversing above line A is equal to the significance level for the test of H_0. This significance level will be unadjusted for the multiplicity of tests.

Stone ordered the cells by their distance to one source to examine clustering about that focus. The cells could be ordered by their distance from *any* focus. Suppose there are two foci in a study region. The cell which is closest to either of the sources than any of the remaining cells, would be labeled cell 1. The process would continue as it did for the investigation of a single focus. Suppose there were two foci and the distance between cell i and focus f is denoted d_{if}, $f = 1, 2$. The cell that satisfied $\min_i(d_{i1}, d_{i2})$ would be labeled cell 1. This adaptation can be used to see if clustering seems to occur around the foci as a group. Some problems can arise from this change. The foci are treated as if the association between exposure and geographic distance is the same for each focus. The foci may interact to increase exposure and may release different levels of contamination. Detailed exposure data would be required to accommodate any heterogeneity between the foci. Because the test statistic is based on the maximum value of a ratio of observed to expected cases, it may not effective for detecting mild clustering.

2.2.3 Waller et al. Statistic

If quantitative exposure data are available, or an exposure model is proposed, these values can be used in the definition of a focused test. Otherwise, a surrogate for measured exposure may be used. Waller et al. [10], [11] consider a model where exposure and

geographic distance are inversely related. All individuals within cell i are assumed to have the same exposure to the foci, labeled g_i, $i = 1, \ldots, I$, which is taken to be the reciprocal of the distance from the focus to the centroid of cell i, $i = 1, \ldots, I$. This convention is reasonable since a cell which is 200 km from a focus may have 1/2 the exposure of a cell which is 100 km from the source.

Let E_i be the expected number of cases in cell i under the null hypothesis defined earlier, where $E_i = n_i c./n.$, $i = 1, \ldots, I$. Waller et al. consider a multiplicative alternative which is

$$H_1 : E(C_i) = n_i\theta(1 + g_i\varepsilon), \qquad i = 1, \ldots, I.$$

and represents an increase in relative risk for individuals living in cells near the foci. Here, ε is unspecified but positive and equals zero under the null hypothesis. With this alternative, the expected number of cases in cell i is proportional to the exposure of the individuals within that cell, $i = 1, \ldots, I$. Under H_1, the disease counts C_i, $i = 1, \ldots, I$, are still independent.

Waller et al. developed a focused test of the null hypothesis which would maximize local power against this alternative. Following the development of locally most powerful (LMP) tests described in Cox and Hinkley [14], the test statistic becomes

$$U = \sum_{i=1}^{I} g_i(C_i - E_i). \tag{10}$$

Therefore, U is the sum of the deviations of the observed incidence for each cell from its expectation under H_0, weighted by the exposure. Under the null hypothesis, $\varepsilon = 0$ and θ is the only parameter. The likelihood may be expressed as a single-parameter exponential family. This test will be uniformly most powerful (UMP) because a UMP test exists for the one parameter exponential family, and the fact that UMP tests must maximize local power when the family of alternatives includes local values. Thus, U will be a UMP test as well.

Because the test is LMP, under the null hypothesis U has mean zero and variance equal to the Fisher information, which is approximately

$$var(U) = \sum_{i=1}^{I} g_i{}^2 E_i.$$

With standardization, $U^* = U/(var(U))^{1/2}$ and U^* has an asymptotic standard normal distribution.

The test proposed by Waller et al. is based on a more specific alternative than Stone's test. Whether or not exposure and distance are inversely related may be questionable. An individual residing downstream from a river polluting source may suffer more exposure than an individual living nearby but upstream from that source. In addition, if cells are large the assumption that each individual within a cell has the same exposure may not be justified.

The methods described above are all considerate of the underlying population distribution. The discussion outlined some of advantages and disadvantages of each statistical method. The Whittemore et al. statistic is unable to distinguish close cases due to clustering or population density. British Columbia has some areas of high population density and it is as important to find clusters there as well as in rural, sparsely populated areas. Openshaw's GAM cannot provide quantitative assessment of clustering. The methods proposed by either Turnbull et al. or Besag and Newell would be suitable for our situation. The Besag and Newell procedure is preferred, because it could also be used for a focused test. Hence, the focused and general tests devised by Besag and Newell are used for our analysis.

3 Data Description

The Besag and Newell method and its modification detailed in Section 4.2 require cancer cases by administrative regions as well as the corresponding populations at risk. Section 3.1 and Section 3.2 specify the sources of data for cancer patients and population, respectively. The centroid determination for each school district is outlined in Section 3.3.

3.1 Cancer Data

The provincial Department of Health recognized cancer as a disease in 1932. Private physicians began informing the B.C. Cancer Registry of cancer cases in 1935. By 1966, the register contained all known live cancer patients. Information was collected from private physician submissions, larger hospital medical records and from data collected by then the B.C. Cancer Institute.

The Registry has data on every B.C. resident who has been diagnosed with a malignant neoplasm since 1970. Malignant neoplasm recorded includes in-situ and borderline tumours. Many details are collected from each patient including the patient's sex, age, year of diagnosis, address of residence at the time of diagnosis, including postal code, along with its school district. The type of cancer, or site, diagnosed is also recorded. The B.C. Cancer Registry is the primary source of cancer information in this study.

During the years 1983 to 1989, there is a total of 80,131 cases of cancer reported to the Registry. Of these, 78,378 (41,282 male and 37,096 female) have complete school district information representing 98%. There are over thirty cancer sites of interest in this study. All skin cancers, except for melanoma, are excluded from the study. The term "all cancers" represents all non-skin cancers plus melanoma. A list of sites investigated along with the corresponding number of patients afflicted is listed in Table 1 of the Appendix. It is easily seen that not only does each site have a different incidence

rate but the cancers affect the sexes differently. The different eitologies require analyses to be conducted on each sex separately.

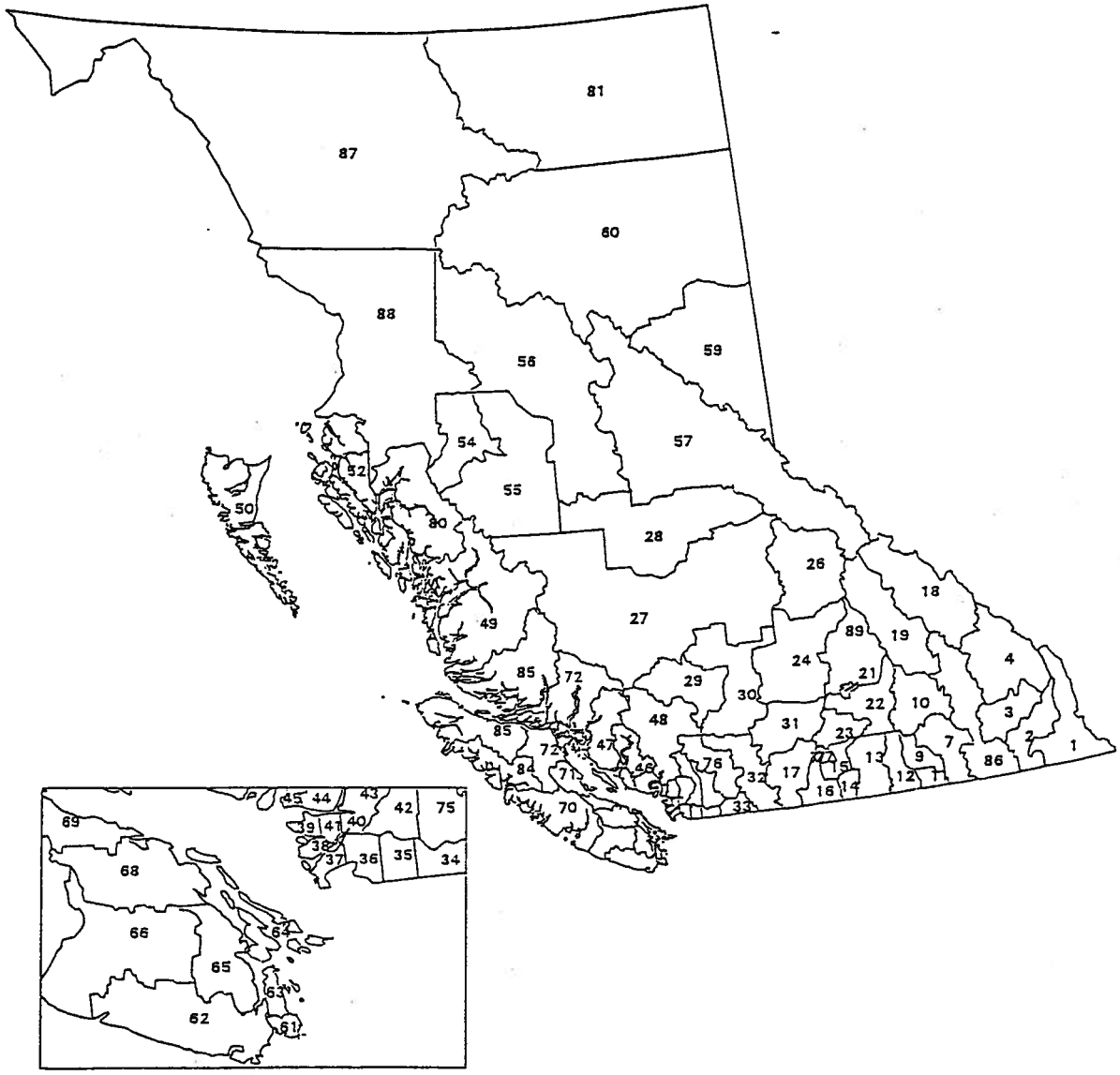
3.2 Population Data

The school district is the smallest administrative region for which population figures are available in the Division of Epidemiology, Biometry and Occupational Oncology at the BCCA. The school district is our choice for a cell. British Columbia had 74 school districts during the years 1983–89, which can be seen in Figure 1. The school districts have various geographical sizes. The northern part of the province has much larger school districts than the lower mainland area.

The yearly estimated populations by school district were provided to the BCCA by Mr. Dave O'Neil, Population Section, Ministry of Finance and Corporate Affairs. These populations were estimated based on the 1981 and 1986 census data. The sex and age group of an individual is recorded in the population data. The age groups are formed by combining ages into five year intervals. Thus, ages 0–4 define age group 1, 5–9 form age group 2, 10–14 form age group 3 and so on with 18 as the maximum age group. The population data gives the number of individuals in each sex and age group in each school district for every year of interest.

The population size also varies between school districts. The lower mainland region has very high population density and the northern areas are sparsely populated. The disparity can be seen when Stikine is compared with Vancouver. In 1989, the total population of males residing in Stikine and Vancouver are $1,319$ and $222,037$, respectively. The bar chart found in Figure 2 shows the total number of people in each school district for 1989. The bars are ordered by the school district number and we can see the vast differences in population between cells.

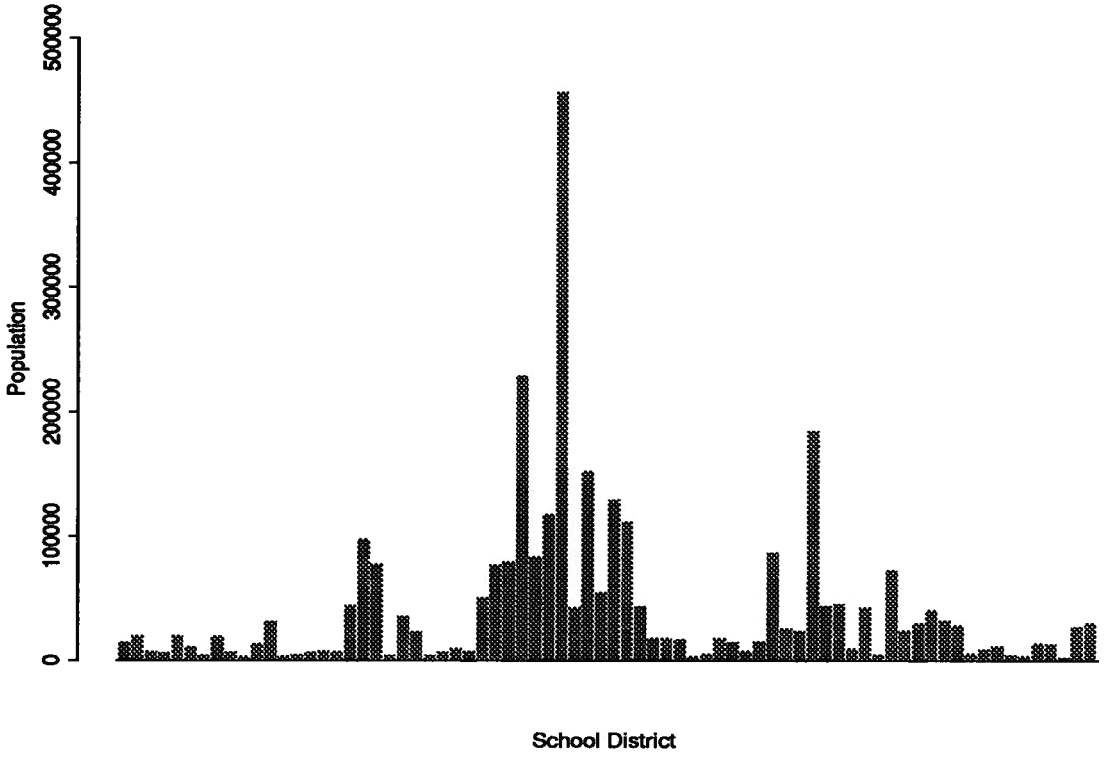
Figure 1: British Columbia School Districts 1983–89



Map courtesy John Smith & MapInfo.

1 Fernie	19 Revelstoke	35 Langley	50 Queen Charlotte	69 Qualicum
2 Cranbrook	21 Armstrong-Spallumcheen	36 Surrey	52 Prince Rupert	70 Alberni
3 Kimberley		37 Delta	54 Smithers	71 Courtenay
4 Windermere	22 Vernon	38 Richmond	55 Burns Lake	72 Campbell River
7 Nelson	23 Central Okanagan	39 Vancouver	56 Nechako	75 Mission
9 Castlegar	24 Kamloops	40 New Westminster	57 Prince George	76 Agassiz-Harrison
10 Arrow Lakes	26 N Thompson	41 Burnaby	59 Peace River S	77 Summerland
11 Trail	27 Cariboo-Chilcotin	42 Maple Ridge	60 Peace River N	80 Kitimat
12 Grand Forks	28 Quesnel	43 Coquitlam	61 Greater Victoria	81 Fort Nelson
13 Kettle Valley	29 Lillooet	44 N Vancouver	62 Sooke	84 Van Isl West
14 S Okanagan	30 S Cariboo	45 W Vancouver	63 Saanich	85 Van Isl North
15 Penticton	31 Merritt	46 Sunshine Coast	64 Gulf Islands	86 Creston-Kaslo
16 Keremeos	32 Hope	47 Powell River	65 Cowichan	87 Stikine
17 Princeton	33 Chilliwack	48 Howe Sound	66 Lake Cowichan	88 Terrace
18 Golden	34 Abbotsford	49 Central Coast	68 Nanaimo	

Figure 2: Population Distribution by School District 1989



3.3 Centroid Determination

Two types of centroids can be considered as the centroid of a school district. A *geographic centroid* is defined as the geographic center of a region, whereas a *population centroid* is the location which represents the center of the population. In small cells with high population density, the geographic and population centroids coincide. In our study, most cells are quite large and not very densely populated. For large areas, the population and geographical centroid can very different. Since the goal is to estimate the location of cases within a cell, the geographical centroid is inappropriate. Where population does not exist, no cases will be found. If the geographic centroid of a cell is in an unpopulated region, the centroid is not at all an estimate of the location of the cases. Cases can only be located in areas of population. We expect more cases in a highly populated area than

in a sparse one, so it makes sense to choose the population-based centroid as an estimate of the location of the cases within a cell. Only population centroids will be used in this study. The exact locations of all people in the province is unknown. Under the null hypothesis, the location of all cancer cases from all sites estimates the population-based centroid. This determination is a reasonable estimate of the real population centroid since large numbers of cases are involved. Of the total cases reported to the Registry in all sites considered, about 91%, or 73,092, patients have both postal code and school district information complete. These patient's postal codes are used to estimate the school district centroids.

The data is transformed by Geocodes/PCCF software [12] into latitude and longitude coordinates. The Geocodes Postal Code Conversion File (PCCF) system is produced by the Geography Division of Statistics Canada. The current version contains over 118,000 postal code records for British Columbia up to the year ending 1991. The package enables its user to gain information about standard geographical areas by use of the six character postal code. Users can cross-reference geographic coordinates and census regions.

The content of the PCCF has three key factors. These components are the postal code, the 1991 Enumeration Area (EA) code, and the postal code coordinates. The postal code coordinate is given in Universal Transverse Mercator System and latitude/longitude coordinates. The coordinates are determined by representative points that are "proxies" for postal code locations. They may be EA representative points or block-face representative points. An enumeration area representative point is based on either automated or manual judgement of the visual center of an EA. This point is usually located at or beside predominant building or street clusters. A block-face is generally one side of a city street between consecutive intersections with other streets in urban areas. The block-face representative point is the midpoint of the block-face, set

back a perpendicular distance of 22 metres from the street center line. The enumeration area code contains many levels of census divisions such as Census Subdivision (CSD) and Federal Electoral District (FED).

The program first links any postal codes which are unique on the PCCF. Unique in this case means that the postal code is linked to a single FEDEA or block-face. If a postal code is not unique on the PCCF, other levels of geography such as Census Division/Census Subdivision can be used to clarify any ambiguity.

With nonunique postal codes on the PCCF, observations with the same postal code will be distributed across all applicable enumeration areas (or block-faces) which are identified by that postal code. Whenever a postal code can be linked with more than one block-face or FEDEA, observations are distributed uniformly, within a postal community's service region, to each applicable FEDEA. Suppose the PCCF indicates a particular rural postal code serves ten different FEDEA's, with 7 in one CSD and the rest in another. The FEDEA's would be randomly mixed and each successive occurrence of the postal code would be assigned to the next applicable FEDEA. The distribution of events would be 7/10 in the first CSD and 3/10 in the second CSD. This method gives an approximately population-weighted random distribution since FEDEA's have about the same population throughout the postal code's service area.

The first three characters in the postal code represent a set of well-defined and stable areas known as Forward Sortation Areas (FSA's). The last three postal code characters designate areas known as the Local Delivery Unit (LDU). A single postal code can correspond to several types of LDU's in urban areas. One block-face, a Community Mail Box, an apartment building, a business building, a large firm or organization, a federal government department, a mail delivery route, general delivery at a specific post office, one or more post office boxes are all examples of LDU's. In rural areas, a postal code refers to all services which originate from a post office or postal station.

When a postal code was not exactly matched on the PCCF an error, termed Error 0, is reported. When a postal code is not exactly matched to one contained in the program partial geography can be assigned based on the consecutive characters which do match on the PCCF. For example, if the LDU does not match, the geography may be assigned by the first five characters of the postal code which do match on the PCCF. If the postal code was linked to a Post Office Geography (Error 1) rather than a place of residence or was not linked to a residential address at all (Error 2) the user is also informed. The program also warns if a postal code was linked to a business building, commercial or institutional building, or a retired postal code.

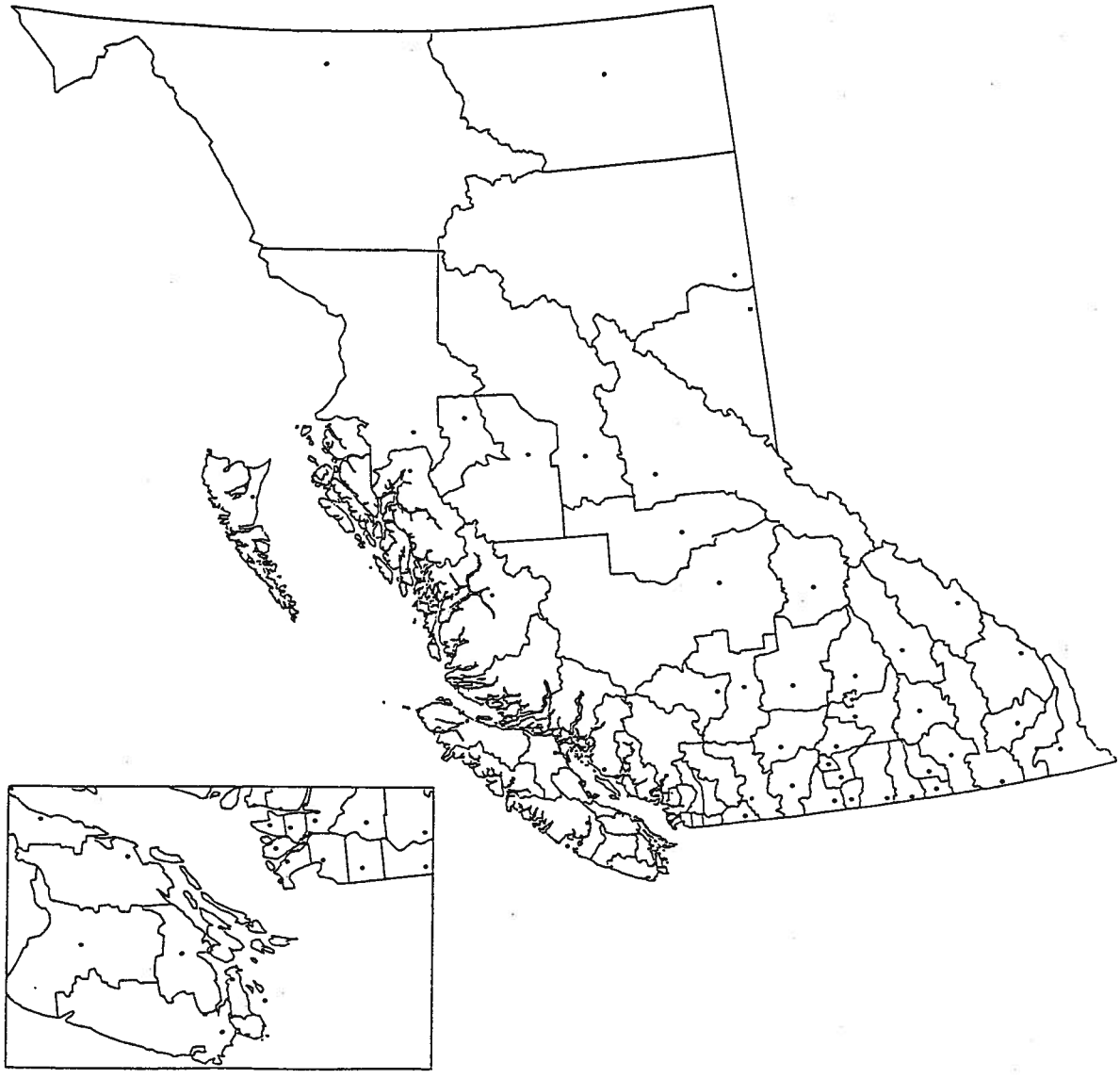
The school districts of Langley, Surrey, Delta, Richmond, Vancouver, New Westminster, Burnaby, Coquitlam, North Vancouver and West Vancouver have particularly high Error 0 rates. These regions contain 35,128 cases of which 32,163 are not matched on the PCCF. The highly populated regions seem to have the most unmatched postal codes. Overall, about 59% of codes do not match exactly, 92% due to the lower mainland school districts just mentioned. For these cases, some of the first characters of the postal code are used to assign a latitude/longitude coordinate. These rates may sound alarming, however, the coordinates assigned are representative of the school district in question. More FSA's exist in highly populated areas. If a postal code is not exactly matched, the FSA can be used to assign geographic coordinates. With the LDU unmatched, the geographic coordinates assigned by the FSA may differ from the real location by a block-face or apartment building or Community Mail Box. The coordinates will be representative of the area, even though they may not be as accurate as if the postal code was exactly matched. One can easily tell if the geographic coordinates given by PCCF actually are plausible. Comparing the coordinates to the school districts on a map indicates any which are not contained within the school district's boundary. These lower mainland districts occupy a small geographic area with respect to the rest of the

province. High rates of nonmatching postal codes are not disconcerting since the exact location of each cancer case is not the objective. In the lower mainland, the population density does not vary greatly within a school district. Even with inexact geographic coordinates, the location is likely still representative of the population which resides there. We also recognize that with rural postal codes, the latitude/longitude may correspond to a postal outlet and not to an actual place of residence. Postal outlets are located in areas of population, so the coordinates are accurate estimates of the location of a case.

With the latitude and longitude coordinates that Geocodes/PCCF produced, the population centroids can be approximated. The set of coordinates which corresponded to a specific school district are used to estimate the population centroid. The coordinates of patients in Vancouver school district estimate the population centroid of Vancouver, for example. For each school district, the median latitude and median longitude are taken to represent the population centroid. With this determination, the choice of centroid is based on the underlying population distribution. If a school district is square-shaped and all the population lives in the northwest corner, placing the centroid at the geographic center would not be an accurate centroid. If the disease incidence is random and independent of location, highly concentrated areas of cases should also have a high underlying population at risk. Under the null hypothesis, distribution of cases should be representative of the distribution of the population at risk. Of course, the population centroid chosen by this method will only approximate the actual cell population centroid. Figure 3 displays the estimated population centroid of each school district.

British Columbia has twenty-two pulp and paper manufacturers within its borders. These mills are considered as foci for the focused tests. Table 2 found in the Appendix, lists the name, location and corresponding school district of each pulpmill. Postal codes are known for each mill and the mill coordinates are also given by the PCCF. Of the 22 pulpmills, five postal codes are unmatched. The coordinates given are good estimates of

Figure 3: School District Centroids in British Columbia 1983–89



Map courtesy John Smith & MapInfo.

the actual locations. Mills are generally located near or within a town. The mills are not found in deserted areas, but places where resources and the work force are nearby. The coordinates can be double checked by using a map. The Prince George mills coordinates given by the PCCF can be cross-referenced with the town's coordinates. The town of Prince George can be seen on a map and the latitude and longitude can be recorded. The Prince George mill coordinates should be fairly close to the town of Prince George to be reliable. For all mills considered, the coordinates determined by PCCF are very close to the towns the mills actually are near. From this, we conclude that the coordinates given by the PCCF program are excellent estimates for the geographic locations based on their full addresses. The mill locations are plotted on the map given in Figure 4. A few school districts have multiple mills located within their borders. The Prince George school district, in particular, has five mills within its boundary.

Figure 4: Pulpmill Locations in British Columbia 1983–89

Map courtesy John Smith & MapInfo.

1	Prince George	9	Powell River	17	Skookumchuck
2	Prince George	10	Prince George	18	Ocean Falls
3	Castlegar	11	Prince Rupert	19	Mackenzie
4	Kitimat	12	Port Alice	20	Campbell River
5	Crofton	13	Squamish	21	Mackenzie
6	Port Mellon	14	Kamloops	22	Quesnel
7	Port Alberni	15	Gold River		
8	Nanaimo	16	Quesnel		

4 Analysis

The application of the Besag and Newell method is now discussed. The data is first tested under the general test. Problems encountered in the application of the Besag and Newell general test also arise in the focused test. Because the two tests are analogous, discussion is concentrated on the general test. A combined year analysis is discussed for the general and focused tests followed by a yearly examination. A modification for the Besag and Newell method is motivated by the combined year analysis and is introduced in Section 4.2. The differences between the modification and the original method are also examined.

The nearest neighbours of a cell or foci are required for the method. The distance between cells is taken to be the distance between their centroids. In Table 3 the three nearest neighbours to each school district are listed.

For the focused analyses, the location of a focus is considered its own cell. Within this cell the number of cases and population are both equal to zero. Each focus is analyzed in turn by looking at the closest school districts to it. Table 4 gives the five nearest school district centroids for each mill. The Prince George school district has five pulpmills within its boundary. Two of these are in MacKenzie and three are in Prince George. The latitude and longitude coordinates, as calculated by the GEOCODE/PCCF software, are identical for the three mills located in Prince George. This means that the nearest neighbouring school districts are the same for all three mills. Thus, one analysis based on only one focus of the three is required. From Table 4, the two mills in MacKenzie have quite similar nearest neighbours, with identical first two nearest neighbours, to the mills in Prince George. The Skookumchuck mill is located in the Cranbrook school district, but it is closest to the centroid of the Kimberley school district. All other mills are closest to the centroid of the school district in which they are located.

The cancer sites investigated have varying incidence rates in the different age groups

and sexes. Both general and focused tests are conducted on each site and sex separately. Once one analysis is conducted for any strata involved, it is repeated for every site and for each sex. For example, male lip cases are tested then female lip cases are tested. All analyses use age group as a stratum.

4.1 Combined Year Analysis

The general test is applied first for the combined year analysis and the details below describe the procedure.

The choice of cluster size, k, is a serious consideration. Besag and Newell use the values 2, 4, 6 and 8 for k in their analysis of the incidence of childhood leukemia in northern England. In their case, the counties, or cells, are relatively small and leukemia incidences in each cell are probably either zero or one. A cluster size larger than 8 is probably not very realistic in their situation. In our case, the different regions have very dissimilar numbers of incident cases. The cases may be lower than 10 or higher than 100 in each administrative region. The variation among regions increases when more common cancers are examined. The lower mainland school districts may reflect incident cases in the low thousands while a northern district has less than 100 cases. With this variability, the cluster size we should test is not clear.

To follow their approach, several different cluster sizes are chosen to account for differences between administrative regions' population sizes. The selection of each cluster size depends on the population of the school districts. Smaller school districts need to be tested at smaller cluster sizes while large school districts need a large cluster size. Several different cluster sizes may be chosen to reflect the school district diversity. This determination hopefully ensures that the choice of k does not favour any particular population size. The detection of clusters in a densely populated area is just as important as detecting a cluster in a sparsely populated region. Choosing multiple cluster sizes

may alleviate any bias towards a specific population size. To examine its feasibility, ten different cluster sizes, $k_1, k_2, \ldots, k_{10}$, are used for each sex and site. Let c_{iys} represent the number of cases in school district i, year y, and age group s, $i = 1, \ldots, 74$, $y = 83, \ldots, 89$, $s = 1, \ldots, 18$. The total number of cases, $c_{i..}$, is calculated in each school district i over the years of 1983–89, where $c_{i..} = \sum_{y=83}^{89} \sum_{s=1}^{18} c_{iys}$. The median value of the $c_{i..}$'s is evaluated and labeled k_1. Twice the maximum value of the $c_{i..}$'s is named k_{10}. The remaining eight choices for the cluster size are evenly spaced between k_1 and k_{10} with any fractional parts dropped. Thus $k_x = k_1 + \lfloor x(k_{10} - k_1)/8 \rfloor$ for $x = 2, \ldots, 9$ with $\lfloor t \rfloor$ the greatest integer less than or equal to t.

The analysis proceeds for each cluster size. Let n_{iys} denote the population in school district i, year y, and age group s, $i = 1, \ldots, 74$, $y = 83, \ldots, 89$, $s = 1, \ldots, 18$. The average provincial population in age group s during the seven study years is labeled $n_{..s}$, $n_{..s} = \frac{1}{7} \sum_{i=1}^{74} \sum_{y=83}^{89} n_{iys}$. The estimated mean number of cases expected over the combined years for each school district is determined using age categories. Let $m_{iys\ell}$ represent the total population in cell i and its ℓ nearest neighbours for year y and age group s. The average population over the seven study years for cell i and its ℓ nearest neighbours is denoted $\bar{m}_{i \cdot s\ell}$. The estimated mean number of cases expected during the years 1983–89 for school district i, $i = 1, \ldots, 74$, is calculated as

$$\lambda_{i\ell} = \sum_{s=1}^{18} \bar{m}_{i \cdot s\ell} \frac{c_{..s}}{n_{..s}}. \tag{11}$$

The result for male lip cancer, which is somewhat typical for this approach, is given in Table 5. Results are not consistent from cluster size to cluster size. Most districts are possible clusters for one or two values of k_x, but fail to show any consistency throughout the cluster sizes considered. The observed value of the test statistic also fluctuates quite noticeably. Many school districts are detected as possible clusters because of the multiple cluster sizes investigated. For rare cancers, such as lung adenosquamous cancer, the resulting cluster sizes detected are less than twenty. For more common cancers, like

colo-rectal, the cluster sizes range from 32 to 1,643. A problem could arise if the cluster size is too large. The significance level of the Besag and Newell test is dependent on the cumulative Poisson distribution. If enough terms are summed the cumulative distribution will be very close to one. Since k is the number of terms summed, with sufficiently large cluster sizes the Poisson cumulative distribution can be close to one. If this case occurs, by equation (6) the significance level will be very close to zero and a cluster will be identified. When a cell attains a low significance level, an interpretation problem emerges. Investigators must decide if this significant cell is a result of a real cluster or a consequence of the cluster size being too large.

Just as Besag and Newell use four values in their analysis, we try to systematically determine the cluster size based on the number of cases in different school districts. This situation makes the multiple testing problem even worse. The regular multiplicity quandaries are compounded by the assorted cluster sizes. How these results are interpreted is also a problem. Of course, most school districts for which a possible cluster is detected for one value of k_x, are no longer identified as possible clusters at higher or lower values of this cluster size. Since the significance level achieved is influenced by the choice of k, the interpretation of any results must be based on the choice of k.

These difficulties lead us to conclude that detecting cancer clusters with a fixed size across British Columbia, where school districts have substantially different populations, is neither reasonable nor worthwhile. Instead, we try to detect cancer clusters with different sizes for distinct areas in B.C. The sizes are chosen so that a common interpretation can be obtained for the analyses.

As commonly seen in epidemiology literature, a relative risk of 1.5 (with at least 5 cases) due to some specific exposure is considered to be sufficient evidence for further examination. We incorporate this idea in choosing cluster sizes. That is, for each school district, a cluster size is chosen so that it is about 1.5 times the expected number

of cases if no clustering is present. For example, if cell 1 has 1000 residents and the provincial incidence rate is 0.01, 15 would be the cluster size. When the age groups are incorporated, the cluster size investigated for cell i is $k_{1.5,i}$ defined by,

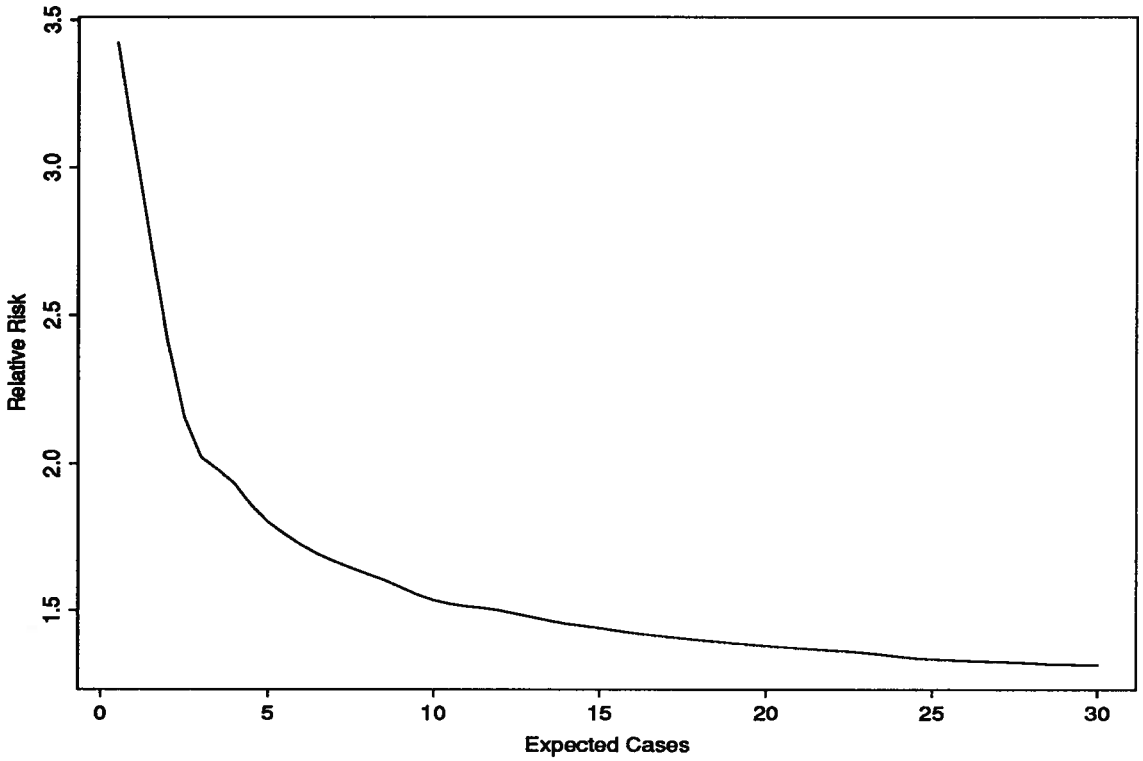
$$k_{1.5,i} = \lfloor 1.5 \sum_{s=1}^{18} \bar{m}_{i \cdot s\ell} \frac{c_{\cdot\cdot s}}{n_{\cdot\cdot s}} \rfloor, \qquad i = 1, \cdots, 74. \tag{12}$$

With this cluster size valuation, the analysis proceeds. If the cluster size is less than five, 5 is taken as the cluster size. The estimated mean number of cases expected for cell i is still given in equation (11). Note that with this choice of the cluster size, a conclusion of cancer clusters in the region is interpreted as evidence of local areas having excess relative risk.

Equation (12) shows that the cluster size evaluated for each school district reflects the inherent variation in the population sizes. Large values of L are no longer required to achieve k cases when a cell with small population is considered, which helps in interpretation. Certainly a cell which is a possible cluster, has a relative rate of 1.5, and at least five cases causes alarm. Some clusters are detected using this determination of the cluster size, however, the method proves to be unable to detect larger clusters in small regions where expected numbers of cases are low. If, for example, cell i has 2 cases expected ($\lambda_{i0} = 2$), $k_{1.5,i}$ equals 5. If that cell has 7 cases observed, $\ell = 0$ and the p-value is insignificant. The cell is intuitively alarming because of the very high relative rate. With over 5 cases and a relative rate of 3.5, the district causes concern and the cluster detection method should support this conclusion. Besag and Newell also think the relative rate is important but did not incorporate it in their method.

In fact, the procedure performs relatively well when the expected number of cases within a region is greater than 15. With the mean less than 5, however, the mean needs to be multiplied by a much higher relative risk to detect unpredictably large clusters in a small area. Figure 5 shows what relative risk is required to detect a cluster at 5% for each value of the mean, smoothed for display.

Figure 5: Minimum Relative Risks for Significance at 5%



The y-axis in this figure is the 95^{th} percentile of the Poisson distribution with mean λ divided by λ. Any observed relative risks which lie above the curve yield a cell with the corresponding expected number of cases to be significant at 5%. For $\lambda > 15$, this procedure is able to perform well because 1.5 lies above the curve in that region. With small values of λ, 1.5 lies well below the curve and no cells are significant for those values of λ. We also notice that lower than 1.5 relative rates will return a significant result when the expected number of cases is large. From this figure it is easy to see that with smaller means, the relative risk required to detect a possible cluster increases. A fixed relative risk across the region may be reasonable for common cancers where expected number of cases are relatively large, but it may not be desirable for rare cancers where the expected numbers may be small and a potential cluster may be missed. This led us

to try an alternate function of the expected number of cases within each cell.

4.2 Modified Besag and Newell Method

The previous discussion displayed some of the problems we encounter with the application of the Besag and Newell statistic. Specifically we have problems with the appropriate choice of cluster size. One cluster size cannot detect all possible clusters within the province. A different cluster size for each school district based on the population within that district seems desirable. We now propose a method to determine which cluster sizes to test for each school district.

The significance level calculations with the Besag and Newell approach are based on the cluster size investigated. The p-value may not represent the true degree of clustering if the observed number of cases is much larger than the cluster size being tested. If the cluster size is 10, for example, the same p-value will be achieved for cell i if it has 10 or 50 cases within its boundary. The test statistic is zero in both cases and the p-values are identical. Surely the latter situation represents more clustering than the former. The Besag and Newell method would benefit from a systematic way of determining the cluster size so that small changes in the choice of cluster size do not alter the significance level dramatically. Certainly, it is undesirable to have a particular cell insignificant for k but significant for $k+1$, when in both situations $\ell = 0$. Testing for a specific cluster size may not be of interest. Instead, areas which have statistically significant excess cases may be of concern, whatever that excess size may be.

These observations motivate some alterations based on the idea of allowing the number of cases representing a cluster size to vary as cell i is combined with its nearest neighbours. If the value of the cluster size is not important to the investigator, the cluster size shall be chosen to represent the minimum size for which the area examined is a statistically significant cluster. This size corresponds to a specific percentile of the

Poisson distribution with mean determined by the area under scrutiny.

Consider cell i, where $1 \leq i \leq I$. Recall that the estimated total number of cases expected in cell i and its w nearest neighbours is denoted by λ_{iw}, $\lambda_{iw} = m_{iw}c./n.$, $0 \leq w \leq I-1$. Also recall that m_{iw} is the total population in cell i and its w nearest neighbours. Define $k_{1-\alpha,i,w}$ to be the $100(1-\alpha)$ percentile of the Poisson distribution with mean λ_{iw}. Thus, $k_{1-\alpha,i,w}$ is the smallest integer such that

$$1 - \sum_{x=0}^{k_{1-\alpha,i,w}-1} exp(-\lambda_{iw})\lambda_{iw}{}^{x}/x! \leq \alpha. \tag{13}$$

A cluster size equal to $k_{1-\alpha,i,w}$ is interpreted as the minimum number of cases which would have to be observed to cause cell i and its nearest w neighbours to be significant at level α.

Each cell has some expected number of cases no matter how minute, so for any cell i, the sequence of λ_{iw}'s is strictly increasing, $\lambda_{i0} < \lambda_{i1} < \ldots < \lambda_{i(I-1)}$. It follows that for any i, the sequence of $k_{1-\alpha,i,w}$'s is non-decreasing, $k_{1-\alpha,i,0} \leq k_{1-\alpha,i,1} \leq \ldots \leq k_{1-\alpha,i,I-1}$; i.e. the mean of the Poisson distribution increases so the $100(1-\alpha)$ percentile is non-decreasing. However, the Poisson distribution is discrete, so very small increments in the mean may not change the $100(1-\alpha)$ percentile.

Cell i may be tested at cluster size $k_{1-\alpha,i,0}$. If the actual number of cases in cell i exceeds this cluster size, cell i is significant at $100\alpha\%$. The determination of the cluster size guarantees this result. With a cluster size of $k_{1-\alpha,i,0}$, only cells which are possible clusters on their own are guaranteed be significant. This cluster size may only identify significant cells for which the test statistic is zero, $\ell = 0$. If, on the other hand, the actual number of cases in cell i is less than $k_{1-\alpha,i,0}$, the test statistic increases by one and the expected number of cases in cell i and its nearest neighbour equals λ_{i1}. The $100(1-\alpha)$ percentile is re-evaluated and these two cells are probably insignificant even if a true cluster exists.

In general, testing cell i at cluster size $k_{1-\alpha,i,0}$ determines if cell i alone is a possible

cluster. Testing the same cell at $k_{1-\alpha,i,1}$ indicates if cell i and its nearest neighbour are significant when combined together. Two cells can be significant together without either being a possible cluster individually. This circumstance requires that not one, but several cluster sizes be tested.

The following testing algorithm is proposed. Consider the sequence of cluster sizes $k_{1-\alpha,i,0}, k_{1-\alpha,i,1}, \ldots, k_{1-\alpha,i,w}$ for some integer $w \in \{0, 1, \ldots, I-1\}$ for cell i. Test cell i at cluster size $k_{1-\alpha,i,0}$. If it is significant, no further testing is done on cell i. If cell i is not significant, it is combined with its nearest neighbour and tested at the new cluster size $k_{1-\alpha,i,1}$. Again, if cell i is significant for this cluster size the algorithm terminates. Otherwise, cell i is tested at the next cluster size in the sequence. In general, test each cell until either it is significant or it has been tested at every cluster size in the sequence. For cell i, the results from the last cluster size tested are recorded. The p-value from this last test will be referred to as the p-value for the cell.

Generally speaking, w should not be very large. Large values of w correspond to testing if huge portions of the study area are significant. These tests probably do not yield any new information on clustering: either smaller groups of the huge portion are significant at smaller cluster sizes or the combination of many cells yields normal disease rates. If cells with low disease counts are combined with cells of high disease counts, the resulting combination probably has about normal disease counts and is not a cluster. The multiple testing problem becomes more serious as w becomes large. The upper bound for the expected number of cells which may be significant due to chance is equal to αI for each cluster size investigated. If the number of cluster sizes investigated is large, many spurious clusters may be identified. Consequently, keeping w small aids in interpretation of results.

The interpretation of the p-value for a cell is slightly different with the values of k chosen. The school district with the lowest p-value is the most likely cluster of the

particular size investigated, if all cells are tested at the same cluster size. With the modified method, most of the p-values are very close to 0.05. Hence, the individual p-value is no longer the best measure of the most plausible cluster of size k. The relative rate is a way of assessing which of the possible clusters are actual clusters. Those cells with the highest relative rates should be of most concern to health authorities.

The overall test of clustering introduced by Besag and Newell is important to the interpretation of the results produced by our modified method. When several cluster sizes for each cell are tested, many cells may be significant by chance. If only one cluster size is tested for each cell, αI cells are expected to be significant. If each cell is tested at w or less cluster sizes, the expected number of cells found significant by chance is at most $w\alpha I$. If the investigator tests each cell at many cluster sizes, the Monte Carlo simulation can help determine if any apparent clustering can be attributed to chance.

For our school district application we consider three cluster sizes ($w = 2$). Most of the school districts are geographically large. Choosing to combine 4, 5 or more of the cells may result in testing a large fraction of the province. Testing more cluster sizes allows more significant results by chance. Spurious clusters are unappealing. With these considerations, testing at most three cluster sizes seems reasonable in our situation.

The cluster sizes $k_{.95,i,0}$, $k_{.95,i,1}$, and $k_{.95,i,2}$ for cell i are the 95^{th} percentiles of the Poisson distributions with means λ_{i0}, λ_{i1}, and λ_{i2}, respectively. These means correspond to the expected number of cases in cell i alone, cell i and its nearest neighbour, and cell i and its two closest neighbours. Specifically, $\lambda_{i\ell} = \sum_{s=1}^{18} \bar{m}_{i\cdot s\ell} c_{\cdot\cdot s}/n_{\cdot\cdot s}$ and $\bar{m}_{i\cdot s\ell}$ is the average population over the seven study years in age group s for the ℓ nearest neighbours of cell i. If any of the three cluster sizes are less than 5 we set them equal to five. Each cell is tested at $k_{.95,i,0}$, then at $k_{.95,i,1}$, and at $k_{.95,i,2}$, if necessary. The algorithm proceeds for each cell and the significant cells with relative rates at least 1.5 are recorded. The individual p-values will all be near 0.05 because of the way each $k_{.95,i,w}$ is determined.

Those cells with the highest rates should be of most concern to health authorities.

A Monte Carlo simulation is performed to help determine the overall significance of the number of clusters detected. The total number of cases $c_{..}$ are distributed randomly to each of the strata based on the appropriate probability. The probability that a case would fall in cell i is the proportion of the provincial population which that cell contains. The above method of analysis is then applied to the simulated data. The simulation is iterated 1000 times and the number of significant cells, R, for each iteration is recorded. The overall p-value is then the proportion of the simulations which attain at least the observed value of R. Sites for which many school districts appear significant may be more alarming than sites which have few possible clusters. With three values of k used on each cell at most $3 \times 0.05 \times 74 = 11.1$ cells, not necessarily distinct, are expected to be significant by chance. This expectation is much lower when considering only significant cells with relative rates of at least 1.5 and testing each cell at a maximum of three different cluster sizes. The Monte Carlo simulation may help to evaluate the significance of overall clustering when more than the expected number of clusters appear significant. Note that the lack of statistical overall significance should not deter investigation of individual clusters which appear to exist. Overall tests are of secondary consequence and only help assess the situation when many possible clusters are detected. In our analysis, only a few sites seem to have many possible clusters. The Monte Carlo simulation, nevertheless, is done on all sites.

The focused test for combined years is conducted analogously. For each mill i, $i = i, \ldots, 18$, three cluster sizes are determined. The mill itself has exactly zero cases expected, so the cluster sizes are evaluated based on the nearest neighbours. The 95^{th} percentiles $k_{.95,i,0}$, $k_{.95,i,1}$, and $k_{.95,i,2}$ now correspond to slightly different Poisson distributions. The first cluster is the 95^{th} percentile based on the number of cases expected in the nearest neighbour to mill i. The other two percentiles are based on the number of

cases expected in the two and three closest neighbours to mill i, respectively. A Monte Carlo simulation is also performed in the same manner described for the general test to obtain an overall p-value.

Our modification yields some improvements to the Besag and Newell method. Most importantly, a systematic determination of the cluster size investigated is offered. This cluster size is guaranteed to detect possible clusters at a certain significance level based on the size's determination. The cluster size is determined by a percentile of a Poisson distribution. If the observed number of cases is as large as or greater than the percentile, the cell is significant and is detected as a possible cluster. We have the added advantage that the value of k is chosen according to the underlying population or equivalently, its expected number of cases. The choice of cluster size is less *ad hoc* with this modification. A Monte Carlo simulation can still be applied to provide some overall significance to the number of apparent clusters which are detected in the study region.

A discussion of the general and focused results obtained follows in Section 5. The next section provides the yearly analysis procedure.

4.3 Yearly Analysis

The combined year analysis identified school districts which have enough cases over the study period to be considered possible clusters. Investigators may wish to know if the excess of cases occurs in a specific year or is consistent across the years. To see if excesses of cases are consistent through time, we look at each year separately to see if any pattern emerges. A school district may have a significant excess number of cases in particular years within the study period. Although a cell is not significant for the combined year analysis, it still may be significant for a particular year. We specifically want to see if the relative rates are consistent through time. If a school district is significant for several years we may be more concerned with this area than a cell which is significant

for an isolated year.

To try to compare results from seven years of data, it seems appropriate, for a particular site and sex, to choose one cluster size for each school district and test each year at that cluster size. With the cluster size fixed across all years, the statistic L would show different values for different years and the p-value calculated would indicate the degree of clustering. We would be able to easily compare years if the same cluster size is used for each year. This would be feasible because the population in each school district does not fluctuate too much from year to year, and hence the expected number of cases are about the same for each year. We use the combined year cluster size chosen for a cell and divide by seven to get the yearly cluster size. The minimum yearly cluster size investigated is two since a cluster of size one is unreasonable.

The same sort of problem arises when trying to look at one cluster size across all years as we had for one cluster size across all school districts. An area may be not significant for any year because the cluster size chosen is too low. Consider the situation where a cell has disease counts equal to zero for all years but one, 1988 say. In 1988, suppose this cell has 13 cases observed. If the expected number of cases over all years is seven, this cell is significant at 5% when k equals thirteen. When the yearly analysis is conducted, we use a cluster size equal to 2 since 13/7 is less than two. For each year, the expected number of cases are about one. None of the years are significant even though the number of cases in 1988 seems to be a cluster. With this type of situation arising in our analysis we conclude that the use of one cluster size for each year is inappropriate.

If the cluster size must differ across the study years, we want to choose the best k for each year, so that cells with seemingly excess numbers of cases are significant. The modified method developed for the general test could be applied to the yearly analysis. Each year is treated separately, as if it was the only data, and the general test with three possible cluster sizes is performed. For cell i and year y the sequence of cluster sizes

would be $k_{.95,i,0,y}$, $k_{.95,i,1,y}$, and $k_{.95,i,2,y}$. The 95^{th} percentile, $k_{.95,i,\ell,y}$, would be based on the Poisson distribution with mean $\lambda_{iy} = \sum_{s=1}^{18} m_{iys\ell} c_{.ys}/n_{.ys}$. The term $m_{iys\ell}$ is the population in cell i and its ℓ nearest neighbours for age group s and year y, $i = 1, \ldots, 74$, $s = 1, \ldots, 18$, $y = 83, \ldots, 89$. Here, as in the combined year case, the minimum cluster size for which a cell is significant is recorded. The p-value obtained at the minimum cluster size is called the p-value for the cell.

Seven p-values are recorded for each school district under the yearly analysis. A combination of these p-values may indicate if a cell is part of a possible cluster consistently throughout the study period. Let p_{iy} be the p-value obtained for cell i in year y, $i = 1, \cdots, 74$ and $y = 83, \cdots, 89$. Assuming that the yearly analyses are independent, the statistic,

$$T_i = -2 \sum_{y=83}^{89} \ln p_{iy} \tag{14}$$

can be approximated by a χ^2 distribution with 2×7 degrees of freedom. Consistently small p-values for a school district produce a large value of T. Large p-values would yield a small value of the statistic. If T is small, we accept the hypothesis that no consistency of apparent clustering is seen in the yearly analyses. For large values of T we reject the hypothesis. The p-value from each year can be transformed in this way and an overall p-value for consistency can be calculated from the ${\chi^2}_{14}$ distribution. We call this p-value the consistency p-value in order to distinguish it from the p-value calculated for each year.

The focused yearly analysis is carried out in the same manner as the general yearly situation just described. The years are considered individually. Three cluster sizes are tested for each mill and a combination of the yearly p-values is made. Again, the cluster sizes are based on the population in the mill's nearest neighbours.

5 Discussion of Results

5.1 Combined Year Analysis

The male and female findings by cancer site, in Tables 6 and 7, are listed in the Appendix. Only the sites for which at least one school district or mill, with a relative rate of at least 1.5, was significant at 5% are displayed. The observed value ℓ of the statistic L is listed along with the cluster size, k, and the expected number of cases within the school district and its L nearest neighbours, λ. The actual number of cases observed within the school district or mill and its nearest L neighbours is denoted O. The relative rate is labeled O/λ and individual p-value is called p. The p-value obtained from Monte Carlo simulation for the overall test is called $\mathcal{P}$. Sites for which this $\mathcal{P}$ is less than 0.1 have the significant school districts shaded on a map of the province in the general analysis. The term "NSD" for the focused test refers to the mill's nearest school district.

5.1.1 General Male Findings

No significant school districts with relative rates at least 1.5 are identified for the sites of colon, lung adenocarcinoma, all cancers except lung, and all cancers for males.

Lip

Lip cancer proves to be a site with many significant cells. From Table 6.1 and shaded regions of the map, the school districts around Grand Forks have some of the highest relative rates for lip cancer. Within Grand Forks' borders, 7 cases are observed when only 1.17 are expected. The relative rate here is a high 5.98 and influences the neighbouring school districts. We note that this result would not be detected if $k_{1.5}$ was the cluster size investigated. The p-value for Grand Forks is equal to 0.01 and its neighbours have individual p-values which are between 0.02 and 0.04. Peace River South is also startling with a relative rate of 4.08. The high rate here heavily influences the

results for Peace River North. Cranbrook comes next with 3.37 times more cases than expected. Neighbours Fernie, Kimberly and Creston-Kaslo also form a possible cluster. Chilliwack, Creston-Kaslo, and Abbotsford each have high relative rates which affects the cells neighbouring them. Cariboo-Chilcotin and Quesnel have a relative rate of 1.96 when considered together. Lip cancer is one of the rarest forms of cancer considered in this study. It is surprising to find so many cells which have very high rates. The zero Monte Carlo p-value supports the extreme overall clustering we appear to see.

Oral Cavity

Castlegar and New Westminster are listed for oral cavity cancer. Some clustering is seen in the Vancouver, New Westminster, Castlegar and Trail areas in Table 6.2. Castlegar has the highest relative rate and lowest individual p-value of the group equaling 2.93 and 0.02, respectively. These values influence the neighbouring district of Trail. Trail's relative rate is 1.56 which is slightly above 1.5. Vancouver has a relative rate of 1.63 with 314 observed cases. New Westminster has just over twice the observed cases than expected. Both Vancouver and New Westminster are considered clusters alone. Both of these two have observed test statistics equal to zero. The Monte Carlo p-value is evaluated as 0.402. Overall clustering is not supported with this site although some individual relative rates are quite high.

Esophagus

The same can be said for esophagus cancer. Although, overall clustering is not supported by the Monte Carlo p-value of 0.813, Cariboo-Chilcotin and Quesnel have high relative rates which are listed in Table 6.3. Cariboo-Chilcotin has nine cases observed when only 4.65 were expected, yielding a relative risk of 1.93. Quesnel's results are effected by neighbour Cariboo-Chilcotin. Consequently, the relative rate for Quesnel is listed as 1.96.

Stomach

Table 6.4 lists seven significant districts for stomach cancer. The Monte Carlo p-value is equal to 0.052 which suggests some overall clustering. Clustering appears to be located in some northern regions of Vancouver Island, Central Coast, Queen Charlotte, and Prince Rupert. Princeton has the highest relative rate of 2.59 with an individual p-value of 0.03. Vancouver Island North has a relative rate of 2.37 which influences neighbour Central Coast. Alberni has a relative rate of 1.78 and does not require any cells to be combined to achieve at least 19 cases. Campbell River also has the test statistic equal to 0 and a relative rate of 1.64. Prince Rupert and neighbour Kitimat give Prince Rupert a significant result. The relative rate is 1.78 with 14 cases observed in the two cells. Queen Charlotte's test statistic is 2. It along with Prince Rupert and Kitimat have 16 cases observed and a relative rate of 1.75. Both Prince Rupert and Queen Charlotte appear to be influenced by Kitimat even though Kitimat does not appear in this table.

Rectum

Rectal cancer has one area of possible clustering. The Hope and Agassiz-Harrison region have high relative rates which can be seen in Table 6.6. Agassiz-Harrison has a startling relative rate of 2.29 which influences its neighbour Hope. Hope together with Agassiz-Harrison have a relative rate of 1.64. The overall p-value is equal to 0.565. This value suggests that overall clustering for this site is not seen in the province.

Liver

Parts of the lower mainland region are significant for liver cancer as seen in Table 6.7. Vancouver and New Westminster have test statistics equal to zero and relative rates 1.84 and 2.19, respectively. Richmond is a possible cluster when considered with neighbours Delta and Vancouver. New Westminster's high relative rate influences neighbour Burnaby. Burnaby has a relative rate of 1.58 when considered with its neighbour.

A relative rate of 1.71 is seen for North Vancouver when combined with Vancouver. West Vancouver's relative rate is equal to 1.64 when considered along with neighbours North Vancouver and Vancouver. Although several school districts are listed the Monte Carlo p-value of 0.266 suggests that overall clustering is not apparent.

Pancreas

Pancreatic cancer has seven districts which have relative rates above 1.5 and are significant at 5%. The Monte Carlo p-value found in Table 6.8 is calculated as 0.115. Arrow Lakes has the highest relative rate of this group equal to 3.26. Only 1.84 cases are expected in this school district and five are actually observed. Prince George, Cowichan, and Shuswap each have test statistics of zero. The relative rates for these three are 1.58, 1.90, and 1.73. Revelstoke and Lake Cowichan both have require one neighbour to be combined with them. Shuswap is instrumental in Revelstoke's significance and relative rate of 1.51. Cowichan does the same for Lake Cowichan which results in a relative rate of 1.78. Nechako is influenced by neighbours Prince George and Burns Lake. The Nechako and neighbours expect 17.75 cases but observe 26 cases which gives a relative rate of 1.52.

Larynx

Nechako and Prince George also have high relative rates for cancer of the larynx. As seen in Table 6.9, Prince George has a relative rate of 1.56 and 18 observed cases. Neighbour Nechako, influenced by Prince George, has a relative rate equal to 1.52. Princeton and Vancouver Island West also have large relative rates of 2.5 and 1.58, respectively. Princeton is combined with neighbour Keremeos to achieve that result. Vancouver Island West must be combined with Campbell River and Courtenay to give a relative rate of 1.58. With four school districts listed the Monte Carlo p-value is a high 0.479.

Lung Squamous

The lung squamous results are given in Table 6.10. Howe Sound, Smithers, Sooke, and Campbell River have test statistics equal to zero. Of these, Smithers has the highest relative rate equal to 1.87. Howe Sound, Campbell River, and Sooke follow with relative rates of 1.71, 1.65, and 1.58, respectively. Vancouver Island West along with neighbour Campbell River have a relative rate of 1.61. Stikine is influenced by Fort Nelson and Smithers with relative rate 1.74 and 14 cases observed. This site has an overall p-value of 0.030. This value implies that overall clustering within the province exists.

Lung Adenosquamous

Lung adenosquamous has four significant school districts which are found in Table 6.11. These four do not suggest overall clustering since the Monte Carlo p-value is 0.306. Nanaimo has zero as the observed test statistic. Only 1.92 cases are expected in the school district and six are actually observed giving Nanaimo a relative rate of 3.13. Qualicum is influenced by Nanaimo's results and has a similarly high relative rate. Sunshine Coast when considered with Nanaimo is also significant and has a relative rate of 2.77. Lake Cowichan along with Cowichan and Nanaimo are also significant. It is apparent that the high relative rate in Nanaimo causes its neighbours also to appear as possible clusters.

Lung Small Cell

Nanaimo is again listed as significant for lung small cell cancer. In Table 6.13 we can see that Nanaimo has 44 cases observed when only about 27 were expected. Revelstoke has the highest relative rate of those listed. With 2.67 times more cases observed than expected, it has an individual p-value of 0.03. Golden is influenced by neighbour Revelstoke, and thus the relative rate for the combined area is 2.35. Lillooet is also significant when neighbours South Cariboo and Merritt are combined with it. Lillooet and neighbours have 12 cases observed and a relative rate of 1.80. The overall p-value

for this site is 0.413. This number implies that overall clustering is not supported.

Lung Others

Overall clustering is supported in the lung others sites, however. In Table 6.14, the Monte Carlo p-value calculated to be zero. The school districts which have zero as their test statistic are Fernie, Revelstoke, Merritt, New Westminster, Queen Charlotte, Prince George, Mission and Fort Nelson. Fort Nelson tops the list when relative rate is considered. Fort Nelson has about one case expected but has five observed within its borders. These values give a high relative rate of 4.64. These cases obviously influence Stikine whose relative rate is above 3. Queen Charlotte expects 1.9 cases but observes five. New Westminster has about 41 cases expected and 63 are actually observed. Revelstoke has a relative rate of 2.25 and influences Golden. Merritt has a relative rate of 2.16 with 12 cases observed. Lillooet together with South Cariboo and Merritt has 21 observed cases while about 13 were expected resulting in a relative rate equal to 1.59. Prince George has a relative rate of 1.71 and effects the results found for neighbour Nechako. Mission has a relative rate of 1.69 as 31 cases were observed when only 18.39 were expected.

All Lungs and Non-small Cell Lung

Both all lungs and non-small cell lungs have the same significant school districts. These sites are found in Table 6.15 and Table 6.16 listing Revelstoke, Merritt and Fort Nelson. Each school district has test statistic equal to zero for both sites. Fort Nelson has the highest relative rate followed by Merritt and Revelstoke. For all lungs the relative rates are 2.40, 1.85, and 2.70, respectively. When non-small cell lungs are considered, the values are 2.57, 1.81, and 1.53. While both sites have the same significant school districts, they have dissimilar Monte Carlo p-values. The all lungs site is significant for overall clustering with a Monte Carlo p-value equal to 0.036. On the other hand, non-small cell lungs had 0.069 as the Monte Carlo p-value and mildly suggests an overall

pattern of clustering.

Soft Tissue Sarcoma

Soft tissue sarcoma findings are displayed in Table 6.17. No overall pattern of clustering is suggested by the Monte Carlo of 0.071. Grand Forks and Kettle Valley have extreme relative rates for soft tissue sarcoma, 2.93 and 1.89, respectively. Kettle Valley's result is influenced by the five cases seen in Grand Forks. Vancouver has a relative rate of 2.01 and test statistic equal to 0. North Vancouver is affected by Vancouver and gives a relative rate of 1.85 when both regions are considered together. Both school districts cause West Vancouver to be significant with relative rate 1.79. Vancouver apparently also influences Burnaby and Richmond. Both areas list the same relative rate of 1.69 and test statistic equal to two. Mission is significant itself with a relative rate of 1.89 and ten observed cases.

Melanoma

Three districts are noted for melanoma in Table 6.18. All three have test statistics equal to zero and the Monte Carlo p-value is evaluated as 0.544. Merritt has the highest relative rate of the bunch, 2.43, and nine cases are observed in its school district. Saanich has 34 cases observed to give a relative rate of 1.72. Thirty-one cases are seen in West Vancouver which is just over 1.5 times what is expected.

Prostate

Table 6.20 lists three districts for prostate cancer. The overall p-value is equal to 0.006 here and strongly indicates overall clustering. Burns Lake, Nechako, and Prince George are each significant individually. The relative rates are 1.69, 1.55, and 1.55, respectively. Burns Lake has 24 cases observed and Nechako has 42 observed. One hundred seventy-eight cases are seen in Prince George when only about 115 are expected.

Testis

Testicular cancer results show some clustering in the Gulf Islands, Courtenay, and

Vancouver Island North areas. Table 6.21 shows Gulf Islands with the highest relative rate of 4.16 and individual p-value 0.01. Only 1.2 cases are expected in that area and five are actually found. Vancouver Island North has 2.95 cases expected and eight observed giving a relative rate of 2.71. This result affects neighbour Central Coast producing a relative rate of 2.55. Courtenay is significant with a relative rate 1.92 which allows neighbour Powell River to also be listed with a relative rate of 1.85. Trail is seen with about three cases expected and seven actually observed. With six school districts listed, the Monte Carlo p-value is calculated to be 0.254.

Bladder

Seven districts give a Monte Carlo p-value of 0.019 indicating overall clustering for bladder cancer. In Table 6.22, South Cariboo has the highest relative rate with 2.45 and lowest individual p-value equal to 0.02. These values seem to induce a significant result for Lillooet as well. Lillooet's test statistic is equal to two and has a relative rate of 1.59. Campbell River follows next with a relative rate of 2.36 and thirty-two cases observed. It apparently affects neighbours Vancouver Island North and West for they too have relative rates above two. Specifically, Vancouver Island West has a relative rate of 2.36 while Vancouver Island North has Relative rate 2.20. Mission and Terrace are also listed with relative rates 2.01 and 1.70, respectively.

Kidney

A few patches throughout the province are seen to be significant for kidney cancer. The Monte Carlo p-value of 0.069 suggests some overall clustering. The largest relative rate is visible at Lake Cowichan in Table 6.23. Five cases are observed when less than two are expected. The relative rate for Lake Cowichan is 2.70. Kitimat has a relative rate just below Lake Cowichan at 2.68. Seven cases are observed in this district when about three would be expected. These results produce significance for Queen Charlotte and Prince Rupert. The former has a relative rate of 1.71 while the latter has 1.84.

Mission, Cranbrook, and Maple Ridge each have zero as their observed test statistic. Cranbrook has 12 cases observed when only 6.10 are expected. Maple Ridge and Mission have relative rates of 1.74 and 1.76, respectively.

Brain

Maple Ridge is the only possible cluster for brain cancer. Table 6.24 shows that this school district has a relative rate of 1.76 with nineteen cases observed. With only one possible cluster the intuition is that overall clustering is not present. This is supported by the overall p-value which is 0.923.

Hodgkins Disease

Smithers and Burns Lake are possible clusters for Hodgkins Disease. Smithers has an observed test statistic equal to 0 as seen in Table 6.25. Smithers has a relative rate of 3.52 with five observed cases and causes Burns Lake also to appear on the table. Burns Lake, when combined with Nechako and Smithers give a relative rate of 2.43, mostly due to the five cases in Smithers. The Monte Carlo p-value is a high 0.813 which is not suggestive of overall clustering.

Non-Hodgkins Lymphoma

Non-Hodgkins lymphoma comes next in Table 6.26. The Monte Carlo p-value of 0.298 is also not suggestive of overall clustering for this site. Maple Ridge and Vancouver are significant on their own. The former has 33 observed cases and relative rate equal to 1.61 while the latter has 42 observed cases and a relative rate of 1.52. Cranbrook and Kimberly are significant together, have a relative rate of 1.55 and twenty-one cases observed.

Multiple Myeloma

Multiple myeloma has a Monte Carlo p-value of 0.002, found in Table 6.27. A few patches of high relative rates are seen. The Nelson, Castlegar, Arrow Lakes, and Trail regions are a possible cluster. Arrow Lakes has a relative rate of 2.00 and the remaining

school districts of this area have 1.74 as a relative risk. The South Okanagan and Keremeos need to be combined with Penticton to have significant results. Twenty-one cases are observed in the three school districts giving a relative rate of 1.5. Merritt has six cases observed, a relative rate of 4.66 and individual p-value equal to 0.01. Merritt induces Lillooet also to be significant for this site with a relative of 2.30. Nechako and Prince George together have a relative rate of 1.73 and fifteen observed cases. Campbell River's eight cases influence Vancouver Island West and North. Campbell River has a relative rate of 2.22 while both Vancouver Island North and West have relative rates of 2.09.

Leukemia

For leukemia, listed in Table 6.28, overall clustering is not supported by the Monte Carlo p-value of 0.136. Vancouver Island North has the highest relative rate of 2.48 with eight cases observed. Its result influences Central Coast giving 1.92 as the relative rate. Qualicum comes next with twenty-five cases observed and a relative rate equal to 1.83. Cowichan has a relative rate of 1.72 which affects neighbouring Lake Cowichan. The resulting relative rate for Lake Cowichan is thus 1.65. Cowichan also affects its neighbour Gulf Islands which subsequently has a relative rate of 1.6 and forty observed cases.

Acute Leukemia

Qualicum also appears under the acute leukemia site appearing in Table 6.29. It has nine observed cases and a relative rate of 3.78. Nanaimo is influenced be Qualicum and together they have a relative rate of 1.79 and 21 cases observed. Lillooet, when combined with South Cariboo and Merritt, has six observed cases and a relative rate of 2.32. Neither South Cariboo nor Merritt appear significant when combined with any of their neighbours. The overall p-value is evaluated as 0.681 and overall clustering is not suggested.

Chronic Leukemia

Cowichan appears to be the center of clustering for chronic leukemia. In Table 6.30, Cowichan has twenty-seven observed cases when only 13.39. The relative rate is calculated to be 2.02. Gulf Islands and Lake Cowichan are effected by this and are also listed as significant. Gulf Islands has a relative rate of 1.85 while Lake Cowichan's relative rate is evaluated as 1.96. Vancouver Island itself is significant with six cases and a relative rate of 2.82. The overall p-value for this site is 0.465 and is not suggestive of overall clustering.

Other Sites

Nechako and Powell River appear for other sites in Table 6.31. Nechako has eleven cases when 5.20 are expected, producing a relative rate of 2.12. Powell River has a relative rate of 1.64 with fifteen observed cases. With only two districts listed, overall clustering is not expected and the Monte Carlo p-value of 0.733 supports that expectation.

Primary Unknown

Primary unknown possible clusters are noted in Table 6.32. Prince Rupert has 17 observed cases and a relative rate of 1.75. These results influence Queen Charlotte. When Queen Charlotte is combined with Prince Rupert the relative rate is 1.64. Overall cluster is not apparent with an overall p-value of 0.546.

Colo-Rectal

Colo-rectal results appear in Table 6.36. Only Agassiz-Harrison is noted with nineteen cases found within its borders. The relative rate is 1.85 and the individual p-value is 0.03. With only one significant school district, overall clustering is not expected. The Monte Carlo p-value is calculated as 0.632 and supports the expectation.

5.1.2 General Female Findings

The female findings for the general test are tabled in the Appendix starting at page 125. There is insufficient evidence to suggest that the sites of lip, liver, lungs:non-small cells, all lungs, soft tissue sarcoma, breast, all cancers except lung, and all cancers have any possible clusters in our analysis.

Oral Cavity

Alberni is the only cell listed as significant for oral cavity cancer found in Table 7.2. Its relative rate is 2.28 with twelve cases observed. Overall clustering is not seen as indicated by a Monte Carlo p-value equal to 0.922.

Esophagus

Table 7.3 lists four significant school districts for esophagael cancer. Prince George is the only one listed with a test statistic equal to zero. The relative rate is 2.46 and seven cases are observed. When Quesnel is combined with Cariboo-Chilcotin and Prince George it is significant with relative rate equal to 1.84. Gulf Islands and Cowichan are combined with Saanich both cells have a relative rate of 1.66 and sixteen observed cases. The overall p-value is calculated as 0.501 for this case. Thus, no overall pattern of clustering is implied.

Stomach

Four school districts are listed again for stomach cancer noted in Table 7.4. Campbell River has a high relative rate of 1.92. Nine cases are observed for that school district when 4.69 are expected. When Vancouver Island North is considered with neighbours Vancouver Island West and Campbell River, it too is significant. Those three districts combined have a relative rate calculated as two. Thirty-seven cases are observed in Richmond when only about 22 are expected. This situation produces a relative rate of 1.68. Richmond also influences Delta's results. Together the two have a relative rate of 1.54. Overall clustering is also not suggested for this site with a Monte Carlo p-value of

0.497.

Colon

Table 7.5 displays the significant school districts for colon cancer. Kettle Valley and Sunshine Coast both have zero as their observed test statistics. Kettle Valley has seven cases producing a relative rate of 2.37. Sunshine Coast has a lower relative rate evaluated to be 1.69. Again, the overall p-value (0.454) does not indicate overall clustering.

Rectum

Rectal cancer is next in Table 7.6. Only two school districts appear significant. The Monte Carlo p-value was calculated to be 0.694. Nine cases are observed in Princeton giving an extreme relative rate of 3.48. Powell River has a lower relative rate which is equal to 1.65 and eighteen cases are seen within its border.

Pancreas

Trail appears to be the center of a possible cluster containing Nelson, Castlegar, and Grand Forks for the pancreas site. Table 7.8 shows Trail with a relative rate equal to 2.49 with seventeen cases observed. Castlegar's rate is 2.01 while Nelson and Grand Forks have relative rates just around 1.75. Langley and Cowichan also are significant with relative rates 1.53 and 1.63, respectively. Both are possible clusters on their own and have around twenty cases observed. The Monte Carlo p-value for this site is equal to 0.186. With such a value, overall clustering in the province is not evident.

Larynx

The larynx site is given in Table 7.9. Greater Victoria is the only cell listed with zero as the observed test statistic. The relative rate is 1.81 with seventeen actual cases within its boundary. Sooke's nearest neighbour is Greater Vancouver. Hence, Sooke's relative rate of 1.70 is influenced by Greater Victoria. Lake Cowichan along with neighbour Cowichan have six observed cases when only 1.77 were expected. These numbers result in a relative rate of 3.39. This site does not appear to have overall clustering as conveyed

by the Monte Carlo p-value, 0.538.

Lung Squamous

Table 7.10 lists the significant school districts which are found for lung squamous cancer. With nine possible clusters, the Monte Carlo p-value of 0.044 suggests overall clustering within the province. Quesnel, Nanaimo, and Courtenay have the test statistic equal to zero. The relative rates for these three are calculated as 2.16, 2.02, and 1.99, respectively. Nanaimo's results influence Sunshine Coast, Lake Cowichan, and Qualicum. Sunshine Coast has a relative rate of 1.92 while Lake Cowichan and Qualicum have about 1.6 times as many cases observed than expected. Courtenay affects Powell River and Campbell River producing relative rates of 1.84 and 1.93, respectively. When Vancouver Island West is combined with both Courtenay and Campbell River, the cell is significant with a relative rate of 1.90 and an individual p-value of 0.03.

Lung Adenosquamous

Fourteen cells are significant for the site lung adenosquamous. Table 7.11 indicates that the relative rates are very high for the cells listed. The value of L is very interesting for these districts. The lowest value for the statistic occurs for Nanaimo. Nanaimo and its two neighbours, Qualicum and Sunshine Coast, have five cases observed producing a relative rate of 3.13. The remaining cells are influenced by these three and also appear significant even with large values of L. With only 30 cases in the entire province, it is quite startling to have 1/6 of the cases in this area of the province which contains roughly 4% of the province's population of women. The Monte Carlo p-value is given as 0.003 which is not surprising under the circumstances.

Lung Adenocarcinoma

Cariboo-Chilcotin and Kamloops have the highest relative rates for lung adenocarcinoma found in Table 7.12. The relative rates are, respectively, 1.76 and 1.55. Kamloops' values influence neighbouring North Thompson. Its relative rate is 1.52 with 43 cases

observed. With only three districts significant, overall clustering is not expected. The Monte Carlo p-value is 0.521 which does not connote overall clustering.

Lung Small Cell

Lung small cell cancer has many districts listed as significant with a Monte Carlo p-value (0.014) which suggests overall clustering. Chilliwack and Courtenay appear to be the regions of most concern in Table 7.13. Chilliwack has nineteen observed cases resulting in a relative rate of 1.61 while Courtenay has three fewer observed cases and a relative rate of 1.81. Their neighbours appear to be influenced by the number of cases observed in these two districts. Hope and Agassiz-Harrison are influenced by each other and Chilliwack. Together, the three have a relative rate of 1.53. Campbell River and Powell River significant results are based on Courtenay's. Alberni and Vancouver Island West are also influenced by Courtenay and have relative rates 1.53 and 1.68, respectively. Lake Cowichan along with Cowichan have a relative rate of 1.62. Kamloops and Merritt together have a relative rate of 1.54.

Lung Others

Table 7.14 has lung others with an overall p-value calculated as 0.162. Overall clustering is not implied by this result although Quesnel has a relative rate of 2.33. With eleven cases observed and 4.73 expected the individual p-value for Quesnel is 0.02. New Westminster has a relative rate of 1.5 with 36 cases observed within its border. Sunshine Coast has fourteen cases observed with a relative rate of 1.68. Peace River South has 2.06 times more cases observed than expected. This value causes Peace River North and Fort Nelson to also appear significant.

Melanoma

Melanoma has six school districts with an overall p-value for 0.113. In Table 7.18 Kimberley has the highest relative rate which equals 2.13. West Vancouver has a relative rate of 1.82 with 41 observed cases. Howe Sound is influenced by neighbour West

Vancouver and also appears in this table. Cowichan's relative rate is 1.52 with an individual p-value of 0.04. Cowichan induces Gulf Islands to be significant as well. The relative rate for Langley is 1.54 with 44 cases found in its district.

Bladder

Bladder cancer comes next in Table 7.22. With a Monte Carlo p-value of 0.673 overall clustering is not suggested. West Vancouver has a relative rate of 1.68 which induces neigbhouring Howe Sound to appear significant. When Princeton is combined with Keremeos, six cases are observed producing a relative rate of 3.11.

Kidney

When Golden is amalgamated with Revelstoke, five cases of kidney cancer are observed in Table 7.23. The relative rate is given as 2.55 and 1.96 cases were expected. Queen Charlotte in combination with Prince Rupert yields a relative rate of 2.73 and seven observed cases. Chilliwack must be combined with Mission and Agassiz-Harrison to produce a 1.52 times more cases than expected. The Monte Carlo p-value for this site is 0.649 and overall clustering is not supported.

Brain

Brain results are found in Table 7.24. Castlegar has a relative rate of 2.56 which causes Trail to also be significant. North Vancouver, West Vancouver, and Cowichan have relative rates 1.76, 1.64, and 1.78 respectively, with zero as the test statistic. Sunshine Coast is influenced by Nanaimo and North Vancouver for its significance. Howe Sound has a p-value equal to 0.04 when combined with North and West Vancouvers. Lake Cowichan with Nanaimo and Cowichan gives a relative rate of 1.51. The Monte Carlo p-value is 0.103 and implies some overall clustering.

Hodgkins Disease

When Delta and Richmond are combined, twenty-two cases of Hodgkins Disease are observed. The relative rate for these two is 1.57 as seen in Table 7.25. Coquitlam has

fifteen cases observed when only 8.87 are expected yielding a relative rate of 1.69. The Monte Carlo p-value in this case is 0.652 and again clustering is not suggested.

Non-Hodgkins Lymphoma

The Monte Carlo p-value for non-Hodgkins lymphoma is 0.258 as seen in Table 7.26. Revelstoke and Hope have relative rates 2.47 and 2.73, respectively. Terrace has ten cases observed yielding a relative rate of 2.02. The high rate in Terrace produces Smithers as a significant school district with relative rate 1.92. Lake Cowichan has test statistic zero with five observed cases and a relative rate of 2.98.

Multiple Myeloma

Multiple myeloma produces eight possible clusters in Table 7.27. Penticton has a relative rate of 2.28 and fifteen observed cases. Keremeos and South Okanagan are influenced by the high relative rate and are also significant with 1.90 as their relative rates. Summerland also is significant due to its neighbour Penticton. Langley has a relative rate of 1.83 and causes Abbotsford to also be a possible cluster. Nechako and Prince George together have relative rate 2.11. With an overall p-value of 0.104 this site may suggest some overall clustering.

Leukemia

Penticton influences South Okanagan and Keremeos for leukemia. In Table 7.28 Penticton has test statistic zero and relative rate 1.76. The Gulf Islands and Cowichan form an area with a relative rate of 1.57 and twenty-five observed cases. The Monte Carlo p-value of 0.283 suggests that overall clustering is not apparent.

Acute Leukemia

Table 7.29 shows Campbell River as the primary location of clustering of acute leukemia. With a relative rate of 2.95 and seven observed cases, it causes neighbouring Vancouver Island West to also appear on the table. With only two districts listed the overall p-value is 0.799.

Chronic Leukemia

Chronic leukemia findings are noted in Table 7.30. Here again, as it was in leukemia, Penticton has a high relative rate which influences South Okanagan and Keremeos. Penticton has a relative rate of 1.86 while the other two have relative rate 1.68. Abbotsford has 23 cases found within its borders and relative rate 1.71. Mission's nearest neighbour is Abbotsford and is significant as well. Cowichan has relative rate 1.83 and induces significance in Gulf Islands and Lake Cowichan. With eight school districts significant, the overall p-value is calculated as 0.073.

Other Sites

In Table 7.31, Grand Forks has the highest relative rate for other sites. With a test statistic equal to zero, Grand Forks has a relative rate of 2.35. Neighbour Kettle Valley is affected with fifteen observed cases and relative rate 2.23. The overall p-value was 0.655 and does not suggest any overall clustering.

Primary Unknown

Overall clustering is suggested for primary unknown cancer. Five school districts are listed in Table 7.32 with a Monte Carlo p-value calculated as 0.088. Cariboo-Chilcotin has relative rate 1.56 with twenty-two observed cases. Merritt's relative rate is 2.41 and causes neighbouring Lillooet also to be significant. When Lillooet is combined with Merritt and South Cariboo the resulting relative rate is 1.65. Prince Rupert and Mission have zero as their test statistics and relative rates 1.78 and 1.55, respectively.

Ovary

Only Creston-Kaslo appears for ovarian cancer in Table 7.34. With seventeen observed cases the relative rate is 1.72. No overall clustering is apparent with a Monte Carlo p-value of 0.895.

Cervix

Table 7.35 has three significant school districts for cervix. Princeton, with five ob-

served and 1.65 expected cases, has an individual p-value of 0.03. Quesnel has a relative rate equal to 2.23. Central Coast is significant with relative rate 1.78 when combined with Vancouver Island North and Burns Lake. With an overall p-value of 0.535 overall clustering is not indicated.

Colo-Rectal

Princeton and Sunshine Coast appear in Table 7.36 for colo-rectal. Princeton has sixteen observed cases giving a relative rate 2.19. Sunshine Coast has a relative rate of 1.53 and 56 actual cases found within its borders. Again, no overall clustering is suggested with a Monte Carlo p-value of 0.314.

Endometrium

Endometrial results are displayed in Table 7.39. The Monte Carlo p-value is 0.221 with Gulf Island producing the highest relative rate. Gulf Islands has a relative rate of 1.87 with test statistic zero. West Vancouver's rate of 1.68 causes neighbouring Howe Sound to appear significant as well. Summerland expects about ten cases but observes sixteen giving it a relative rate of 1.61.

5.1.3 Focused Findings

The combined year results for the focused test start at Table 8 found in the Appendix. The notation used is the same as was found in the tables for the general test. The term NSD means the nearest school district centroid to the focus. We call the school district where the focus is located, the home school district. The results mostly mimic those found in the general test for school districts which contain pulp and paper mills. The nearest cell centroids to the foci are generally the nearest centroids to the foci's home school district. When we consider the first few nearest neighbours results this is certainly true. The Ocean Falls mill is an exception. Ocean Falls home school district is Central Coast. Ocean Falls' three closest neighbours are Central Coast, Kitimat, and Terrace,

respectively. However, the Central Coast's first two closest neighbours are Vancouver Island North and Burns Lake. Therefore, the focused results for Ocean Falls will not correspond to the general results for its home school district. Skookumchuck is another exception. Although the Skookumchuck mill is located in the Cranbrook school district, its nearest neighbour is the Kimberley school district. Any result which Skookumchuck has will be represented in the general results for Kimberley.

MacKenzie and Prince George have the same first three nearest neighbours. Thus, their results are identical. Although both will appear significant for some site, they really only represent one region.

Individual results for the foci are almost identical to the results found in their home school district. Only the observed value of the test statistic is one larger because the foci itself does not contain cases or population. When only testing foci and not all cells within the province, the Monte Carlo p-value will not be the same as it was for the general test.

In the general test for males, the sites of lip, stomach, lung squamous, lung others, all lungs, lungs:non-small cells, soft tissue sarcoma, prostate, bladder, kidney, and multiple myeloma all had Monte Carlo p-values at most 0.1. The focused test also shows evidence of overall clustering for stomach, lung squamous, lung others, prostate, bladder, kidney, and multiple myeloma. The Monte Carlo p-value for pancreatic cancer suggests overall clustering in the focused test with a p-value of 0.070. In the general framework, the pancreas site had an overall p-value just above 0.11.

A few mills are possible clusters for a few different sites while others appear significant. Quesnel is significant for lip and esophagus. Skookumchuck is listed for lip and only Castlegar is a possible cluster for oral cavity. Port Alberni only appears significant for stomach cancer. Prince Rupert is significant for stomach, lung others, kidney, and primary unknown. Port Alice is also a possible cluster for stomach and the

sites of testis, leukemia, and chronic leukemia. Ocean Falls is listed for stomach and kidney while Campbell River is significant for stomach, lung squamous, bladder, and multiple myeloma. Prince George and MacKenzie possible clusters for pancreas, larynx, lung others, prostate, and multiple myeloma. Crofton appears significant for pancreas, leukemia, and chronic leukemia. Squamish is only listed for lung squamous. Gold River also appears for that site and the sites of bladder, multiple myeloma. Nanaimo may be a cluster for lung adenosquamous and lung small cell. Powell River is significant for testis and other sites. Kitimat only appears significant for kidney cancer.

The female lung squamous, lung adenosquamous, lung small cell, chronic leukemia, and primary unknown sites has overall p-values at most 0.1 for the general test. In the focused situation listed in Table 9, lung squamous, lung adenosquamous, and lung small cell sites also have Monte Carlo p-values which suggest overall clustering. Melanoma and endometrium have focused Monte Carlo p-values 0.052 and 0.099 which also suggest overall clustering.

Port Alberni is a possible cluster for oral cavity. Prince George and MacKenzie have significant results for esophagus, lung adenosquamous, and multiple myeloma. Campbell River may be a cluster for stomach, lung squamous, lung small cell, and acute leukemia. Port Mellon is listed for colon, lung others, melanoma, bladder, brain, colo-rectal, and endometrium. Powell River is a possible cluster for rectum, lung squamous, and lung small cell. Castlegar is significant for pancreas and brain while Crofton is significant for those sites as well as melanoma, leukemia, and chronic leukemia. Lung squamous and lung adenosquamous have Nanaimo as a possible cluster. Quesnel is listed for lung squamous, lung others, and cervix. Kitimat only appears significant for lung adenosquamous. Prince Rupert may be a cluster for lung adenosquamous and primary unknown. Lung adenocarcinoma and lung small cell both have Kamloops as a possible cluster. Squamish appears significant for melanoma, bladder, and endometrium. Gold River is

only listed for acute leukemia.

Generally speaking, the results are quite consistent between the general and focused tests. This consistency is expected because of the choice of cluster size each mill or school district is tested at and the fact that the mill neighbours are similar, if not exact, to the home school district.

5.2 Yearly Analysis

The results for the yearly general analysis are listed starting on page 138 of the Appendix. The school districts or mills which satisfied at least one of the following conditions are listed for each site. Only cells which had either a consistency p-value at most 0.05, or two consecutive significant years, or at least 3 significant years are listed. The consistency p-value calculated over the seven years is denoted p_c. The cluster size, observed value of the statistic, and the relative rate, labeled k, ℓ, and O/λ, respectively, are listed for each year, 1983 through 1989. When a school district or mill is significant at 5% for a particular year, that year's relative rate has an asterisk ($*$) beside it. When k is small the number of expected cases is also very small, usually less than one. The relative rates may seem very extreme since the expected cancer counts are real numbers and the observed are integer values. When k is small, we note that the relative rate is inflated because a fraction of a person cannot have cancer even though that is what is expected.

5.2.1 General Male Findings

Lip

Grand Forks and Kettle Valley appear significant in the years 1985 and 1986 for lip cancer in Table 10.1. Kamloops and South Cariboo have two significant years in the beginning of the study period. The same can be said for the Peace River districts and Fort Nelson. The years 1986–88 are significant for Hope, Chilliwack and Agassiz-

harrison. The cluster sizes are very small here and the relative rates are inflated. With such small cluster sizes, the expected number of cases is very small, close to zero for sparsely populated cells. The relative rates, thus, look more startling that they actually are.

Oral Cavity

Oral cavity cancer displays some school districts with consistently significant years. In Table 10.2, we see that the lower mainland cells figure prominently; Vancouver and Burnaby have six significant years each. Vancouver has relative rates ranging from 1.36 to 2.06 during the significant years. Except for 1985 Burnaby has relative rates ranging from 1.30 to 1.90 with a consistency p-value equal to zero. New Westminster has high relative rates for the last four study years. The relative rates are between 1.62 and 3.88 for that period. Richmond is significant for all years except 1986 and 1988. The maximum relative rate occurs during 1983. Castlegar is an apparent cluster for 1983, 1988 and 1989. In those years, the test statistic is zero while in the remaining years, the test statistic is ten or eleven. The relative rates are very high due to the very small number of cases expected, usually less than one. West Vancouver's results are closely related to neighbour North Vancouver. Both are significant for 1983–85 and 1989. Both have consistency p-values less than 0.05. Prince Rupert only has low values of the test statistic for 1985–86. During these two years, the relative rates are 3.15 and 4.41, respectively. Both years have fewer than five cases. Castlegar, Vancouver and New Westminster are also significant for the combined year analysis.

Esophagus

Vancouver also shows a consistency for esophagael cancer, which is listed in Table 10.3. Vancouver has relative rates of 1.83 and 1.47 in 1984 and 1986, respectively. The remaining years have large values of the test statistics. North Thompson and Cariboo-Chilcotin have consistency p-values equal to zero. Cariboo-Chilcotin was sig-

nificant in the combined year analysis and has significant results for the years 1984, 1988, and 1989. The relative rates exceed 3.5 for these years but less than five cases are observed. North Thompson has a very extreme relative rate of 23.65 in 1984. Only a very small fraction of one case is expected when the cluster size is 2. In 1989 the same is seen where the relative rate is 28.10 and a minimum of two cases are observed.

Stomach

Queen Charlotte, Prince Rupert, and Vancouver Island North are significant for 1986 and 1987 for stomach cancer. Table 10.4 shows that the lowest consistency p-value is equal to 0.04 for Queen Charlotte. Queen Charlotte is influenced by Prince Rupert which has relative rates equal to 3.59 and 4.38 for 1988–89, respectively. Vancouver Island North, when combined with Vancouver Island West and Campbell River, has relative rates of 2.61 and 2.64 for the same two years. All three cells listed are also significant for this site when years are combined.

Rectum

Most of the districts listed for rectal cancer in Table 10.6 have a couple of significant years without any overall consistency shown. Hope and Agassiz-Harrison were significant for the combined year analysis although neither appears here. Sunshine Coast is only significant for 1988–89 with relative rates about 1.66 in each of those years. Peace River South has a relative rate of 2.62 and five observed cases in 1984. In 1985 the district is also significant with a relative rate of 1.84 when considered with Peace River North and Prince George. Nanaimo has three significant years. In 1986, 1988, and 1989 the cluster sizes are all equal to fifteen with observed test statistic zero. The relative rates are 1.66, 1.97 and 1.75 for these years respectively. These values influence neighbour Lake Cowichan which is significant for the last two study years. Campbell River is also significant for those two years with relative rates 2.74 and 1.78. Vancouver Island West is influenced by these rates and is only significant for those two years as well with similar

relative rates. Creston-Kaslo is a possible cluster for the first two years when the test statistic is zero. Both years have relative rates of about 2.5 with five or six observed cases.

Liver

The liver cancer results in Table 10.7 have the same cells listed which were seen in the combined year results. Vancouver seems to affect its neighbours. Vancouver is not a possible cluster for 1986 where the test statistic is four, but is for every other year. In 1985 and 1989 three relative rates are 2.21 and the lowest relative rate for a significant year is 1.58 in 1988. The significant years all have test statistic equal to zero and the consistency p-value is found to be the same. Burnaby is significant for each study year. For most years the test statistic is equal to two meaning Burnaby was combined with New Westminster and Vancouver. The relative rates range from 1.53 to 2.08. New Westminster is a possible cluster for the last two years of study. In 1988 the relative rate was 1.95 while in 1989 the relative rate was 3.53. North Vancouver is significant for the years when it is combined with Vancouver. West Vancouver is a possible cluster when considered along with the two neighbours North Vancouver and Vancouver. Only New Westminster has a consistency p-value which is different from zero and is equal to 0.07. The other school districts significance is based on the high relative rates found in Vancouver.

Pancreas

No school districts satisfied our requirements to be tabled for pancreatic cancer. Only Coquitlam is listed for larynx cancer in Table 10.9. Although it was not significant when years were combined, it is significant for 1986 and 1987. For both years, the statistic equals one. When Coquitlam is combined with New Westminster the relative rates are 2.19 and 2.15 in 1986 and 1987, respectively. The consistency p-value is calculated as 0.26 indicating no overall consistency.

Lung Squamous

For lung squamous, all districts tabled have two consecutive significant years. In Table 10.10 every cell is significant for 1987. Vancouver Island West and Campbell River are also possible clusters for the combined year analysis. Courtenay appears to be the school district which influences its neighbours. In 1986 and 1987 the test statistic is zero and the relative rates are 2.43 and 2.01, respectively. The resulting consistency p-value is equal to 0.09. Campbell River is significant for those two years as well when combined with Courtenay. Vancouver Island West shows the same influence when added to both Campbell River and Courtenay. The relative rates are 2.24 and 1.83 for 1986 and 1987, respectively for Vancouver Island West. Powell River has relative rates around 1.9 for those years when Courtenay is combined with it. For 1987–88 Chilliwack and Agassiz-Harrison are significant with relative rates of about 1.75 in each of those years. When Hope is combined with these two it also has similar relative rates for those significant years.

Lung Adenosquamous

Nanaimo has three consecutive significant years in the site lung adenosquamous. It was significant for combined years and in Table 10.11 the cluster sizes involved are very small. Even with a test statistic of four in 1987 the result is significant. During 1986–88 the relative rates are 6.69, 4.10, and 9.51, respectively, because less than one case is expected. Nanaimo's 1988 value makes neighbour Qualicum significant with a relative rate of 6.24 and cluster size 2. Qualicum is also a possible cluster of size two for 1983 with a relative rate of 11.47. Alberni also has a high relative rate in this year due to its neighbour Qualicum. Lake Cowichan has relative rates of 4.24 and 8.70 for 1987 and 1988, respectively. The cluster sizes are three or less and are affected by Nanaimo and Qualicum. Lake Cowichan, Nanaimo, and Qualicum were each seen listed in the combined year results for this site.

Lung Adenocarcinoma

Lung adenocarcinoma findings are displayed in Table 10.12. Merritt is a possible cluster for 1984–85. Merritt alone has a relative rate of 4.35 for cluster size three in 1984. When Merritt is combined with Kamloops in 1985 the relative rate is 2.05 for a cluster size equal to eleven. Richmond is a possible cluster for the first two study years. In 1983 the relative rate is 1.75 and equals 2.46 in 1984. When Coquitlam is combined with New Westminster it is significant for the same two years with relative rates 1.61 and 1.69. Campbell River is significant for 1986 and 1987 with relative rates 1.74 and 1.86, respectively.

Lung Small Cell

Campbell River also has two significant years for lung small cell cancer seen in Table 10.13. In 1988 it has a relative rate of 2.97 for cluster size four. Together with Courtenay, Campbell River has a relative rate of 2.49 for 1989. The consistency p-value is far above 0.05 for this school district and is evaluated as 0.24. The years between 1986 and 1988 inclusive are significant for Golden. During this period the cluster size is equal to three with relative rates 5.65, 3.67, and 6.66. In 1987 Golden must be combined with Revelstoke and Windermere while the other two significant years require only Revelstoke be added to Golden. Golden is the only one listed here which was also found in the combined year analysis. Burns Lake also has two significant years with a consistency p-value equal to 0.06. In 1986 it is significant alone and significant for 1985 when amalgamated with Nechako.

Lung Others

For lung others, fourteen school districts are tabled. Table 10.14 has Golden significant for the first two study years. The relative rates are equal to 5.18 and 6.61 with cluster sizes 4 and 3 for those two years respectively. Kamloops is a possible cluster of size twelve for both 1987 and 1988. The relative rates are equal to 2.00 and 1.74 for

those years. Quesnel is significant for 1987 and 1989 when combined with neighbours Cariboo-Chilcotin and Prince George. The relative rates are 2.07 and 1.71 for cluster size fifteen. Prince George has zero as its observed test statistic for 1986, 1987, and 1989. The relative rates range from 1.96 to 2.80 in those years while the cluster size tested is either eight or nine. The consistency p-value for this site is equal to 0.01. Nechako has very similar results based on its close proximity to Prince George. Peace River South and Peace River North combined with Prince George are significant for 1986 and 1989 with relative rates 2.21 and 1.79 in those years. Peace River South is also significant with a relative rate of 2.68 in 1984 which also causes Peace River North to be significant for the same year. Merritt is a possible cluster for four of the study years. In 1985 with a cluster size of three the relative rate is calculated to be 3.92. The test statistic is also equal to zero for 1989 where the relative rate is 4.75 for a cluster size of four. Merritt together with Kamloops is significant for 1987–88. South Cariboo has a consistency p-value equal to 0.02 with significant years 1986 and 1987. The 1986 finding is due to the high relative rate for that year in neighbouring Lillooet while the 1987 relative rate of 1.83 occurs when Lillooet and Kamloops are combined with South Cariboo. The significance obtained by Lillooet in 1985 with a relative rate of 3.30 occurs when it is combined with South Cariboo and Merritt. Surrey is significant for 1985, 1987, and 1989 with relative rates less than 1.5. New Westminster has relative rates for 1985, 1986, and 1989 with relative rates 2.75, 2.04 and 1.76, respectively. Queen Charlotte has high relative rates for 1986–86 when two is the cluster size. Kitimat is significant for the two years 1987 and 1988. In the latter year, the test statistic is zero for cluster size three. In the former year, the relative rate is 2.22 when Kitimat is combined with Terrace and Prince Rupert.

All Lungs

For the site of all lungs, South Cariboo, Chilliwack, Surrey, Richmond, Vancouver,

Burnaby, Coquitlam, North Vancouver, and Powell River fail to have significant years in which the relative rate is at least 1.5. In Table 10.15, Kamloops is significant on its own for 1988 with a relative rate of 1.55. This rate induces neighbouring North Thompson to be significant with a relative rate of 1.52 and Merritt as well. Merritt has three significant years, a p-value equal to zero, and was significant in the combined year framework. In 1985 and 1989 the relative rates are 2.42 and 3.49. When a cluster size of twenty is tested for the years 1985 and 1986 Maple Ridge has relative rates 1.52 and 1.65. Courtenay's relative rates are around 1.55 for 1987–88 and produce significance in Campbell River as well for those years. Vancouver Island West's high relative rates happen when it is combined with Campbell River.

Non-Small Cell Lung

Table 10.16 has the non-small cell lung cancer results. Again, several school districts listed have relative rates below 1.5. Merritt appears again as it did in the combined year situation. In 1984 and 1989 the relative rates are 2.37 and 3.66 with a consistency p-value of zero. Kamloops has two consecutive years in which the relative rate was just higher than 1.5. Chilliwack has a relative rate for 1988 equal to 1.58. New Westminster's relative rates for 1985 and 1989 are 1.67 and 1.54, respectively. Courtenay has relative rates of 1.69 in 1986 and 1988 with nineteen as the cluster size. These values induce significance in Powell River and Campbell River for those years and Vancouver Island West in 1986. Campbell River also has a relative rate of 2.09 in 1984 when the test statistic is zero.

Soft Tissue Sarcoma

Parts of the lower mainland area show signs of consistency for soft tissue sarcoma. Burnaby and Vancouver are significant for every year except 1983 as noted in Table 10.17. All cells found here were also obtained significance for the combined year test. Vancouver seems to be the main school districts which influences the lower main-

land. The relative rates range from 1.6 in 1984 to 2.56 in 1987 with zero as both the test statistic and consistency p-value. When Richmond is combined with Vancouver and Delta it is significant for 1985 and 1987–89 with a consistency p-value of zero as well. Burnaby requires no combination of neighbours to be significant for 1984 with a relative rate of 2.10. For the years past 1984, it is significant when combined with New Westminster and Vancouver. North Vancouver is also significant, in combination with Vancouver, from 1985 with a consistency p-value calculated as zero. West Vancouver shows the same results when combined with Vancouver and North Vancouver. Grand Forks also shows some clustering for 1987 and 1989 with relative rates 9.77 and 6.42, respectively. The cluster size is only two here and expected number of cases are less than one.

Melanoma

In 1988 and 1989, the Sunshine Coast is a possible cluster for melanoma. In Table 10.18 Saanich also appears significant for 1984–86 with a consistency p-value of 0.07. Saanich is significant by itself for the years 1984 and 1986 where the relative rates are 2.84 and 2.97, respectively. However, the relative rate of 2.15 in 1985 occurs when Saanich is combined with Gulf Islands. Saanich also was significant when years are combined while Sunshine Coast was not. In 1988 Sunshine Coast and Nanaimo are a significant combination with relative rate 1.97. In 1987 the two along with West Vancouver have a relative rate of 1.88.

Prostate

The Okanagan area figures prominently for cancer of the prostate. South Okanagan, Penticton, and Keremeos are significant for all years but 1984 as seen in Tables 10.20*a* and 10.20*b*. Most of the school districts listed have relative rates less than 1.5 for the significant years and will not be discussed. In 1985 and 1986 the test statistic is zero for South Okanagan and its relative rates are 1.55 and 1.86 for those years. In 1988 with the

influence of Keremeos the relative rate is 1.56. Penticton's relative rates which exceed 1.5 occur for 1986 and 1987 and are both close to 1.7. Keremeos is also significant for for 1986 when South Okanagan's cases are added to give a relative rate of 1.59. These three school districts each have consistency p-values equal to zero. North Thompson has a relative rate of 3.14 for the test statistic equal to zero. Cariboo-Chilcotin has relative rates 1.81, 1.59, and 1.60 for the years 1984, 1988, and 1989. Only in 1989 is the addition of Quesnel's cases required for a significant result. Quesnel is also significant for 1984 when combined with Cariboo-Chilcotin and Prince George yielding a relative rate close to two. South Cariboo's significant relative rate of 2.92 in 1985 causes Lillooet to also be significant for that year. The two combined have a relative rate of 1.98 in 1986. Merritt's relative rate of 1.5 in 1986 arises from combination with Kamloops. Abbotsford, North Vancouver, and West Vancouver mostly have years with relative rates below 1.5. North Vancouver has a relative rate slightly higher in 1988 while West Vancouver's relative rate is 1.58 in 1986. Powell River's three significant years occur by itself or with neighbour Courtenay. Central Coast has two years where the relative rates are 3.72 and 1.86. The latter year's result occurs due to combination with Vancouver Island North and Burns Lake. Similar findings are shown for those years, 1987 and 1988, under Burns Lake. Nechako has several significant years with a consistency p-value equal to zero. The 1985 and 1989 relative rates of 2.18 and 2.16 are when the test statistic is zero. The other significant years, 1984, 1987, and 1988, are significant because of the high relative rate in Prince George for those years. Similarly, Prince George is significant for 1989 when Nechako has a high relative rate. For the years 1984, 1987 and 1988 the relative rates for Prince George are 2.61, 2.01, and 1.43, respectively. Peace River South has a relative rate of 1.74 in 1985 and when combined with Peace River North and Prince George the relative rate is 2 in 1984 and 1.63 in 1987. The same type of results are seen for Peace River North because of its closeness to Peace River South. Mission is significant by

itself with a relative rate of 1.79 in 1984. Summerland is significant by itself or when combined with Penticton. Burns Lake, Nechako, and Prince George all appeared to be possible clusters in the combined year analysis as well.

Testis

Langley was a possible cluster for the first three years of the study period for testicular cancer in Table 10.21. With a cluster size equal to five, the first two years give relative rates 3.36 and 3.26. In 1985 Langley is combined with Surrey and Maple Ridge yields a relative rate of 1.80. Maple Ridge's relative rates above two are caused by the significance obtained in Langley for 1984–85. Powell River and Courtenay together have a relative rate for 1986 which equals 3.23. Four was the cluster size investigated in both regions for that year. Powell River has a relative rate of 6.98 in 1984 when three is the cluster size. This result causes Courtenay also to be significant for that year. Campbell River's results are similar to Courtenay's and has a consistency p-value of 0.03. Vancouver Island North has a high relative rate in 1988 when the cluster size tested is three. Courtenay, Powell River, and Vancouver Island North were each significant in the combined analysis as well and have consistency p-values calculated to be 0.04, 0.02, and 0.04, respectively.

Bladder

Bladder cancer has shows some consistency in the Campbell River, North and West Vancouver Island as found in Table 10.22. For four of the study years Campbell River is significant with test statistic zero and cluster size five. The relative rates for those years are as low as 2.72 and as high as 3.58. Vancouver Island West is significant for the same years as neighbour Campbell River as well as in 1985. Together, with a cluster size equal to six, the two have a relative rate of 2.54. Vancouver Island North also shows similar results due to neighbours Vancouver Island West and Campbell River with a consistency p-value of zero. Lake Cowichan has two significant years when combined

with Cowichan or both Cowichan and Nanaimo. North Vancouver has two consecutive significant years with cluster size fourteen. South Cariboo is significant by itself in 1983 and significant in 1988 when combined with Lillooet and Kamloops. Lake Cowichan and North Vancouver were not significant in the combined year tests while the remaining school districts were.

Kidney

Only Queen Charlotte and Kitimat are tabled for kidney cancer. In Table 10.23 both are significant for small cluster sizes during the last two study years. When Queen Charlotte is combined with Prince Rupert and Kitimat it is significant for a cluster size of four. Kitimat has a relative rate of 7.16 when the cluster size is three in 1989. In 1988 the combination of Kitimat, Terrace, and Prince Rupert have relative rate 2.80. Both of these districts also appeared as possible clusters in the combined year analysis.

Brain

North Thompson and Maple Ridge have two consecutive years for brain cancer. Maple Ridge was significant for this site in the combined year analysis and also appears in Table 10.24. In 1988 the test statistic is zero and the relative rate is 3.34 for the cluster size of five. For 1985 and 1989 Maple Ridge is combined with Langley to be significant with relative rates 2.17 and 2.62, respectively. North Thompson has a very high relative rate for 1987. The cluster size investigated is only two and the expected number of cases are less than one. In 1986 it is also significant when Kamloops is added. Both cells listed here have consistency p-values equal to 0.06.

Non-Hodgkins Lymphoma

For Non-Hodgkins lymphoma, Courtenay has the most significant years, which can be seen in Table 10.26. In 1987 and 1989 the test statistic is zero for this cell and the relative rates are 3.20 and 2.33. Courtenay is also significant for the first two study where Powell River or Powell River and Campbell River are added. Powell River is a

possible cluster itself for 1983 with a relative rate of 3.13 and 0.04 as the consistency p-value. Powell River is also significant in 1987 when combined with Courtenay. Alberni has relative rates 2.88 and 1.80 for 1986 and 1987. In 1987 Alberni is combined with Courtenay and Qualicum to achieve its result. Richmond is significant for 1985-87 with a relative rate exceeding 1.5 only in 1987. Langley has two significant years, however, only 1989 has a relative rate (2.03) which is above 1.5. Surrey has two significant years which have relative rates 1.55. In 1984 combination with New Westminster is required, while in 1988 Surrey is significant on its own.

Multiple Myeloma

Multiple myeloma testing only lists Prince George in Table 10.27. In both 1984 and 1985 the cluster size investigated is four. In the former year the relative rate is 3.48 and the test statistic is zero. The latter year has the combination of Prince George and Nechako yielding a relative rate of 3.47. The consistency p-value is 0.07 and Prince George also appeared significant for the combined year situation.

Leukemia

Cowichan has two significant years for leukemia. In Table 10.28 for the cluster size of six, Cowichan is significant for 1983 and 1986 with relative rates 2.42 and 3.08, respectively. Lake Cowichan is affected by these results and shows similar numbers. However, Lake Cowichan had a consistency p-value of zero while Cowichan's consistency p-value is 0.04. Nanaimo also appears significant for 1987 and 1989. In the last year the test statistic is zero with relative rate 2.08. In 1987 the neighbours Qualicum and Sunshine Coast must be added to Nanaimo to have at least fourteen cases. Nanaimo was not significant during the combined year tests although both Cowichan and Lake Cowichan were.

Acute Leukemia

Table 10.29 contains the acute leukemia results. The last three years are signifi-

cant for Qualicum with relative rates 6.04, 2.38, and 3.32 for cluster sizes 3, 6, and 5, respectively. Qualicum was significant for the case where years were combined as well. Vancouver for 1987 and 1988 has relative rates about 1.76. These values effect North Vancouver's results which are also significant for those two years. The Cranbrook-Kimberley area is significant for the last two study years for chronic leukemia. Together the two have a relative rate of 3.93 for 1988 in Table 10.30. The two also are significant for 1989 where the cluster size investigated is still quite small. Keremeos has a very high relative rate for a cluster size equal to two in 1983 In 1984 it, along with South Okanagan and Penticton, has a relative rate of 2.21. South Okanagan's results are similar to that of Keremeos because of their close proximity. Lake Cowichan has only one year significant and the relative rate is 3.27. The school district was significant also for the combined year tests. Greater Victoria has a relative rate of 1.64 in 1984. In 1985 the relative rate is 1.55 when Sooke and Saanich are combined with Greater Vancouver. Sooke similarly shows that result and is also significant for 1984.

Primary Unknown

Only Queen Charlotte and Prince Rupert were significant when years were combined but are not listed for primary unknown in Table 10.32. Powell River has the first two years significant with relative rates 2.76 and 2.08 respectively. The 1984 results occur when Powell River is combined with Courtenay. Quesnel in 1988 has a relative rate of 2.69 with five as the cluster size. The relative rate of 1.96 in 1987 happens when Cariboo-Chilcotin is added. The relative rate in 1985 occurs when Cariboo-Chilcotin and Prince George are considered together. Vancouver has a consistency p-value of zero and is significant by itself for the years starting after 1984. The relative rates, however, are less than 1.5. Vancouver results affect Richmond, Burnaby, and North Vancouver. In 1988 a relative rate of 1.63 is seen for Richmond. Burnaby for the same year has its only relative rate above 1.5.

Colo-Rectal

Campbell River has a relative rate above 1.5 for colo-rectal cancer. Table 10.36 shows that the relative rate is 1.92 in 1988. This result also causes Vancouver Island West to have a relative rate of 1.99 for the same year. Mission is significant with a relative rate above 1.5 for 1988 only. The relative rate is 1.89 for that year and the consistency p-value is 0.47. Nanaimo is significant for three years with one year having a relativer rate less than 1.5. In each of these years the test statistic is equal to zero. These results influence Qualicum which shows a similar pattern. Surrey's significant years have relative rates less than 1.3. Vernon has relative rates just slightly above 1.5 for 1986–87.

For all cancers except lung, the relative rates do not exceed 1.5. Vancouver, North and West Vancouver, Keremeos, and South Okanagan are significant for several of the years studied. Table 10.38 shows the results for all cancers except lung while Table 10.46 chronicles the site all cancers. The same is basically seen in the all cancers site. Only Merritt has a year in which the relative rate exceeds 1.5. Most of the school districts have relative rates which are not alarming.

5.2.2 General Female Findings

Lip

Langley has two significant years for lip cancer. Table 11.1 shows that the years 1985 and 1986 are significant with a consistency p-value equal to 0.08. In both years the test statistic is zero requiring Langley to be combined with neighbours Surrey and Maple Ridge. The cluster sizes are very small and produce the high relative rates 3.10 and 4.52. For the other years this school district has fairly large values of the test statistic. In the combined year examination no school districts were found to be significant with relative rates above 1.5.

Oral Cavity

Alberni was the only school district found significant for the combined year analysis of oral cavity cancer. It does not appear in the yearly examination given in Table 11.2. Surrey has three possible years of clustering. In 1983 and 1989 a zero test statistic is found with relative rates 12.17 and 1.80, respectively. In 1988 Surrey amalgamated with New Westminster and Langley produces a relative rate of 1.94 for cluster size 13. Richmond, on the other hand, must be combined with Delta and Vancouver to be significant for 1986–87. Only in 1986 though, does the relative rate exceed 1.5. Both districts show a consistency p-value equal to 0.08.

Esophagus

Lower mainland areas are listed in Table 11.3 for cancer of the esophagus. While none were featured as significant for the combined year situation, the consistency p-values are all at or below 0.04. Vancouver is significant by itself for 1985 and 1988 with relative rates equal to 1.87 in both years. Vancouver's other significant year is due to North Vancouver's high relative rate of 3.86 in 1989. Similarly, North Vancouver's significance in 1988 is because of neighbour Vancouver. Vancouver's value for that year also influences Burnaby which also needs to be considered with New Westminster. The relative rate is listed as 1.78. Richmond is also significant in 1985 and 1988 when combined with Delta and Vancouver. Vancouver seems to be the cell which influences the others to also be significant.

Stomach

Stomach cancer is exhibited in Table 11.4. Richmond has a relative rate of 3.38 in 1984 which causes neighbour Delta also to be significant for that year. Richmond and Delta together have a relative rate of 2.21 for the year 1989. Delta's relative rate of 2.59 in 1987 occurs when the cluster size is five. Both of these districts have consistency p-values which are below 0.04 and were possible clusters in the combined year examination.

Cowichan is listed with a relative rate of 3.26 for 1987 and when considered with close cells Gulf Islands and Saanich has a relative rate of 2.18 for 1986.

Colon

Only the Sunshine Coast is listed for colon cancer in Table 11.5. In the first two study years the relative rates are 2.54 and 2.40, respectively, with test statistic zero and cluster sizes at or near seven. The remaining years have a test statistic equal to four. Sunshine Coast was also tabled in the combined year situation and has a consistency p-value of 0.36 in this yearly analysis.

Rectum

Table 11.6 has Princeton and New Westminster listed for rectal cancer. Princeton was significant in the combined year analysis and has two significant individual years. In 1985 and 1989 the relative rates are 7.27 and 8.07, respectively, when the cluster size investigated is three. New Westminster is a possible cluster for 1983, 1984, and 1988. The last two of these three years have zero as a test statistic and relative rates of two or above. The first study year requires the combination of New Westminster and Burnaby to be significant with a relative rate of 1.57.

Liver

Although no cells were significant for liver cancer in the combined year investigation, Qualicum appears in Table 11.7. The two consecutive years 1986 and 1987 caused this site to be listed. In 1987 the cluster size is very small and the resultant relative rate is 5.97. In the previous year, Nanaimo and Qualicum together have significance with a relative rate of 3.36 when the cluster size is four. The consistency p-value for this school district was evaluated to be 0.46.

Pancreas

The Castlegar-Trail area shows some consistency for pancreatic cancer and was also significant in the combined year analysis. Trail 1986 and 1987 as significant years in

Table 11.8. In both periods the test statistic is zero and the relative rates are above three with very small cluster sizes. These results cause Castlegar also to be significant for the same years. In addition, the two together have a relative rate of 3.12 in 1984 when the cluster size examined is four. The consistency p-values are 0.02 for Castlegar and 0.03 for Trail.

Larynx

Larynx cancer has five districts listed in Table 11.9. In the combined year framework, Greater Victoria was also found to be significant. The yearly investigation shows that 1983 and 1989 have relative rates 3.73 and 2.96, respectively. In the first year, the cluster size is four while in the last year the cluster size is a bit larger at six. Cariboo-Chilcotin has a high relative rate of 11.79 for 1984. Here, however, the cluster size is only two and less than one case is expected. Similarly high relative rates are seen in Kamloops for 1985–86 and 1988. In all these years the cluster size investigated is two. The high rates in Kamloops cause neighbours North Thompson and South Cariboo also to be significant for the same years. In 1986 Kamloops must be combine with South Cariboo, Merritt, and Shuswap to be significant. The consistency p-values are 0.03 for all cells except South Cariboo. South Cariboo has a consistency p-value equal to 0.04.

Lung Squamous

All districts listed for lung squamous in Table 11.10 have consistency p-values which are zero or 0.01. Courtenay, Campbell River, Sunshine Coast all have four significant years. Sunshine Coast is significant itself in 1985 for the cluster size three. The years 1984, 1987, and 1988 have relative rates 2.78, 4.86, and 2.46, respectively, when Sunshine Coast is combined with Nanaimo. Nanaimo's test statistics for all of those years is zero with relative rates exceeding 2.7. Qualicum is influenced by Nanaimo and is significant for the years 1987–88. The relative rates are 2.27 and 2.40 for those years, respectively. Courtenay is significant itself for 1983 and 1987 where the cluster size is four. The high

relative rates cause Powell River to obtain significance for the same years. Courtenay and Powell River together have a relative rate of 3.13 in 1985 which causes Campbell River to be significant with a relative rate of 2.75 in that year as well. Powell River's relative rate of 5.31 for cluster size three in 1984 also produces a significant year for Courtenay and Campbell River. Campbell River's relative rate of 4.68 when three is the cluster size influences Vancouver Island West and Powell River to also be significant in 1983. Vancouver Island West also has a significant year in 1987 when considered along with Courtenay and Campbell River. All of these districts were also possible clusters for the combined year tests.

Lung Adenocarcinoma

Table 11.12 has the significant cells for lung adenocarcinoma cancer. Surrey has the lowest consistency p-value which is 0.03. In 1985 it is significant with relative rate 1.96 and test statistic zero. The other two significant years found have relative rates lower than 1.5. New Westminster has a relative rate equal to 2.36 in 1987 when the test statistic is zero and the cluster size is eight. This induces Coquitlam also to be significant for that year. In 1984 the combination of New Westminster and neighbours Burnaby and Coquitlam produces a relative rate of 1.58. Burnaby's only significant year where the relative rate is above 1.5 is 1988. The cluster size investigated is 18 and the corresponding relative rate is 1.56. This result influences Coquitlam and New Westminster which produces relative rates smaller than 1.5. Coquitlam is also significant itself for 1984 with relative rate 1.90.

Lung Small Cell

Lake Cowichan has a very high relative rate for lung small cell cancer in 1986. Table 11.13 shows this rate to be 16.50 for a cluster size of two. In this situation, the expected number of cases is extremely small. This school district is also significant for the following year when considered with Cowichan. The cluster size there is a bit

larger at five and the relative rate is 3.46. Powell River is significant on its own for the last study year with cluster size three. In 1987 the addition of Courtenay causes a relative rate of 2.93. When Campbell River is combined with Courtenay in the same year the relative rate is 2.77. These two school districts and Vancouver Island West are also a possible cluster for that year with a relative rate of 2.73. Powell River has the lowest consistency p-value of 0.01. Lake Cowichan and Vancouver Island West both have consistency p-values equal to 0.03. All of these districts were also significant when years were combined.

Lung Others

Lung others is featured in Table 11.14. Peace River North has a consistency p-value of 0.04 without one individual significant year. Peace River South itself is significant for 1986 when the cluster size is three. Prince George has relative rate 2.91 with at least five observed cases for 1987 with a consistency p-value equal to 0.04. Sunshine Coast has two consecutive years with cluster sizes less than five. In 1984 the relative rate is 3.96 while in 1985 the relative rate is 3.72. All cells except for Prince George were also found in the combined year results.

All Lungs

Powell River has the most significant years for all lungs. In Table 11.15 Powell River is significant by itself in 1984 and 1989 with relative rates 2.70 and 2.20, respectively. For the years 1983 and 1987 the relative rates are slightly above 1.5 when it is combined with Courtenay and Campbell River. For those years, Courtenay and Campbell River are each significant. Courtenay is significant by itself in 1984 and 1987 with relative rates 1.86 and 2.06, respectively. These values influence Campbell River which is also significant for that time period. Vancouver Island West is significant for the years where Courtenay and Campbell River are combined with it (1983,1984 and 1987). Sunshine Coast has two consecutive significant years. In 1984 the relative rate is 2.34 while the

relative rate in 1985 is 2.63 where the cluster sizes are both eight. Qualicum is significant for a couple of years in which the relative rates do not surpass 1.5. Cowichan has the last two study years as possible clusters and a consistency p-value equal to 0.40. The relative rate for both of these years is around 1.63 and the cluster sizes investigated are fifteen or sixteen.

Non-small Cell Lung

Non-small cell lung cancer is featured in Table 11.16. Alberni has two years in which its test statistic was zero and the relative rates exceed two. Cowichan has the same situation. In every year prior to 1988 the test statistic is five and Cowichan is not significant. With zero as the test statistic in the last two years the relative rates are around 1.7. Sunshine Coast also shows the same feature when the test statistic is zero for 1984–85. In those years the relative rates are 2.52 and 3.24 with at least seven cases observed. Cariboo-Chilcotin is significant by itself in 1985, in 1986 when combined with Quesnel and North Thompson, and in 1989 when amalgamated with Quesnel. Courtenay has a relative rate of 2.12 in 1984 and 2.22 in 1984. Campbell River is influenced by Courtenay and has significant years four 1983–84 and 1987. The relative rate range from 1.65 to 1.90. Vancouver Island West also shows the same pattern when combined with both Courtenay and Campbell River.

Melanoma

West Vancouver and Howe Sound have the most significant years for melanoma. West Vancouver is significant for every year except 1984 and 1989 as depicted in Table 11.18. For 1983, 1985, and 1986 the relative rates are 2.90, 2.84, and 2.73, respectively. In 1988–89, it must be combined with North Vancouver to obtain significance. The consistency p-value is zero for this school district. Howe Sound is significant when combined with West Vancouver for those same years. It is also a possible cluster in 1987 when considered with West Vancouver and North Vancouver with a relative rate of 1.56. Burnaby is

significant by itself for 1984 with a relative rate equal to 1.72 and cluster size 13. When combined with New Westminster in 1983, it is also significant with relative rate 1.67. Langley is significant for 1984–86 when the test statistic is zero. The relative rates there range from 2.02 to 2.64 with cluster sizes just under ten. The consistency p-value for Langley is calculated to be 0.06 while the Sunshine Coast has a consistency p-value of 0.44. Sunshine Coast is significant when the cluster size is four in 1986 and in the previous year when influenced by West Vancouver and Nanaimo. Sunshine Coast and Burnaby were not featured in the combined year examination, however, the remaining districts were also significant for that situation.

Bladder

Only West Vancouver is tabled for bladder cancer, with three significant years. In Table 11.22 the consistency p-value for West Vancouver is calculated to be 0.03. West Vancouver was also found to be significant when years were considered together. In 1985 the relative rate is 3.64 with cluster size five. For 1987 and 1989 West Vancouver must be combined with North Vancouver to give relative rates of 2.06 and 1.92, respectively.

Kidney

Queen Charlotte, Creston-Kaslo, and Stikine are listed for kidney in Table 11.23. In 1987, Queen Charlotte has a relative rate of 21.04. Since $\ell = 0$ and the cluster size investigated is only two, a minimum of two cases are found in Queen Charlotte. When the expected number of cases are less than one the relative rate becomes quite extreme. In 1984 the same school district is also significant at the same small cluster size when combined with Prince Rupert. Creston-Kaslo for the last study year has a relative rate of 5.24 and cluster size two. In 1986, Creston-Kaslo along with Nelson, Cranbrook, and Fernie, has a relative rate of 2.54 and is significant. Stikine is significant for two years when combined with Fort Nelson and Smithers. Again, the cluster size is two and very few cases are actually observed. The first two districts listed have consistency p-values

equal to 0.03 while Stikine's is 0.05.

Non-Hodgkins Lymphoma

Non-Hodgkins lymphoma findings are seen in Table 11.26. Langley is significant for the first two years with relative rates 2.61 and 2.40. Delta is a possible cluster itself for 1984 and in 1983 and 1989 when merged with Richmond and New Westminster. Nechako has a relative rate of 4.70 in 1989 with small cluster size. In 1985 it is also significant when considered with Prince George and Quesnel.

Multiple Myeloma

For multiple myeloma in Table 11.27, Burns Lake, Nechako, and the Peace River districts are significant in the first two study years. Nechako has a very high relative rate and small cluster size for 1984. This influences Burns Lake which is also significant for that year. Nechako also has a high relative rate for the first study year when combined with Prince George. The extreme rates in Burns Lake and Nechako also cause Peace River South and North to be significant with high relative rates. The cluster sizes are very small here and very few cases are actually observed. South Okanagan and Keremeos are significant for 1988 with a relative rate of 3.84 when combined along with Penticton. Summerland has a couple of years where the relative rates are high when combined with Penticton. South Okanagan, Keremeos, and Summerland all have consistency p-values which are equal to 0.05. Summerland, Nechako, South Okanagan, and Keremeos were each significant in the combined year investigation and the cluster sizes tested in the yearly analysis are very small.

Leukemia

Vancouver Island North has 1987 and 1988 as significant years for leukemia. It is the only school district listed in Table 11.28. In 1987 it is significant by itself and in 1988 when combined with Vancouver Island West and Campbell River. With less than one case expected in 1987 the relative rate is 7.21.

Acute Leukemia

Sunshine Coast and Nanaimo are both listed for acute leukemia. In Table 11.29 we see Nanaimo is significant for the first two years with test statistic equal to zero and cluster size four. The high rates found for that school district also cause its neighbour to be significant for the same year. Neither Sunshine Coast nor Nanaimo have consistency p-values less than 0.05.

Other Sites

North Vancouver has the most significant years for other sites with 0.00 as its consistency p-value. Five years are significant for this district found in Table 11.31. For the years in which the test statistic is zero, the relative rates exceed 1.5. West Vancouver shows similar results when combined with North Vancouver. In 1985, 1986, and 1988 Grand Forks has relative rates which exceed 3.5. In 1985, Grand Forks must be considered with Kettle Valley while in 1989, the relative rate is 2.15 when Kettle Valley and Trail are amalgamated with it. Nechako is significant for 1984–85 when considered by itself or combined with Prince George. The relative rates during these years are 4.20 and 2.39 with fairly small cluster sizes. Nanaimo is significant with at least eleven cases observed in 1986. This cell also has a relative rate of 1.70 when merged with neighbouring Qualicum and Sunshine Coast.

Primary Unknown

Vancouver has three years of possible clustering for the primary unknown site displayed in Table 11.32. All years, however, have relative rates less than 1.5. Maple Ridge is significant by itself with relative rate 2.52 in 1984. When it is combined in 1985 with Langley the relative rate is 1.81. Mission is only significant when the test statistic is zero for the years 1987–88. The relative rates are 2.83 and 2.67 for those years, respectively.

Breast

In Table 11.33 the significant school districts for breast cancer are displayed. Only

West Vancouver has a year which is significant and has a relative rate above 1.5. In 1984 with a cluster size of 37 the relative rate is 1.53. None of the cells have a consistency p-value which is less than 0.10.

Cervix

For cervical cancer in Table 11.35, Vancouver has rates which seem to influence its neighbours. Five years are significant for Vancouver although only two have rates above 1.5. The 1989 result causes Richmond to be significant with a relative rate of 1.70. The other years show small relative rates. The same can be said for Burnaby and North Vancouver which have relative rates for 1989 equal to 1.73 and 1.67, respectively. The consistency p-values in these school districts are close to zero. Surrey has a relative rate of 1.87 in 1988 and 1.51 in 1987. The last value occurs when Surrey is combined with New Westminster. The Central Coast has excessive relative rates with small cluster sizes for 1985–86. Alberni in combination with Qualicum is significant for 1987 and 1988. The Richmond, Vancouver, Burnaby, and North Vancouver regions all have consistency p-values close to zero. Central Coast is significant for 1985 and 1986. With test statistic zero in 1986 and cluster size 2, the relative rate is 22.71. Only a fraction of one case is expected here, so observing at least two cases gives the extremely high relative rate. In 1985, Central Coast must be combined with Vancouver Island North and have relative rate 5.31 when combined.

Colo-Rectal

New Westminster, Sunshine Coast and Kitimat have three significant years each for colo-rectal cancer. Sunshine Coast was present in the combined year investigation and is also listed in Table 11.36. Sunshine Coast is significant for years in which the test statistic equals zero. The relative rates seen are close to two. Cariboo-Chilcotin has relative rates equal to 1.99 for two consecutive years with a consistency p-value of 0.22. In 1985 Hope is significant with relative rate 2.93 when Agassiz-Harrison is added to it.

The addition of Agassiz-Harrison and Chilliwack yield a relative rate of 1.71 for Hope in 1987. New Westminster's significance in 1984 gives a relative rate of 1.73 while the other years are less than 1.5. Kitimat is significant for three years when considered with Terrace or both Terrace and Prince Rupert. The consistency p-value for Kitimat is 0.09.

Endometrium

For the endometrium site found in Table 11.39, West Vancouver has the most significant years. The years 1984 and 1987 have relative rates above 1.5 for Richmond with 0.06 as the consistency p-value. West Vancouver has a consistency p-value of 0.01 and has relative rates above two when the test statistic equals zero. Howe Sound is only significant if combined with neighbour West Vancouver. Prince George is a possible cluster for the years 1983, 1985, and 1987 with relative rates 2.15, 1.97, and 2.22. Gulf Islands is only significant if considered alone or with neighbour Cowichan for 1985 and 1986.

When all cancers except lung are considered, Kettle Valley has a high relative rate for 1983 and 1984. In Table 11.38, Kettle Valley has relative rates 2.73 and 2.43 for those two years. With a cluster size of 9 investigated in each of these two years, the relative rate is large. The remaining districts displayed have relative rates below 1.5. The same can be said for the site all cancers. Kettle Valley has large relative rates for the first two study years. In Table 11.46 Hope has a relative rate of 1.6 for 1984 and is also significant for 1983.

Overall the results given by the yearly analysis are fairly consistent with those seen in the combined year analysis. If a school district is very significant over all years, it is likely to be significant for at least one year in particular. With school districts which are not as significant, they may not appear significant in any one year. This fact is mainly because of the discreteness of the Poisson distribution. If the expected number of cases is small, the cluster size may be more than the 95^{th} percentile. For example, if

$\lambda = 2$ then the approximate 95^{th} percentile of the Poisson distribution is 6. However, 6 is almost exactly the 98^{th} percentile of that Poisson distribution. With low numbers of cases expected, the yearly results may not be consistent with the combined year analysis for a particular cell. Another reason for lack of consistency can be based on the number of cells combined. Suppose a cell is significant in the combined year analysis with an observed test statistic of 1. Perhaps in the yearly framework the observed test statistics for that cell are all 2. The yearly and combined year analyses will not be examining the same thing because the populations involved are different.

It should also be noted that some of these results showed very high relative rates. The relative rates should be considered along with the cluster size. Small cluster sizes mean that few cases are required to have significance achieved. Small values of λ need smaller values of the cluster size to be able to detect possible clusters at a specified significance. A relative rate of ten would mean very different things depending on the cluster size and underlying population at risk. For example, if one cell has five cases expected and another cell has only 0.1 case expected the relative rate of ten would have a different interpretations. In the first case it would be extremely alarming to have 50 cases observed when only five are expected. In the other cell, expecting 0.1 cases and observing one case would give a relative rate of ten but not be so alarming.

5.2.3 Focused Findings

The focused yearly results for males start on page 165. These findings display some agreement with the with the general yearly results when ℓ is small. When ℓ is larger, the nearest neighbours of the mill are not exactly the same as the nearest neighbours of the school district where the mill is located.

From the male results we see that Port Mellon has several years significant for the sites oral cavity, liver, soft tissue sarcoma, and prostate. Port Mellon also shows this

pattern in some other sites, although the relative rate is not above 1.5 in those years. Campbell River is listed for several sites including all lungs, lungs:non-small cells, testis, and bladder. For the sites of all lungs, lungs:non-small cells, bladder, Gold River shows a pattern of high relative rates. Powell River figures prominently for all lungs, lungs:non-small cells, testis, and non-Hodgkins lymphoma. Prince George has three significant years for lung others. MacKenzie shows similar results but not exactly the same. With larger values of the statistic, the neighbours are not identical for these two mills. Similar results are also seen for prostate and multiple myeloma. Those mills listed under rectum cancer are all significant for 1988 and 1989.

When the female results are considered we see that Port Mellon also appears several times. For oral cavity, colon, melanoma, colo-rectal, and endometrium it has several significant years, and two consecutive significant years for some sites. Powell River, Gold River, and Campbell River are displayed for lung squamous, lung small cell, and all lungs. The last two also appear together for lung:non-small cells. Squamish has four significant years for melanoma.

6 Conclusion

The objective of a large scale surveillance scheme for potential disease clusters is to provide information which can be used to prioritize areas or foci which require further study. Surveillance studies are intended to indicate where local studies should be conducted. The findings from these studies can potentially provide guidelines for allocating limited investigation resources to areas most likely to be actual clusters.

Determining which school districts and mills are possible clusters in British Columbia was the goal of this surveillance study. The diversity of school district population sizes forced the cluster detection technique employed to incorporate the population distribution within each cell. After examination of both general and focused tests considerate of the population distribution, the method proposed by Besag and Newell was deemed most appropriate. Concerns about the choice of cluster size in our analysis motivated a modification to the Besag and Newell method. The modified method was used for both general and focused tests, and for both combined year and yearly analyses. The combined year examination identified mills or school districts with statistically significant excess numbers of cases. To investigate if cells were consistently part of a possible cluster throughout the study years, a yearly analysis was conducted as well.

The Besag and Newell method seemed the most suitable choice due to several factors. Their procedure did not require the amalgamation of partial cells. Trying to split the school districts into regions of equal population was unacceptable with large, sparsely populated regions. Certainly in school districts such as Fort Nelson, a third of the population did not reside in a third of the geographical area. Neither was exposure data required to determine the clustering around a pollutant source, nor did the existing cells need to be redefined to incorporate the focused test. Only the disease counts, population data, and nearest neighbours for each administrative zone were required for the analysis. These aspects made their method suitable for our situation.

The cluster size which should be used was not entirely clear. When cancer counts vary dramatically from cell to cell, the cluster size chosen becomes critical. When zones are very small and disease counts are also small, this choice is not as paramount. For example, when disease counts within a cell are either zero or one, to achieve a certain cluster size k, the test statistic will be at least k. However, when combining regions with higher disease counts, adding one more cell can drastically increase the number of cases observed. With the disparity of population among B.C. school districts, the cluster size chosen had to reflect the possibility of large jumps in the cases observed when the test statistic increased slightly. It was readily apparent that the diverse populations required diverse cluster sizes. Using one cluster size for all cells was not reasonable. Each cell needed its own cluster size dependent on its population. The cluster size for a cell was a function of its population, or equivalently, a function of its estimated expected number of cases.

Our proposed modification used percentiles of the Poisson distribution based on estimated expected number of cases. This modification guaranteed all statistically significant cells or foci will be identified for some prespecified level of significance. Without our alteration, a cell could be tested at two different cluster sizes and produce conflicting results even if the observed test statistic was exactly the same in both situations. This type of incongruency motivated us to choose a cluster size evaluated as the minimum number of cases necessary to be statistically significant.

Each cell was tested at a maximum of three different cluster sizes. Each of these cluster sizes was the 95^{th} percentile of a Poisson distribution with a specific mean adjusted for age distribution in the underlying population. The three means were the estimated expected number of cases for a cell individually, the cell and its nearest neighbour, and the cell and its two closest neighbours. Our cluster sizes represent the minimum number of cases required to obtain significant results based on the estimated expected number

of cases for the corresponding region.

The modified procedure was implemented on each sex and cancer type separately with age group as a stratum. Combined year analyses identified possible clusters for the entire study period. When the modified method was applied to each year separately, the yearly analyses showed if a cell was consistently part of a cluster. A Monte Carlo simulation was conducted to ascertain the degree of overall clustering for the combined year analyses, while in the yearly examination, yearly p-values were transformed to reflect the degree of consistency of yearly results.

The findings of this study were discussed in detail in Section 5. With various sites, sexes, and analyses, the results are difficult to summarize briefly and listing each significant cell would be repeating that discussion. We offer only broad comments about some sites.

Several sites did not have any significant areas with at least a relative rate of 1.5. In males, the sites for which clustering evidence was not supported by the general test are colon, lung adenocarcinoma, all cancers except lung and all cancers. No apparent clustering around mills was indicated by the male focused test in those sites and the sites of rectum, liver, all lungs, lungs:non-small cells, soft tissue sarcoma, melanoma, brain, Hodgkins Disease, non-Hodgkins lymphoma, and colo-rectal. Lip, liver, all lungs, lungs: non-small cells, soft tissue sarcoma, breast, all cancers except lung, and all cancers sites did not have any possible clusters listed for the combined year general female analysis. The focused combined year female results did not suggest clustering around the foci for those same sites, with the exception of lungs:non-small cells, and the sites of esophagus, rectum, lung adenosquamous, lung adenocarcinoma, bladder, kidney, brain, non-Hodgkins lymphoma, chronic leukemia, primary unknown, and ovary. Yearly results showed some school districts and mills were consistently part of possible clusters for a few sites.

Several sites showed overall significance in the Monte Carlo simulation. In males, the sites of lip, stomach, lung squamous, lung others, all lungs, lungs: non-small cells, soft tissue sarcoma, prostate, bladder, kidney, and multiple myeloma suggested overall clustering for the general test. Overall clustering around mills for stomach, pancreas, lung squamous, lung others, prostate, bladder, kidney, and multiple myeloma cancers was supported by the focused test. Overall clustering was not as apparent when women are considered. The general test displayed lung squamous, lung adenosquamous, lung small cell, chronic leukemia, and primary unknown sites with low overall p-values. Those same lung sites as well as melanoma and endometrial cancer also were indicative of overall clustering for the focused test.

This surveillance study involved over thirty cancer sites, two sexes, and seven years of data. Utilization of the modified method identified all cells which were statistically significant. Not all school districts or mills identified can be interpreted as actual clusters due to multiple testing problem. Any apparent excess of cases may be due to factors which were not known to us. Although the age structure was considered, people within an age group were assumed to be homogeneous within that group. We assume, for example, that the women between the ages of 20–24 in Surrey smoke as much or as little as the women in that age group living in Stikine. This may not necessarily be the case. Covariates such as smoking, drinking, diet, occupation, or family history may be factors which contribute to a cluster being detected in a particular school district. The possible clusters detected would be actual clusters if everyone within a stratum, was similar from cell to cell. People with similar ages and of the same sex were considered together irrespective of factors which may make them more susceptible to cancer than someone else in their strata.

Causal relationships between cancer incidences and pulpmills should not be established by our findings. Nor can we say that someone is more likely to get a specific cancer

due to their locations of residence. Even though strong associations between locations of residence and elevated cancer risks may be established, cancer has a long latency and people frequently change their locations of residence, making such statements inappropriate. Every significant cell should not be interpreted as an actual cluster. All we can conclude is that some areas have statistically significant excessive numbers of cases during the study period which cannot be attributed to age group or sex distributions.

The health authority must assess, given its current knowledge on the etiologies of these diseases, which school districts or mills and sites require further study and what form this further study will take. Smaller administrative zones, such as enumeration areas, may also be tested for clustering. The focused test may be more informative if some environmental factors are incorporated in the nearest neighbour relationship. Using wind patterns to determine the nearest neighbours to a pulpmill may be more reasonable than distance alone, for example. Mortality studies could be performed on the school districts which were significant followed by in-depth epidemiological studies, if necessary. The cluster detection analysis conducted here is a preliminary step towards identifying cancer clusters.

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Appendix : Tables

Table 1: Cancer Sites Investigated with Patient Counts

Site Number	Cancer Site	Males	Females
1	Lip 140	328	65
2	Oral Cavity 141 – 9	1167	604
3	Esophagus 150	550	261
4	Stomach 151	1419	753
5	Colon 153	3123	3228
6	Rectum 154	2283	1738
7	Liver 155	396	217
8	Pancreas 157	952	855
9	Larynx 161	653	107
10	Lung Squamous	2368	713
11	Lung Adenosquamous	73	30
12	Lung Adenocarcinoma	1647	1298
13	Lung Small Cell	1038	634
14	Lung Others	2219	1126
15	All Lungs	7345	3801
16	Lungs: non-small cells	6307	3167
17	Soft Tissue Sarcoma 171	605	336
18	Melanoma 172	1210	1283
20	Prostate 185	9613	–
21	Testis 186	494	–
22	Bladder 188	1860	606
23	Kidney 189	1085	578
24	Brain 191	747	501
25	Hodgkins Disease 201	289	220
26	Non-Hodgkins Lymphoma 202	1506	1178
27	Multiple Myeloma 203	503	411
28	Leukemia 204, 5, 7, 10, 11	1231	849
29	Acute Leukemia 204, 5	350	267
30	Chronic Leukemia 207, 10, 11	881	582
31	Other Sites	1371	1773
32	Primary Unknown 199	2552	2068
33	Breast (female)	–	10810
34	Ovary	–	1642
35	Cervix	–	1085
36	Colo-Rectal (4,5)	5406	4966
38	All cancers except lung	33937	33295
39	Endometrium	–	2127
46	All cancers (ex. non-melanoma skin)	41282	37096

Table 2: British Columbia Pulpmills

Code	Company & Division	Location	School District
1	Canadian Forest Products Ltd.		
	Prince George Pulp & Paper Mill	Prince George	57
2	Canadian Forest Products Ltd.		
	Intercontinental Pulp & Paper	Prince George	57
3	Celgar Pulp Co.	Castlegar	9
4	Eurocan Pulp & Paper Co.	Kitimat	80
5	Fletcher Challenge Canada Ltd.		
	Crofton Division	Crofton	65
6	Howe Sound Pulp & Paper Ltd.	Port Mellon	46
7	MacMillan Bloedel Ltd.		
	Alberni Pulp & Paper Division	Port Alberni	70
8	MacMillan Bloedel Ltd.		
	Harmac Division	Nanaimo	68
9	MacMillan Bloedel Ltd.		
	Powell River Division	Powell River	47
10	Northwood Pulp & Timber Ltd.	Prince George	57
11	Skeena Cellulose Inc.		
	Skeena Pulp Operations	Prince Rupert	52
12	Wester Pulp Limited Partnership		
	Port Alice Operation	Port Alice	85
13	Wester Pulp Limited Partnership		
	Squamish Operation	Squamish	48
14	Wyerhauser Canada Ltd.	Kamloops	24
15	Canadian Pacific Forest Prod. Ltd		
	Gold River Mill	Gold River	84
16	Cariboo Pulp & Paper Co.	Quesnel	28
17	Crestbook Forest Industries Ltd.	Skookumchuck	2
18	Crown Zellerback Ltd.		
	Extinct 78	Ocean Falls	49
19	Finlay Forest Industries Ltd.	Mackenzie	57
20	Fletcher Challenge Canada Ltd.		
	Elk Falls Mill	Campbell River	72
21	Fletcher Challenge Canada Ltd.		
	Mackenzie Pulp Division	Mackenzie	57
22	Quesnel River Pulp Co.	Quesnel	28

Table 3: Nearest School District Centroids

Code	Name	Nearest SD 1st	2nd	3rd	Code	Name	Nearest SD 1st	2nd	3rd
1	Fernie	2	3	86	45	W Vancouver	44	39	41
2	Cranbrook	3	1	86	46	Sunshine Coast	68	45	69
3	Kimberley	2	1	86	47	Powell River	71	72	69
4	Windermere	3	18	2	48	Howe Sound	45	44	46
7	Nelson	9	11	10	49	Central Coast	85	55	80
9	Castlegar	11	7	12	50	Queen Charlotte	52	80	88
10	Arrow Lakes	7	9	11	52	Prince Rupert	80	88	50
11	Trail	9	7	12	54	Smithers	88	55	80
12	Grand Forks	13	11	9	55	Burns Lake	56	54	88
13	Kettle Valley	12	14	11	56	Nechako	57	55	28
14	S Okanagan	16	15	77	57	Prince George	56	28	55
15	Penticton	77	14	16	59	Peace River S	60	57	56
16	Keremeos	14	15	77	60	Peace River N	59	57	81
17	Princeton	16	77	15	61	Greater Victoria	62	63	64
18	Golden	19	4	10	62	Sooke	61	63	65
19	Revelstoke	89	18	21	63	Saanich	64	62	61
21	Armstrong-Spallumcheen	22	89	23	64	Gulf Islands	65	63	37
22	Vernon	21	23	89	65	Cowichan	64	63	66
23	Central Okanagan	77	15	22	66	Lake Cowichan	65	68	64
24	Kamloops	31	30	89	68	Nanaimo	69	46	66
26	N Thompson	24	89	19	69	Qualicum	68	70	46
27	Cariboo-Chilcotin	28	26	30	70	Alberni	69	71	68
28	Quesnel	27	57	56	71	Courtenay	47	72	70
29	Lillooet	30	31	24	72	Campbell River	71	47	84
30	S Cariboo	29	24	31	75	Mission	34	42	35
31	Merritt	24	17	30	76	Agassiz-Harrison	33	32	75
32	Hope	76	33	17	77	Summerland	15	23	16
33	Chilliwack	76	75	34	80	Kitimat	88	52	54
34	Abbotsford	75	35	33	81	Fort Nelson	60	59	87
35	Langley	36	42	40	84	Van Isl West	72	71	70
36	Surrey	40	35	43	85	Van Isl North	84	72	71
37	Delta	38	40	36	86	Creston-Kaslo	7	2	3
38	Richmond	37	39	41	87	Stikine	81	54	88
39	Vancouver	44	41	45	88	Terrace	80	54	52
40	New Westminster	41	43	36	89	Shuswap	21	22	24
41	Burnaby	40	39	43					
42	Maple Ridge	35	43	36					
43	Coquitlam	40	41	36					
44	N Vancouver	39	45	41					

Table 4: Nearest School District Centroids to Foci

Code	Mill Location	Nearest SD's 1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
1, 2, 10	Prince George	57	56	28	55	27
3	Castlegar	9	11	7	12	13
4	Kitimat	80	88	52	54	55
5	Crofton	65	64	63	66	68
6	Port Mellon	46	45	39	44	38
7	Port Alberni	70	69	71	68	66
8	Nanaimo	68	69	46	66	65
9	Powell River	47	71	72	69	70
11	Prince Rupert	52	80	88	50	54
12	Port Alice	85	84	72	71	49
13	Squamish	48	45	44	46	39
14	Kamloops	24	31	89	30	21
15	Gold River	84	72	71	85	47
16, 22	Quesnel	28	27	57	56	26
17	Skookumchuck	3	2	1	4	86
18	Ocean Falls	49	80	88	52	85
19, 21	MacKenzie	57	56	60	59	55
20	Campbell River	72	71	47	84	70

Table 5*a*: Combined Year Male Results for Site 1 Lip, $k_1, \ldots, k_{10}$

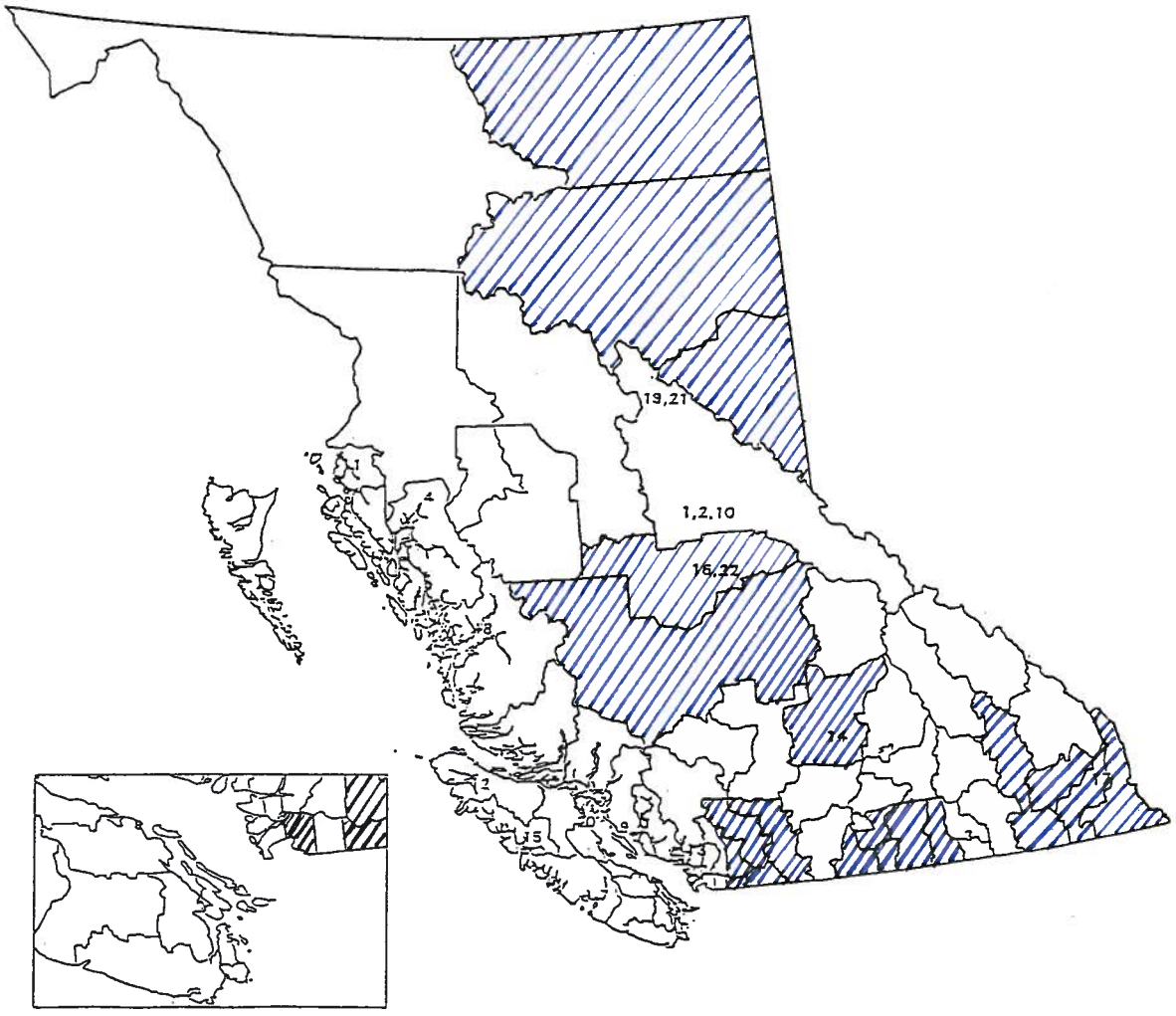
SD		Cluster Size (k) 2	10	18	26	34	42	50	58	66	74
1	p	0.79	0.12	0.01	0.01	0.02	0.24	0.14	0.06	0.01	0.04
	ℓ	1	3	5	10	13	15	16	17	18	22
	λ	2.95	6.47	9.70	16.08	22.83	37.22	42.38	46.79	49.53	59.30
2	p	0.53	0.12	0.01	0.01	0.02	0.24	0.14	0.04	0.02	0.04
	ℓ	0	3	4	9	13	15	16	17	18	22
	λ	1.78	6.47	9.06	15.58	22.83	37.22	42.38	45.12	49.53	59.30
3	p	0.29	0.12	0.01	0.01	0.02	0.24	0.11	0.06	0.02	0.04
	ℓ	0	3	5	9	13	15	16	17	18	22
	λ	1.08	6.47	9.70	15.58	22.83	37.22	41.63	46.79	49.53	59.30
4	p	0.51	0.01	0.03	0.16	0.10	0.01	0.11	0.06	0.03	0.03
	ℓ	1	3	7	12	13	14	16	17	19	21
	λ	1.72	4.01	10.82	20.94	26.53	27.70	41.63	46.77	51.20	58.41
9	p	0.39	0.27	0.04	0.01	0.00	0.00	0.01	0.02	0.03	0.0466
	ℓ	0	3	6	8	9	10	11	13	19	23
	λ	1.34	7.85	11.35	15.17	16.95	22.11	35.61	42.86	51.42	60.19
11	p	0.92	0.27	0.03	0.01	0.00	0.00	0.03	0.02	0.03	0.05
	ℓ	1	3	5	8	9	10	12	14	19	23
	λ	4.09	7.89	10.73	15.17	20.32	22.11	37.27	43.58	51.23	60.19
12	p	0.33	0.06	0.14	0.01	0.39	0.14	0.09	0.08	0.01	0.03
	ℓ	0	3	5	6	9	11	12	16	17	21
	λ	1.17	5.69	13.59	16.18	32.07	35.13	40.72	47.65	49.43	58.72
13	p	0.48	0.01	0.14	0.01	0.23	0.29	0.13	0.06	0.01	0.01
	ℓ	1	2	5	7	8	11	14	15	18	19
	λ	1.60	4.35	13.59	15.98	29.48	38.28	42.15	46.56	49.37	56.22
15	p	0.96	0.04	0.91	0.35	0.35	0.08	0.04	0.13	0.05	0.04
	ℓ	0	0	4	4	8	10	12	15	18	19
	λ	5.15	5.15	23.78	23.78	31.52	33.30	38.55	49.48	53.32	59.35
17	p	0.79	0.29	0.09	0.53	0.43	0.07	0.04	0.04	0.10	0.01
	ℓ	2	3	6	7	9	9	10	11	13	13
	λ	2.93	8.08	12.56	26.05	32.71	32.71	38.30	45.14	55.58	55.58
26	p	0.99	0.19	0.12	0.02	0.03	0.23	0.12	0.07	0.03	0.03
	ℓ	1	1	4	6	9	10	14	15	19	25
	λ	7.22	7.22	13.25	16.77	23.67	37.17	41.77	46.93	51.78	58.58
27	p	0.77	0.03	0.11	0.34	0.33	0.76	0.32	0.74	0.76	0.79
	ℓ	0	2	5	8	11	14	14	20	22	23
	λ	2.78	4.97	12.99	23.61	31.17	46.49	46.49	62.62	71.60	80.73
29	p	0.33	0.40	0.15	0.15	0.01	0.15	0.22	0.03	0.74	0.37
	ℓ	1	3	6	9	9	11	12	12	15	15
	λ	1.17	8.90	13.62	20.82	20.82	35.32	44.45	44.45	70.95	70.95
30	p	0.17	0.29	0.15	0.04	0.04	0.27	0.36	0.07	0.02	0.01
	ℓ	0	2	5	8	10	11	15	15	16	17
	λ	0.74	8.02	13.69	17.85	24.33	37.84	47.26	47.26	49.98	55.13
32	p	1.00	0.22	0.03	0.06	0.00	0.02	0.06	0.61	0.23	0.04
	ℓ	2	2	4	5	5	8	9	10	10	10
	λ	7.50	7.50	10.77	18.49	18.49	30.26	39.39	59.82	59.82	59.82
33	p	0.98	0.09	0.01	0.03	0.00	0.87	0.48	0.12	0.01	0.03
	ℓ	0	0	2	3	3	7	7	7	7	8
	λ	6.03	6.03	9.38	17.10	17.10	49.26	49.26	49.26	49.26	58.39

Table 5*b*: Combined Year Male Results for Site 1 Lip, $k_1, \ldots, k_{10}$

SD		Cluster Size (k) 2	10	18	26	34	42	50	58	66	74
34	p	1.00	0.25	0.02	0.30	0.02	0.82	0.40	0.09	0.01	0.02
	ℓ	0	0	1	3	3	5	5	5	5	7
	λ	7.72	7.72	10.44	23.10	23.10	47.79	47.79	47.79	47.79	57.54
59	p	0.58	0.00	0.28	0.55	0.09	0.04	0.06	0.33	0.08	0.12
	ℓ	0	1	7	13	13	15	20	23	24	28
	λ	1.96	3.56	15.34	26.36	26.36	31.51	39.39	54.41	55.03	64.20
60	p	0.48	0.00	0.36	0.08	0.15	0.07	0.09	0.37	0.09	0.15
	ℓ	0	1	8	12	16	18	22	24	24	32
	λ	1.60	3.56	16.23	19.25	28.05	32.90	40.79	55.17	55.17	65.21
75	p	0.76	0.60	0.02	0.63	0.12	0.82	0.39	0.08	0.01	0.02
	ℓ	0	1	1	4	4	5	5	5	5	6
	λ	2.73	10.44	10.44	27.36	27.36	47.79	47.79	47.79	47.79	56.92
76	p	0.99	0.14	0.02	0.04	0.00	0.28	0.88	0.54	0.18	0.03
	ℓ	1	1	3	4	4	7	8	8	8	8
	λ	6.66	6.66	10.23	17.94	17.94	37.96	58.39	58.39	58.39	58.39
81	p	0.54	0.01	0.34	0.12	0.27	0.12	0.02	0.04	0.33	0.21
	ℓ	1	2	10	12	20	21	23	26	29	31
	λ	1.81	3.77	15.98	20.02	30.22	34.63	36.29	45.27	62.07	67.03
86	p	0.70	0.15	0.00	0.01	0.00	0.00	0.03	0.03	0.03	0.04
	ℓ	0	2	3	8	11	12	13	15	20	22
	λ	2.44	6.82	7.90	14.94	18.76	23.91	37.41	44.66	51.92	59.30

Table 6.1: Male Combined Year General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
1 Lip	1 Fernie	9	2	9	4.03	2.24	0.02	0.000
	2 Cranbrook	5	0	6	1.78	3.37	0.04	
	3 Kimberley	7	1	9	2.86	3.14	0.03	
	12 Grand Forks	5	0	7	1.17	5.98	0.01	
	13 Kettle Valley	5	1	7	1.60	4.36	0.02	
	14 S Okanagan	15	2	15	8.62	1.74	0.03	
	15 Penticton	10	0	10	5.15	1.94	0.04	
	16 Keremeos	15	2	15	8.62	1.74	0.03	
	24 Kamloops	14	2	14	8.46	1.65	0.05	
	27 Cariboo-Chilcotin	9	1	9	4.59	1.96	0.04	
	28 Quesnel	9	1	9	4.59	1.96	0.04	
	32 Hope	13	2	16	7.50	2.13	0.04	
	33 Chilliwack	11	0	15	6.03	2.49	0.04	
	34 Abbotsford	14	0	14	7.72	1.81	0.03	
	36 Surrey	29	0	32	20.43	1.57	0.04	
	59 Peace River S	5	0	8	1.96	4.08	0.05	
	60 Peace River N	8	1	10	3.56	2.81	0.03	
	75 Mission	17	1	18	10.44	1.72	0.04	
	76 Agassiz-Harrison	12	1	16	6.66	2.40	0.04	
	81 Fort Nelson	8	2	10	3.77	2.65	0.04	
	86 Creston-Kaslo	6	0	6	2.44	2.46	0.04	



Map courtesy John Smith & Mapinfo.

Table 6.2: Male General Results 1983–89

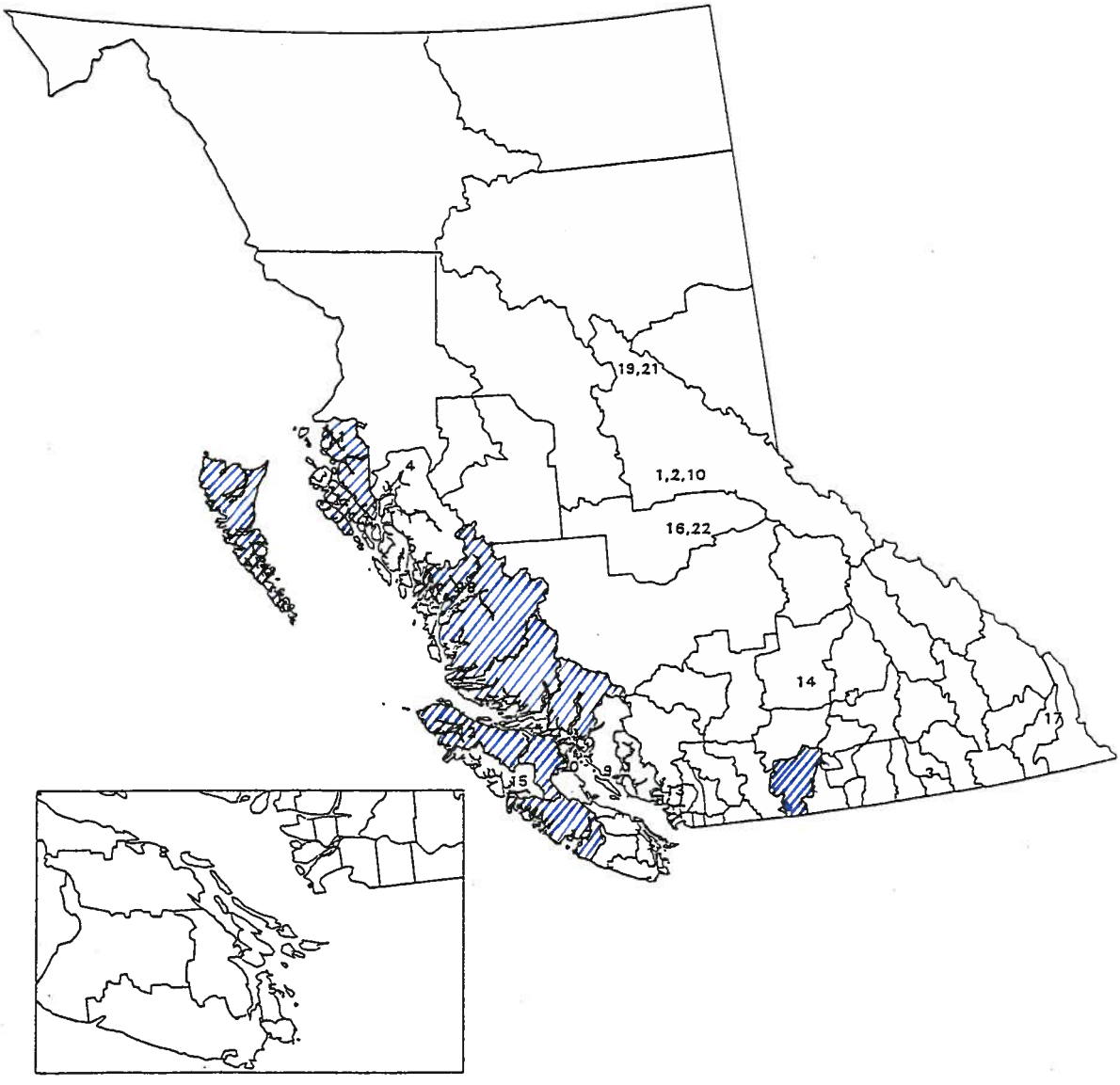
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
2 Oral Cavity	9 Castlegar	10	0	14	4.78	2.93	0.02	0.402
	11 Trail	22	1	22	14.08	1.56	0.03	
	39 Vancouver	217	0	314	192.88	1.63	0.05	
	40 New Westminster	27	0	37	18.36	2.02	0.03	

Table 6.3: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
3 Esophagus	27 Cariboo-Chilcotin	9	0	9	4.65	1.93	0.05	0.813
	28 Quesnel	13	1	15	7.65	1.96	0.05	

Table 6.4: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
4 Stomach	17 Princeton	6	0	6	2.31	2.59	0.03	0.052
	49 Central Coast	9	1	9	4.03	2.23	0.02	
	50 Queen Charlotte	15	2	16	9.17	1.75	0.05	
	52 Prince Rupert	14	1	14	7.86	1.78	0.03	
	70 Alberni	19	0	22	12.37	1.78	0.05	
	72 Campbell River	17	0	17	10.37	1.64	0.04	
	85 Van Isl North	7	0	7	2.96	2.37	0.03	



Map courtesy John Smith & MapInfo.

Table 6.6: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
6 Rectum	32 Hope	17	1	17	10.38	1.64	0.04	0.565
	76 Agassiz-Harrison	9	0	10	4.37	2.29	0.03	

Table 6.7: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
7 Liver	38 Richmond	106	2	146	89.08	1.64	0.04	0.266
	39 Vancouver	84	0	127	69.04	1.84	0.04	
	40 New Westminster	12	0	15	6.85	2.19	0.05	
	41 Burnaby	38	1	44	27.83	1.58	0.04	
	44 N Vancouver	98	1	139	81.42	1.71	0.04	
	45 W Vancouver	106	2	146	89.02	1.64	0.04	

Table 6.8: Male General Results 1983–89

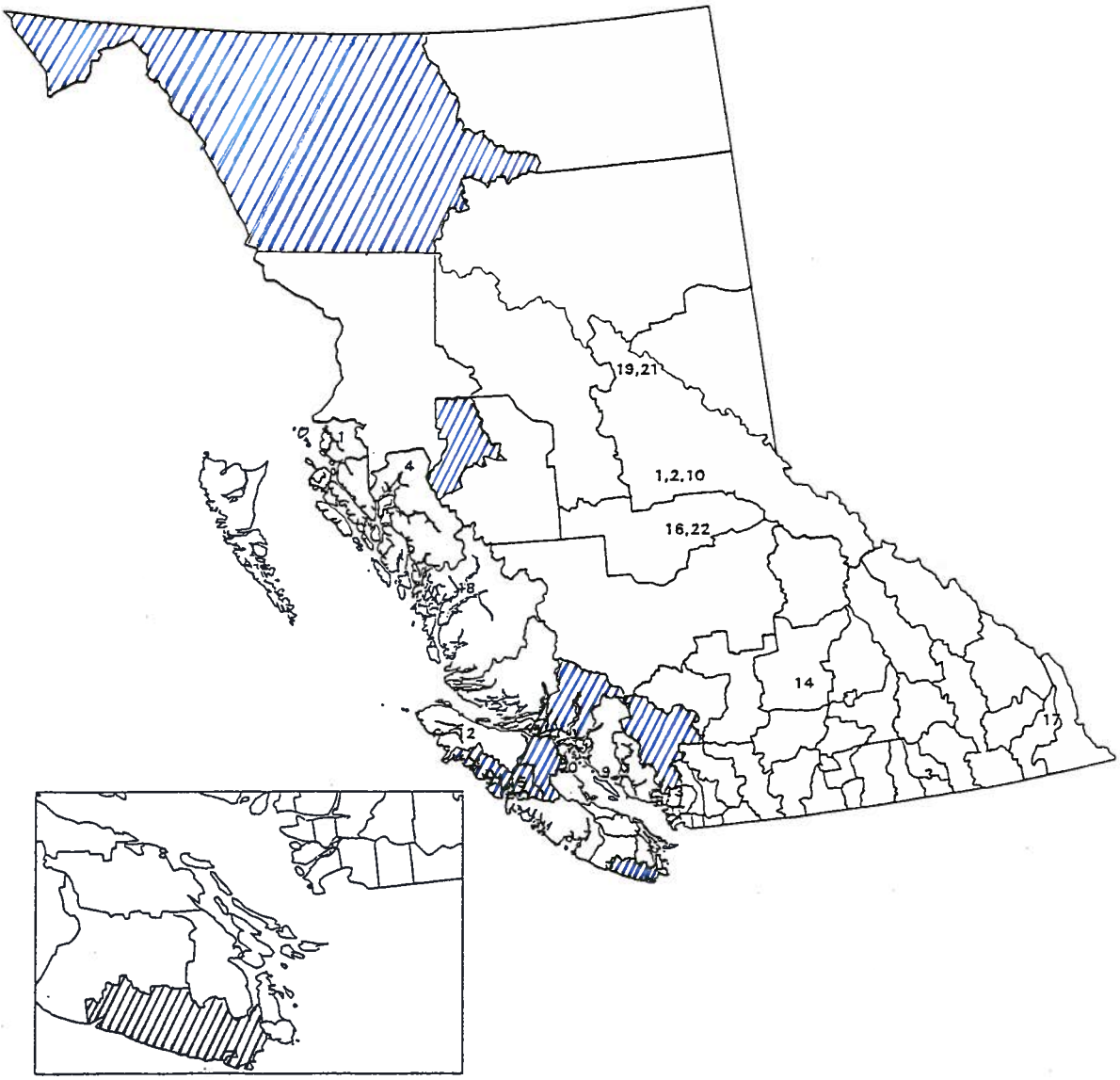
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
8 Pancreas	10 Arrow Lakes	5	0	6	1.84	3.26	0.04	0.115
	19 Revelstoke	23	1	23	15.21	1.51	0.04	
	56 Nechako	26	2	27	17.75	1.52	0.04	
	57 Prince George	21	0	21	13.32	1.58	0.03	
	65 Cowichan	22	0	28	14.76	1.90	0.05	
	66 Lake Cowichan	24	1	29	16.26	1.78	0.04	
	89 Shuswap	21	0	23	13.27	1.73	0.03	

Table 6.9: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
9 Larynx	17 Princeton	6	1	6	2.50	2.40	0.04	0.479
	56 Nechako	21	1	21	13.85	1.52	0.04	
	57 Prince George	18	0	18	11.57	1.56	0.05	
	84 Van Isl West	22	2	23	14.58	1.58	0.04	

Table 6.10: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
10 Lung Squamous	48 Howe Sound	13	0	13	7.61	1.71	0.05	0.030
	54 Smithers	11	0	11	5.89	1.87	0.04	
	62 Sooke	36	0	42	26.58	1.58	0.05	
	72 Campbell River	26	0	29	17.59	1.65	0.04	
	84 Van Isl West	27	1	30	18.62	1.61	0.04	
	87 Stikine	14	2	14	8.05	1.74	0.04	



Map courtesy John Smith & MapInfo.

Table 6.11: Male General Results 1983–89

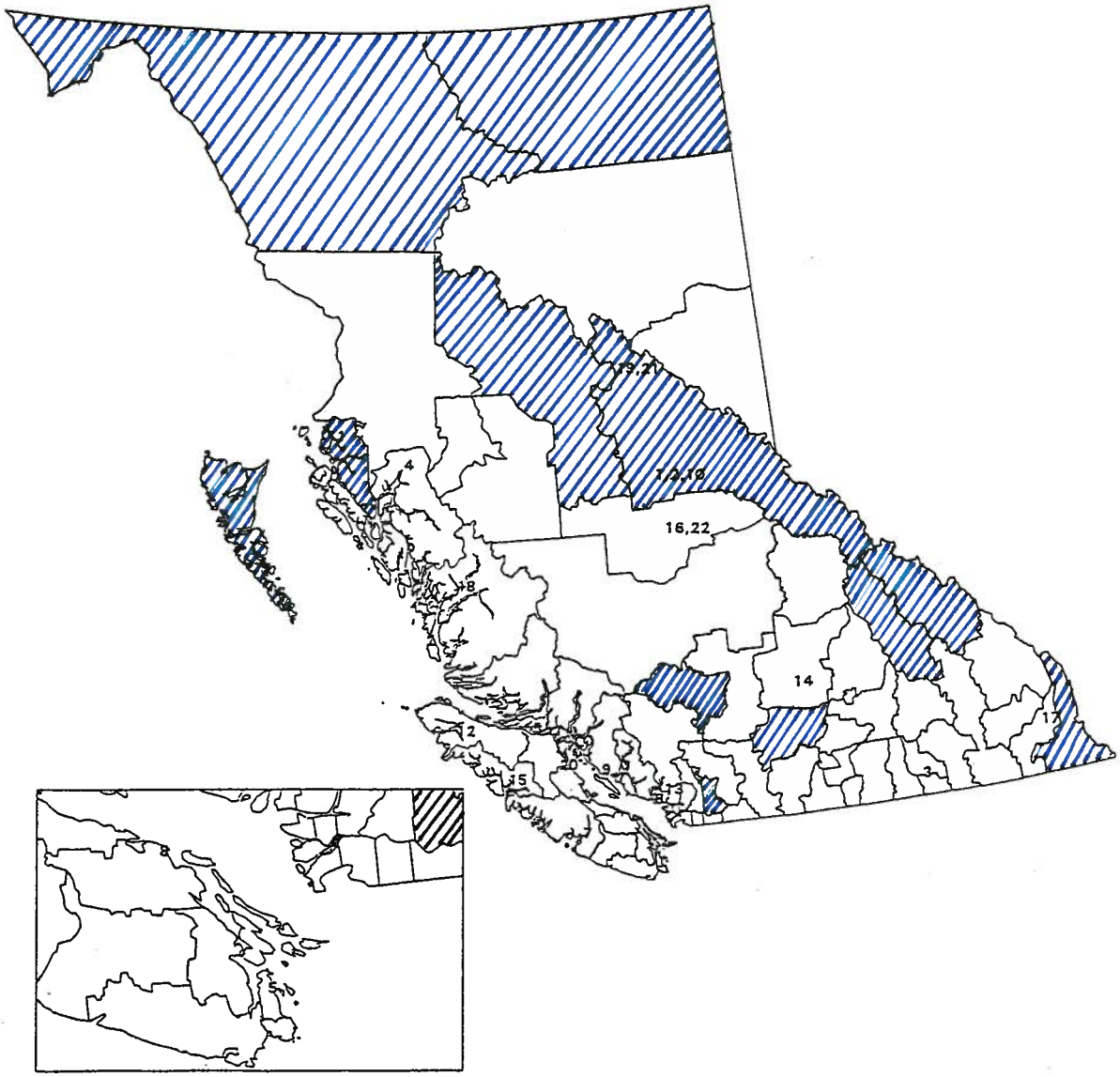
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
11 Lung	46 Sunshine Coast	6	1	7	2.53	2.77	0.04	0.306
Adenosquamous	66 Lake Cowichan	7	2	8	3.19	2.51	0.04	
	68 Nanaimo	5	0	6	1.92	3.13	0.05	
	69 Qualicum	7	1	9	2.88	3.12	0.03	

Table 6.13: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
13 Lung Small Cell	18 Golden	8	1	9	3.83	2.35	0.04	0.413
	19 Revelstoke	6	0	6	2.25	2.67	0.03	
	29 Lillooet	12	2	12	6.66	1.80	0.04	
	68 Nanaimo	37	0	44	27.03	1.63	0.04	

Table 6.14: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
14 Lung Others	1 Fernie	13	0	13	7.16	1.81	0.03	0.000
	18 Golden	13	1	- 15	7.50	2.00	0.04	
	19 Revelstoke	9	0	10	4.44	2.25	0.04	
	29 Lillooet	20	2	21	13.21	1.59	0.05	
	31 Merritt	11	0	12	5.55	2.16	0.03	
	40 New Westminster	53	0	63	40.87	1.54	0.04	
	50 Queen Charlotte	5	0	5	1.90	2.63	0.04	
	52 Prince Rupert	18	1	19	11.23	1.69	0.04	
	56 Nechako	48	1	56	36.48	1.53	0.04	
	57 Prince George	40	0	51	29.86	1.71	0.04	
	75 Mission	27	0	31	18.39	1.69	0.04	
	81 Fort Nelson	5	0	5	1.08	4.64	0.01	
	87 Stikine	5	1	6	1.82	3.29	0.04	



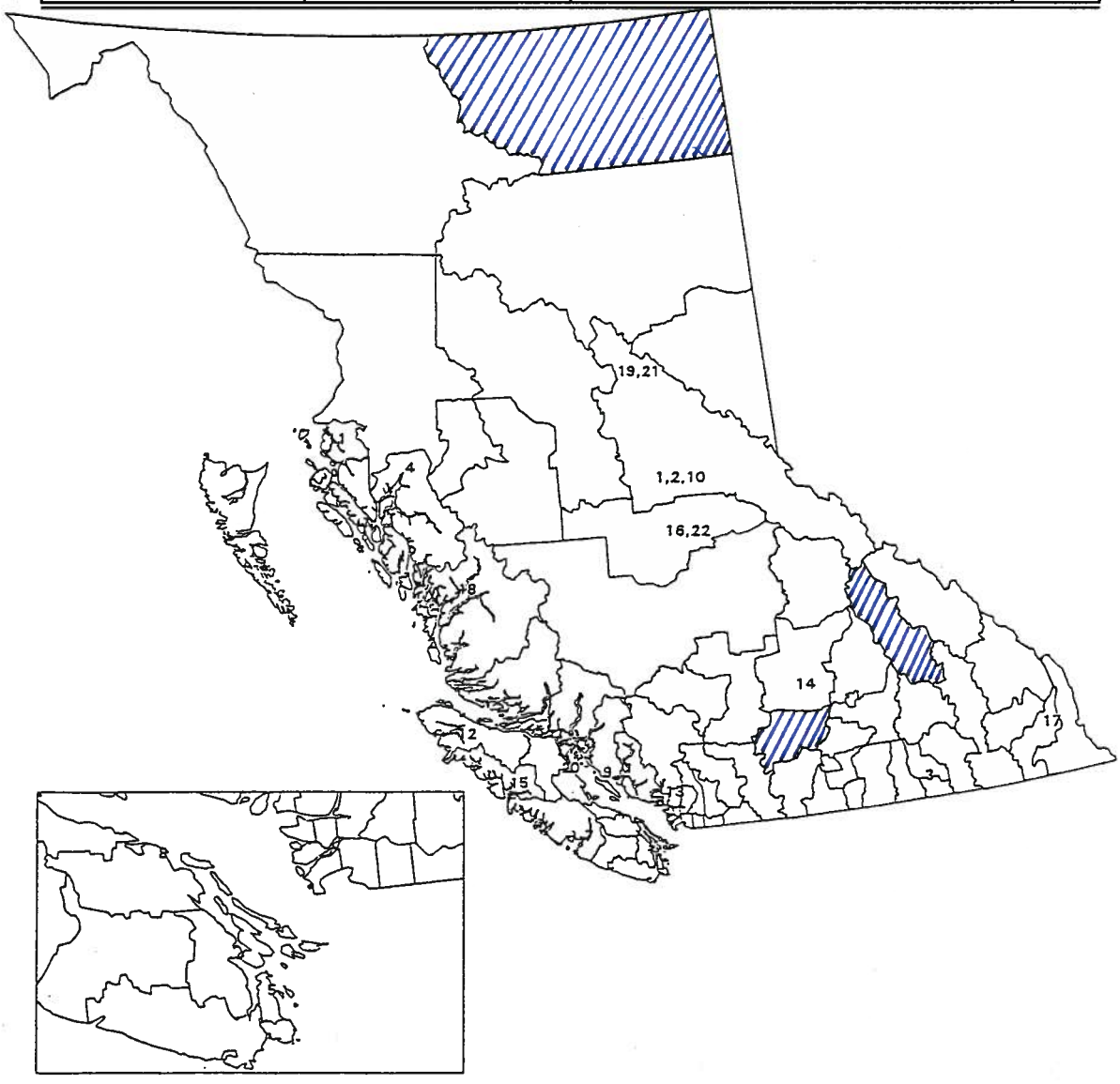
Map courtesy John Smith & MapInfo.

Table 6.15: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
15 All Lungs	19 Revelstoke	23	0	26	15.32	1.70	0.04	0.036
	31 Merritt	28	0	36	19.48	1.85	0.04	
	81 Fort Nelson	9	0	10	4.16	2.40	0.03	

Table 6.16: Male General Results 1983–89

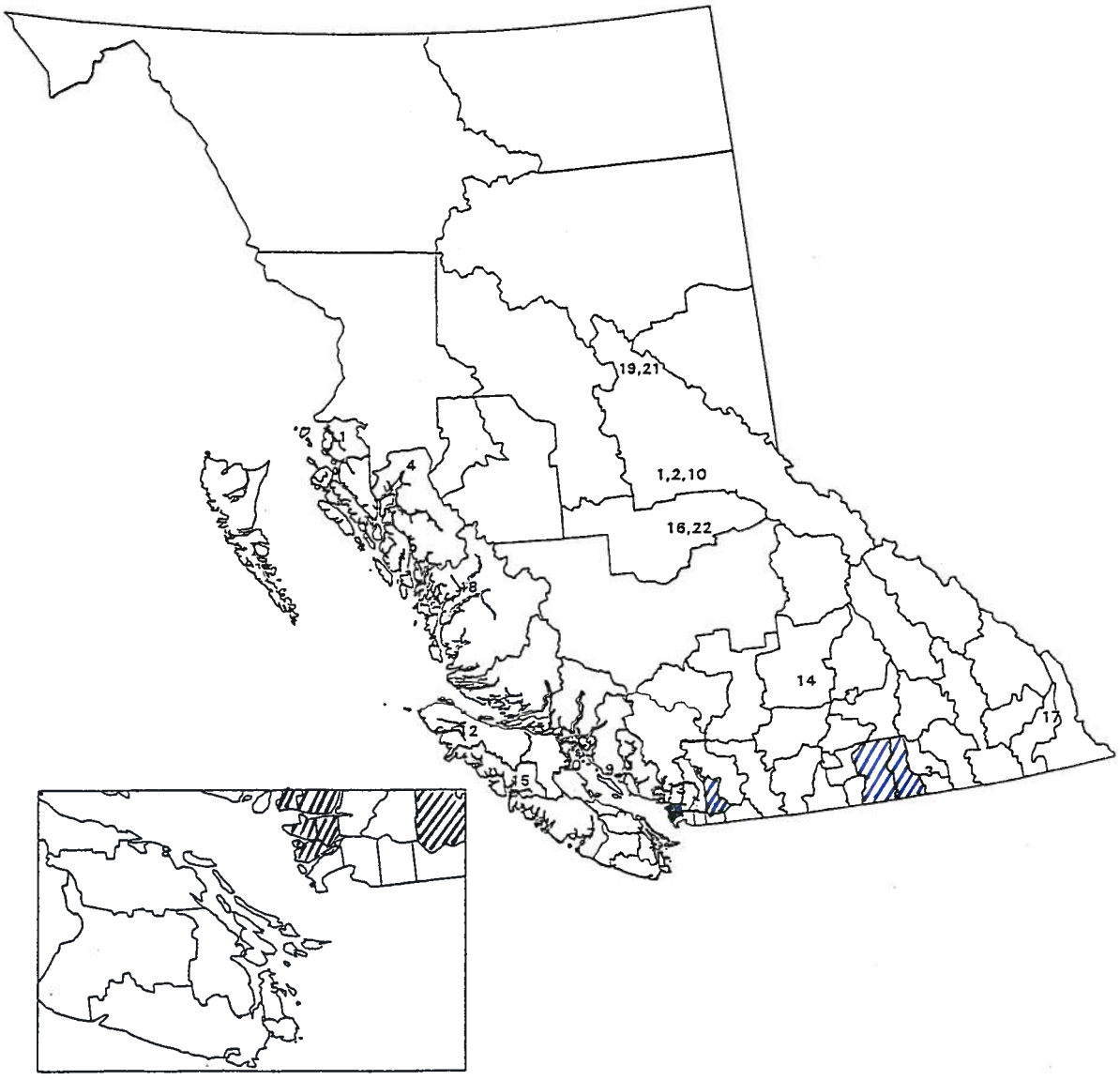
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
16 Lungs: non-small cells	19 Revelstoke	20	0	20	13.07	1.53	0.04	0.069
	31 Merritt	25	0	30	16.60	1.81	0.03	
	81 Fort Nelson	8	0	9	3.51	2.57	0.03	



Map courtesy John Smith & MapInfo.

Table 6.17: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
17 Soft Tissue Sarcoma	12 Grand Forks	5	0	5	1.71	2.93	0.03	0.071
	13 Kettle Valley	6	1	6	2.42	2.48	0.04	
	38 Richmond	156	2	229	135.23	1.69	0.04	
	39 Vancouver	117	0	200	99.44	2.01	0.05	
	41 Burnaby	161	2	236	140.00	1.69	0.04	
	44 N Vancouver	140	1	223	120.43	1.85	0.04	
	45 W Vancouver	150	2	233	129.85	1.79	0.04	
	75 Mission	10	0	10	5.28	1.89	0.04	



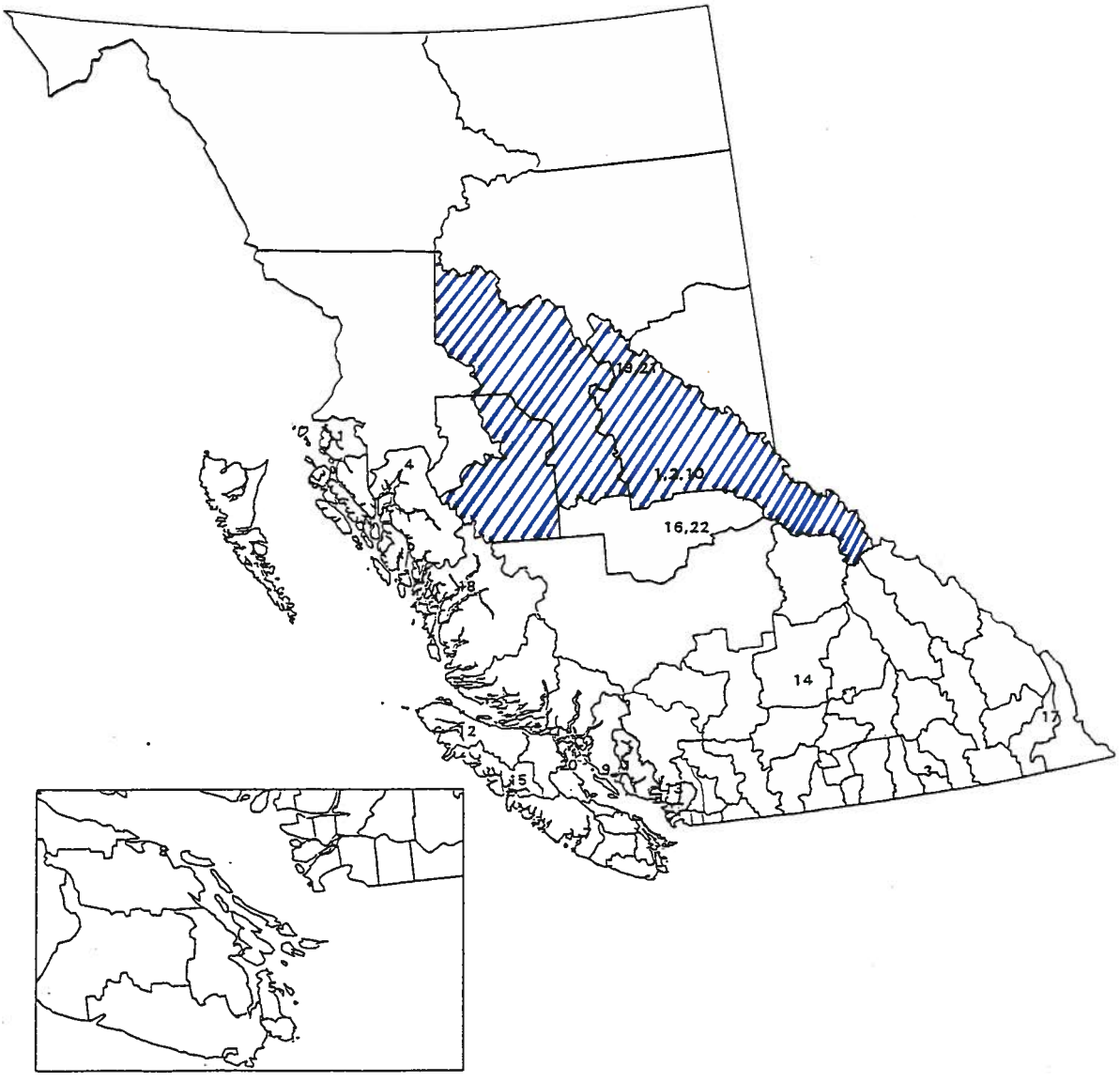
Map courtesy John Smith & MapInfo.

Table 6.18: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
18 Melanoma	31 Merritt	8	0	9	3.70	2.43	0.04	0.544
	45 W Vancouver	29	0	31	20.31	1.53	0.04	
	63 Saanich	28	0	34	19.72	1.72	0.05	

Table 6.20: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
20 Prostate	55 Burns Lake	22	0	24	14.21	1.69	0.03	0.006
	56 Nechako	37	0	42	27.02	1.55	0.04	
	57 Prince George	134	0	178	115.13	1.55	0.05	



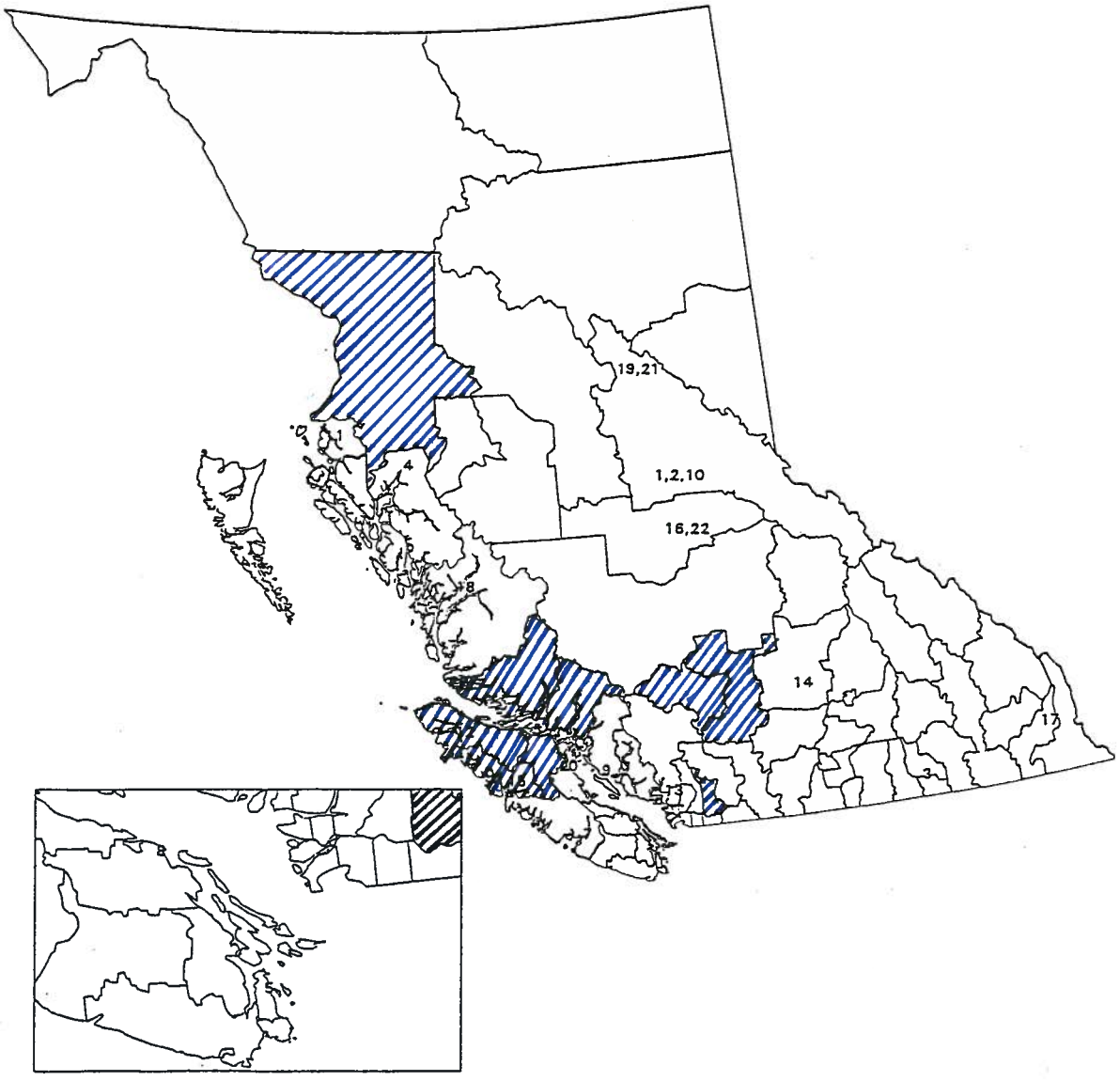
Map courtesy John Smith & MapInfo.

Table 6.21: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
21 Testis	11 Trail	7	0	7	3.25	2.15	0.05	0.254
	47 Powell River	15	1	17	9.19	1.85	0.05	
	49 Central Coast	8	1	9	3.53	2.55	0.03	
	64 Gulf Islands	5	0	5	1.20	4.16	0.01	
	71 Courtenay	12	0	12	6.24	1.92	0.03	
	85 Van Isl North	7	0	8	2.95	2.71	0.03	

Table 6.22: Male General Results 1983–89

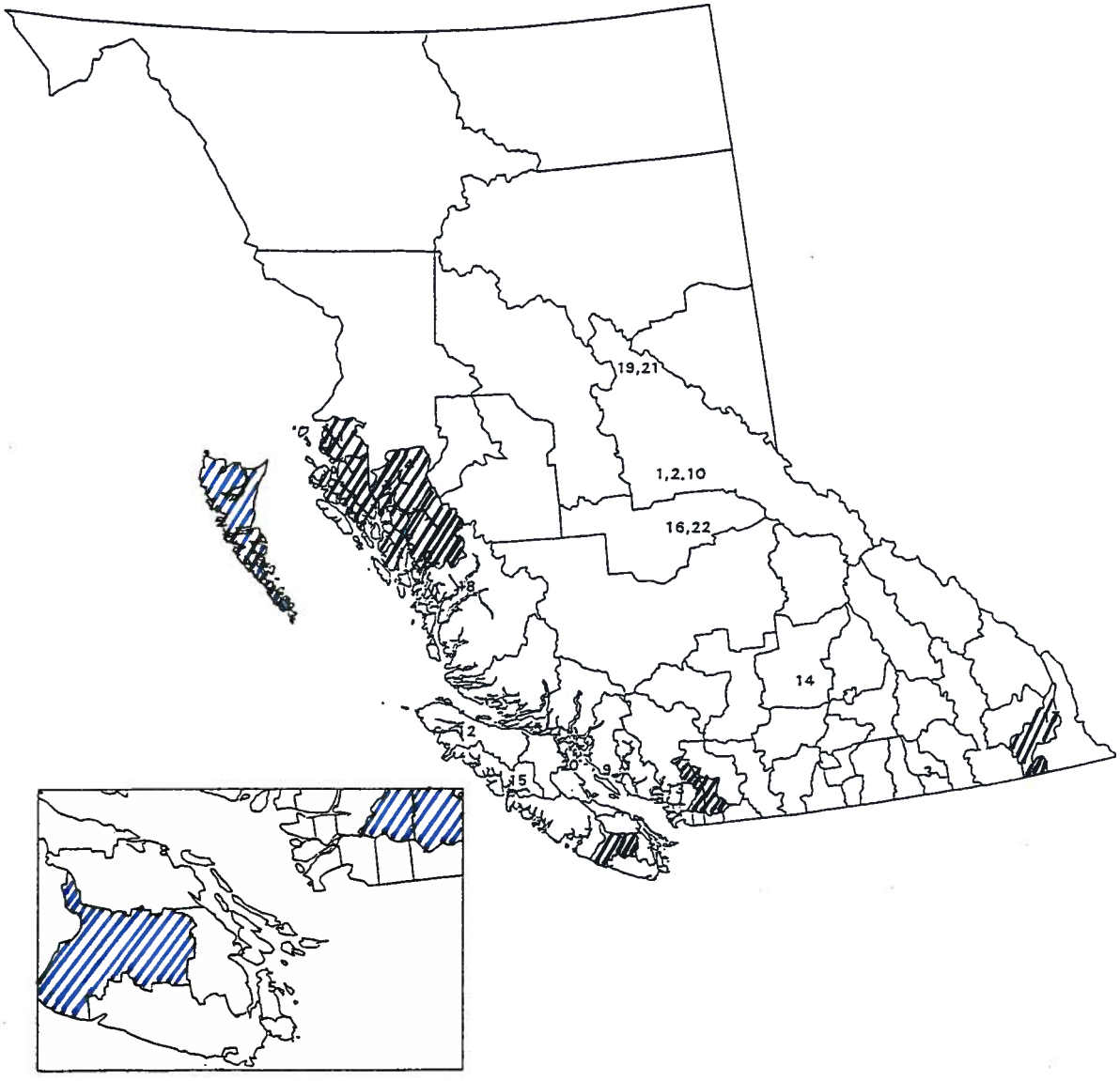
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
22 Bladder	29 Lillooet	18	2	18	11.35	1.59	0.04	0.019
	30 S Cariboo	9	0	10	4.09	2.45	0.02	
	72 Campbell River	21	0	32	13.53	2.36	0.04	
	75 Mission	23	0	31	15.45	2.01	0.04	
	84 Van Isl West	22	1	34	14.38	2.36	0.04	
	85 Van Isl North	26	2	40	18.15	2.20	0.05	
	88 Terrace	15	0	15	8.84	1.70	0.04	



Map courtesy John Smith & MapInfo.

Table 6.23: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
23 Kidney	2 Cranbrook	11	0	12	6.10	1.97	0.05	0.069
	42 Maple Ridge	22	0	25	14.36	1.74	0.04	
	50 Queen Charlotte	14	2	14	8.21	1.71	0.04	
	52 Prince Rupert	13	1	13	7.06	1.84	0.03	
	66 Lake Cowichan	5	0	5	1.85	2.70	0.04	
	75 Mission	15	0	16	9.09	1.76	0.04	
	80 Kitimat	7	0	7	2.62	2.68	0.02	



Map courtesy John Smith & MapInfo.

Table 6.24: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
24 Brain	42 Maple Ridge	17	0	19	10.80	1.76	0.05	0.923

Table 6.25: Male General Results 1983–89

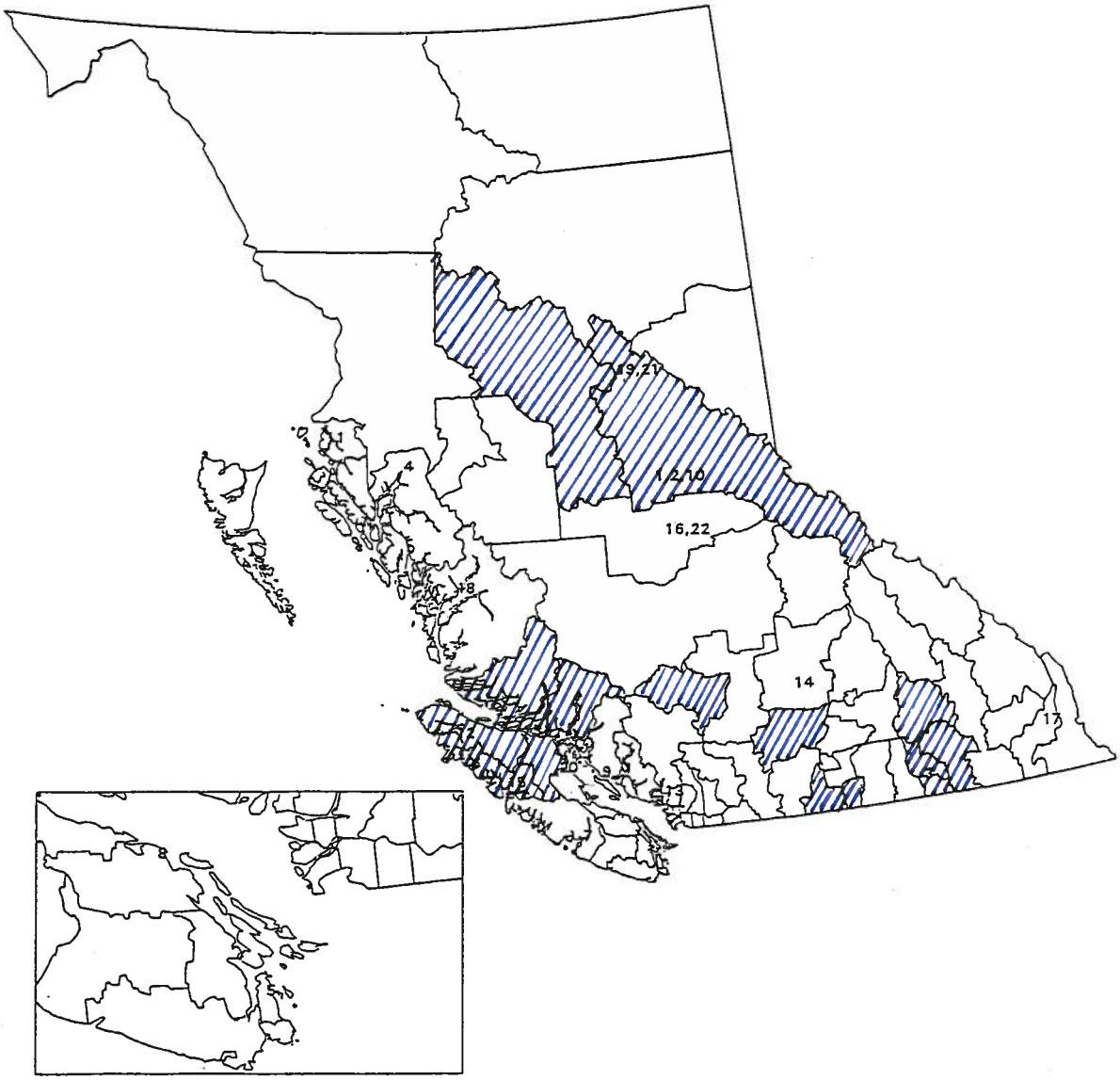
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
25 Hodgkins Disease	54 Smithers	5	0	5	1.42	3.52	0.02	0.813
	55 Burns Lake	8	2	9	3.71	2.43	0.04	

Table 6.26: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
26 Non-Hodgkins Lymphoma	2 Cranbrook	21	1	21	13.59	1.55	0.04	0.298
	3 Kimberley	21	1	21	13.59	1.55	0.04	
	42 Maple Ridge	29	0	33	20.49	1.61	0.04	
	45 W Vancouver	38	0	42	27.62	1.52	0.03	

Table 6.27: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
27 Multiple Myeloma	7 Nelson	17	2	18	10.37	1.74	0.04	0.002
	9 Castlegar	17	2	18	10.37	1.74	0.04	
	10 Arrow Lakes	10	1	10	5.00	2.00	0.03	
	11 Trail	17	2	18	10.37	1.74	0.04	
	14 S Okanagan	21	2	21	13.99	1.50	0.05	
	16 Keremeos	21	2	21	13.99	1.50	0.05	
	29 Lillooet	7	2	7	3.04	2.30	0.04	
	31 Merritt	5	0	6	1.29	4.66	0.01	
	56 Nechako	15	1	15	8.69	1.73	0.03	
	57 Prince George	15	1	15	8.69	1.73	0.03	
	72 Campbell River	8	0	8	3.60	2.22	0.03	
	84 Van Isl West	8	1	8	3.82	2.09	0.04	
	85 Van Isl North	10	2	10	4.79	2.09	0.02	



Map courtesy John Smith & MapInfo.

Table 6.28: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
28 Leukemia	49 Central Coast	9	1	9	4.69	1.92	0.05	0.136
	64 Gulf Islands	34	1	40	24.96	1.60	0.05	
	65 Cowichan	27	0	32	18.56	1.72	0.04	
	66 Lake Cowichan	29	1	34	20.57	1.65	0.05	
	69 Qualicum	21	0	25	13.68	1.83	0.04	
	85 Van Isl North	8	0	9	3.63	2.48	0.03	

Table 6.29: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
29 Acute Leukemia	29 Lillooet	6	2	6	2.59	2.32	0.05	0.681
	68 Nanaimo	19	1	21	11.73	1.79	0.03	
	69 Qualicum	7	0	9	3.24	2.78	0.05	

Table 6.30: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
30 Chronic Leukemia	64 Gulf Islands	27	1	34	18.36	1.85	0.03	0.465
	65 Cowichan	21	0	27	13.39	2.02	0.03	
	66 Lake Cowichan	22	1	29	14.80	1.96	0.05	
	85 Van Isl North	6	0	6	2.12	2.82	0.02	

Table 6.31: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
31 Other Sites	47 Powell River	15	0	15	9.12	1.64	0.05	0.733
	56 Nechako	10	0	11	5.20	2.12	0.04	

Table 6.32: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
32 Primary Unknown	50 Queen Charlotte	19	1	20	12.20	1.64	0.04	0.546
	52 Prince Rupert	16	0	17	9.73	1.75	0.04	

Table 6.36: Male General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
36 Colo-Rectal	76 Agassiz-Harrison	17	0	19	10.27	1.85	0.03	0.632

Table 7.2: Female Combined Year General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
2 Oral Cavity	70 Alberni	10	0	12	5.26	2.28	0.04	0.922

Table 7.3: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
3 Esophagus	28 Quesnel	10	2	10	5.42	1.84	0.05	0.501
	57 Prince George	7	0	7	2.85	2.46	0.03	
	64 Gulf Islands	16	2	16	9.62	1.66	0.04	
	65 Cowichan	16	2	16	9.62	1.66	0.04	

Table 7.4: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
4 Stomach	37 Delta	47	1	55	35.65	1.54	0.04	0.497
	38 Richmond	31	0	37	22.09	1.68	0.04	
	72 Campbell River	9	0	9	4.69	1.92	0.05	
	85 Van Isl North	11	2	12	5.99	2.00	0.04	

Table 7.5: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
5 Colon	13 Kettle Valley	7	0	7	2.95	2.37	0.03	0.454
	46 Sunshine Coast	33	0	40	23.70	1.69	0.04	

Table 7.6: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
6 Rectum	17 Princeton	6	0	9	2.59	3.48	0.05	0.694
	47 Powell River	18	0	18	10.93	1.65	0.03	

Table 7.8: Female General Results 1983–89

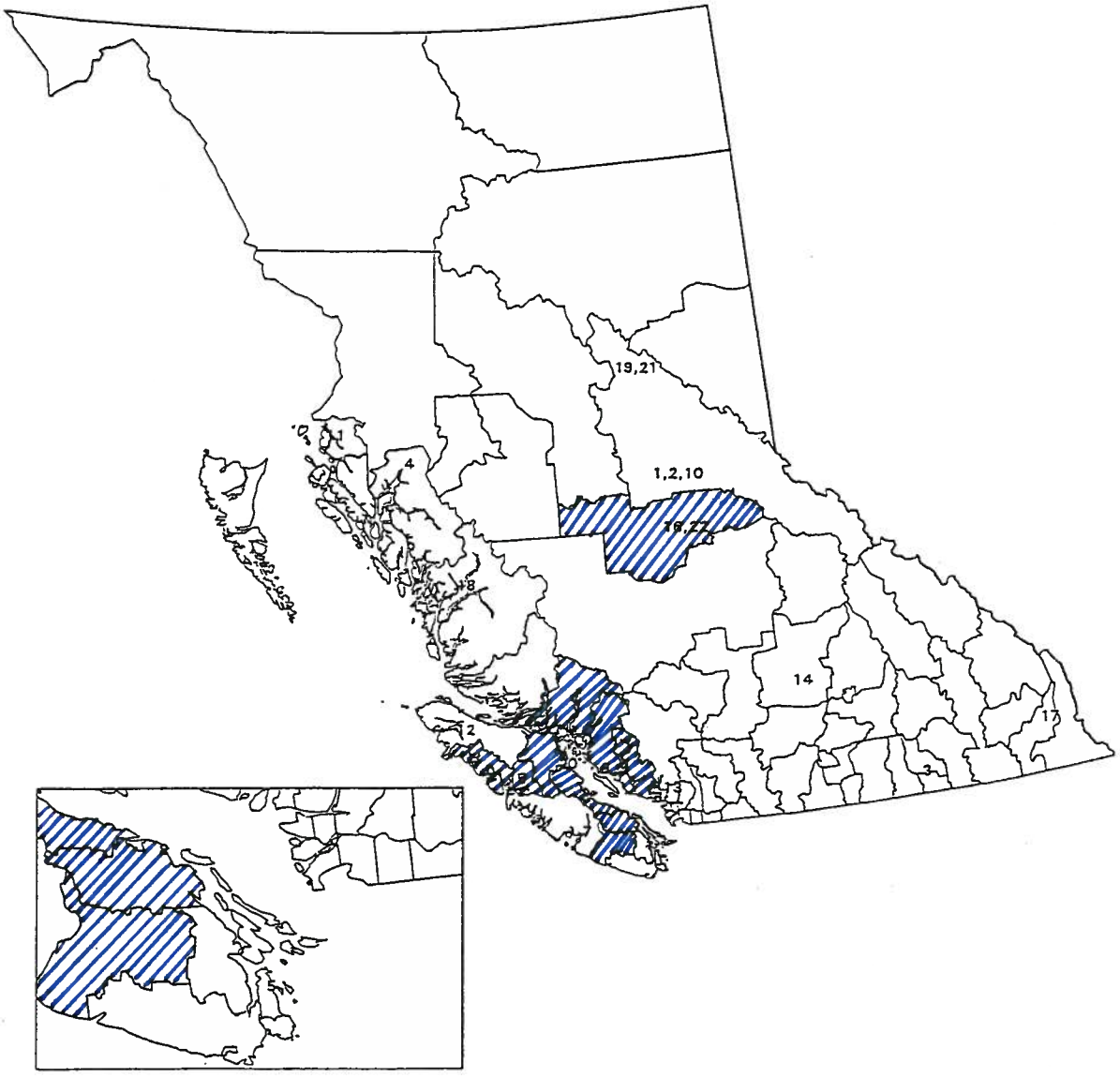
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
8 Pancreas	7 Nelson	24	2	28	16.40	1.71	0.05	0.186
	9 Castlegar	16	1	20	9.95	2.01	0.05	
	11 Trail	12	0	17	6.83	2.49	0.05	
	12 Grand Forks	17	2	18	10.31	1.75	0.03	
	35 Langley	23	0	24	15.68	1.53	0.05	
	65 Cowichan	19	0	20	12.25	1.63	0.04	

Table 7.9: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
9 Larynx	61 Greater Victoria	16	0	17	9.37	1.81	0.03	0.538
	62 Sooke	17	1	18	10.57	1.70	0.04	
	66 Lake Cowichan	5	1	6	1.77	3.39	0.03	

Table 7.10: Female General Results 1983–89

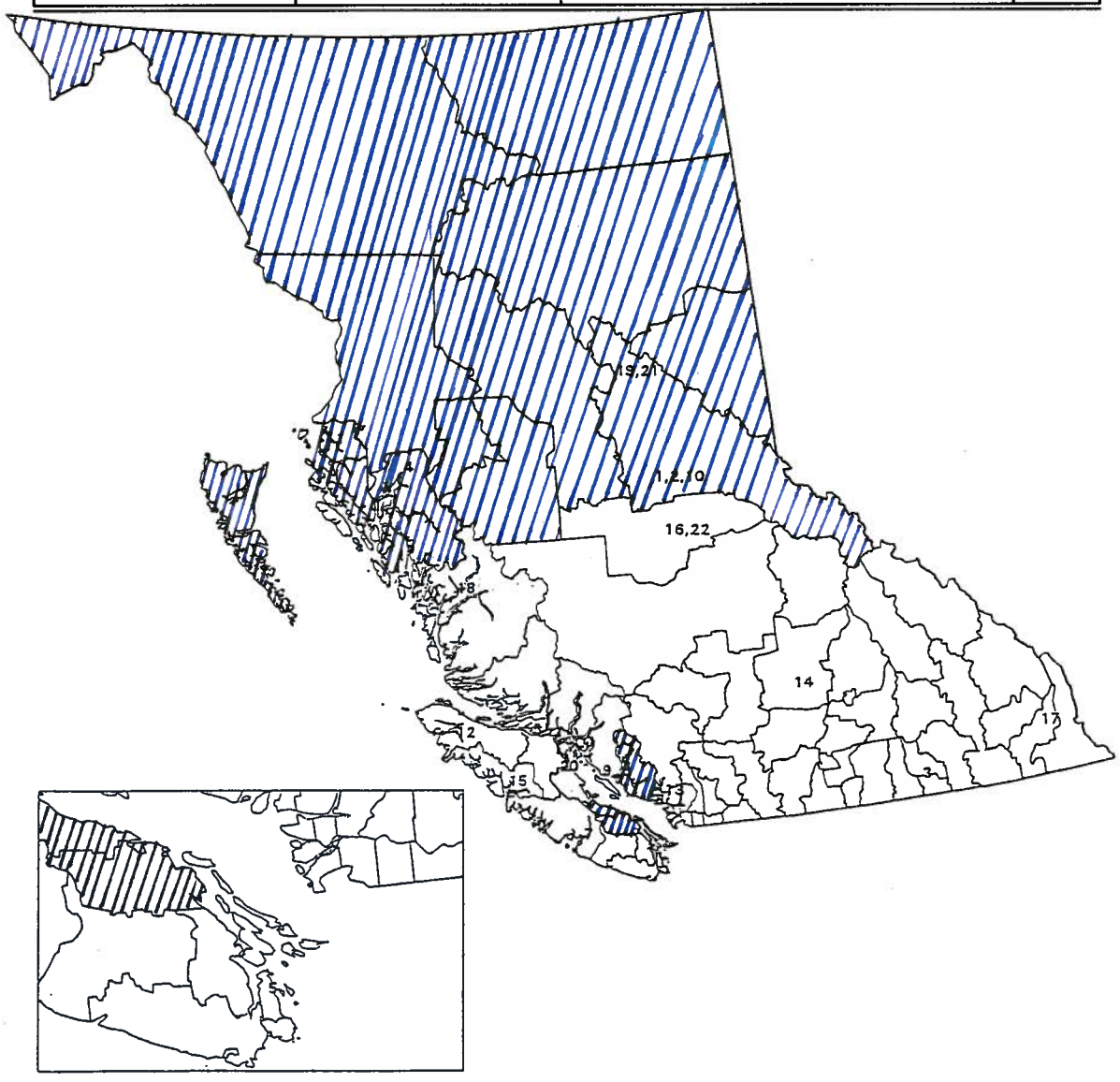
Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
10 Lung Squamous	28 Quesnel	7	0	7	3.24	2.16	0.05	0.044
	46 Sunshine Coast	33	1	46	23.92	1.92	0.05	
	47 Powell River	21	1	25	13.60	1.84	0.04	
	66 Lake Cowichan	40	2	48	30.00	1.60	0.05	
	68 Nanaimo	27	0	37	18.32	2.02	0.03	
	69 Qualicum	37	1	44	27.01	1.63	0.04	
	71 Courtenay	15	0	18	9.05	1.99	0.04	
	72 Campbell River	21	1	27	13.99	1.93	0.05	
	84 Van Isl West	22	2	27	14.19	1.90	0.03	



Map courtesy John Smith & MapInfo.

Table 7.11: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
11 Lung	46 Sunshine Coast	5	3	5	1.96	2.55	0.05	0.003
Adenosquamous	52 Prince Rupert	5	14	5	1.72	2.90	0.03	
	54 Smithers	5	10	5	1.30	3.84	0.01	
	55 Burns Lake	5	9	5	1.39	3.59	0.01	
	56 Nechako	5	8	5	1.28	3.90	0.01	
	57 Prince George	5	6	5	1.28	3.89	0.01	
	59 Peace River S	5	7	5	1.30	3.84	0.01	
	60 Peace River N	5	8	5	1.38	3.63	0.01	
	68 Nanaimo	5	2	5	1.33	3.77	0.01	
	69 Qualicum	5	3	5	1.60	3.13	0.02	
	80 Kitimat	5	11	5	1.47	3.39	0.02	
	81 Fort Nelson	5	9	5	1.19	4.21	0.01	
	87 Stikine	5	11	5	1.32	3.79	0.01	
	88 Terrace	5	11	5	1.47	3.39	0.02	



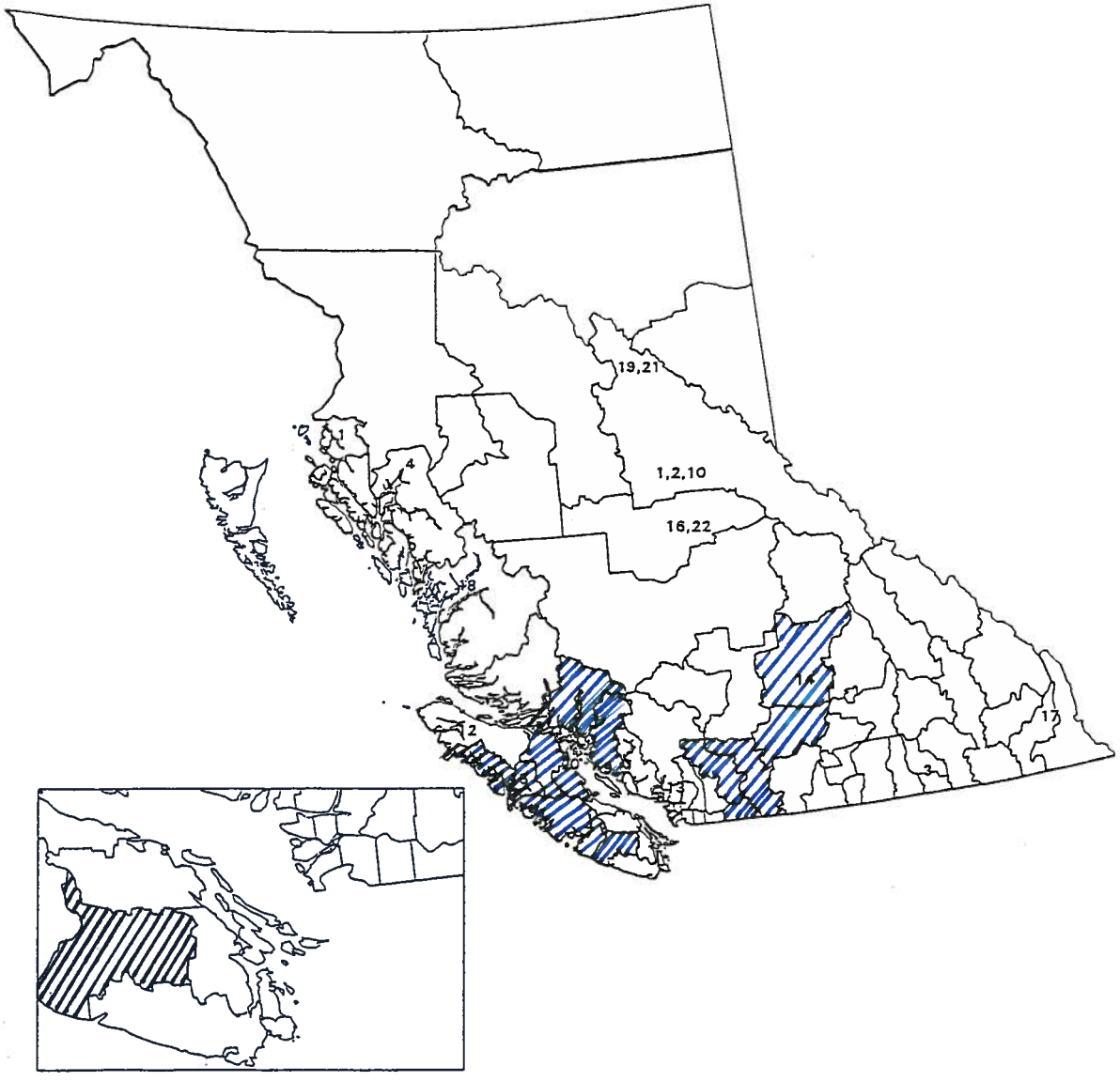
Map courtesy John Smith & Mapinfo.

Table 7.12: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
12 Lung	24 Kamloops	37	0	42	27.04	1.55	0.04	0.521
Adenocarcinoma	26 N Thompson	38	1	43	28.37	1.52	0.05	
	27 Cariboo-Chilcotin	17	0	18	10.24	1.76	0.03	

Table 7.13: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
13 Lung Small Cell	24 Kamloops	22	1	22	14.28	1.54	0.03	0.014
	31 Merritt	22	1	22	14.28	1.54	0.03	
	32 Hope	22	2	22	14.37	1.53	0.04	
	33 Chilliwack	19	0	19	11.79	1.61	0.03	
	47 Powell River	19	1	23	12.32	1.87	0.05	
	66 Lake Cowichan	17	1	17	10.52	1.62	0.04	
	70 Alberni	30	2	33	21.54	1.53	0.05	
	71 Courtenay	14	0	15	8.28	1.81	0.04	
	72 Campbell River	20	1	21	12.90	1.63	0.04	
	76 Agassiz-Harrison	22	2	22	14.37	1.53	0.04	
	84 Van Isl West	20	2	22	13.10	1.68	0.05	



Map courtesy John Smith & MapInfo.

Table 7.14: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
14 Lung Others	28 Quesnel	10	0	11	4.73	2.33	0.02	0.162
	40 New Westminster	33	0	36	23.97	1.50	0.05	
	46 Sunshine Coast	14	0	14	8.32	1.68	0.04	
	59 Peace River S	10	0	11	5.35	2.06	0.05	
	60 Peace River N	16	1	16	9.33	1.72	0.03	
	81 Fort Nelson	16	2	16	9.71	1.65	0.04	

Table 7.18: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
18 Melanoma	3 Kimberley	8	0	8	3.75	2.13	0.04	0.113
	35 Langley	39	0	44	28.50	1.54	0.04	
	45 W Vancouver	32	0	41	22.48	1.82	0.03	
	48 Howe Sound	38	1	45	27.91	1.61	0.04	
	64 Gulf Islands	32	1	36	22.83	1.58	0.04	
	65 Cowichan	26	0	27	17.82	1.52	0.04	

Table 7.22: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
22 Bladder	17 Princeton	5	1	6	1.93	3.11	0.05	0.673
	45 W Vancouver	21	0	23	13.67	1.68	0.04	
	48 Howe Sound	23	1	23	15.14	1.52	0.04	

Table 7.23: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
23 Kidney	18 Golden	5	1	5	1.96	2.55	0.05	0.649
	33 Chilliwack	24	2	24	15.75	1.52	0.03	
	50 Queen Charlotte	6	1	7	2.57	2.73	0.05	

Table 7.24: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
24 Brain	9 Castlegar	5	0	5	1.95	2.56	0.05	0.103
	11 Trail	11	1	12	5.82	2.06	0.04	
	44 N Vancouver	26	0	31	17.63	1.76	0.04	
	45 W Vancouver	15	0	15	9.16	1.64	0.05	
	46 Sunshine Coast	35	2	38	25.03	1.52	0.03	
	48 Howe Sound	39	2	48	28.75	1.67	0.04	
	65 Cowichan	13	0	13	7.31	1.78	0.04	
	66 Lake Cowichan	29	2	31	20.51	1.51	0.04	

Table 7.25: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
25 Hodgkins Disease	37 Delta	21	1	22	14.05	1.57	0.05	0.652
	38 Richmond	21	1	22	14.05	1.57	0.05	
	43 Coquitlam	15	0	15	8.87	1.69	0.04	

Table 7.26: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
26 Non-Hodgkins Lymphoma	19 Revelstoke	6	0	6	2.42	2.47	0.04	0.258
	32 Hope	6	0	7	2.57	2.73	0.05	
	54 Smithers	14	1	15	7.83	1.92	0.03	
	66 Lake Cowichan	5	0	5	1.68	2.98	0.03	
	88 Terrace	10	0	10	4.94	2.02	0.03	

Table 7.27: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
27 Multiple Myeloma	14 S Okanagan	17	2	20	10.50	1.90	0.04	0.104
	15 Penticton	12	0	15	6.57	2.28	0.04	
	16 Keremeos	17	2	20	10.50	1.90	0.04	
	34 Abbotsford	29	2	32	20.30	1.58	0.04	
	35 Langley	13	0	14	7.64	1.83	0.05	
	56 Nechako	11	1	12	5.68	2.11	0.03	
	57 Prince George	11	1	12	5.68	2.11	0.03	
	77 Summerland	15	1	16	8.62	1.86	0.03	

Table 7.28: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
28 Leukemia	14 S Okanagan	27	2	30	18.86	1.59	0.05	0.283
	15 Penticton	19	0	21	11.91	1.76	0.04	
	16 Keremeos	27	2	30	18.86	1.59	0.05	
	64 Gulf Islands	24	1	25	15.94	1.57	0.04	
	65 Cowichan	24	1	25	15.94	1.57	0.04	

Table 7.29: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
29 Acute Leukemia	72 Campbell River	6	0	7	2.37	2.95	0.03	0.799
	84 Van Isl West	7	1	7	2.64	2.65	0.02	

Table 7.30: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
30 Chronic Leukemia	14 S Okanagan	21	2	23	13.67	1.68	0.04	0.073
	15 Penticton	15	0	16	8.62	1.86	0.03	
	16 Keremeos	21	2	23	13.67	1.68	0.04	
	34 Abbotsford	21	0	23	13.48	1.71	0.03	
	64 Gulf Islands	18	1	18	11.07	1.63	0.03	
	65 Cowichan	14	0	15	8.22	1.83	0.04	
	66 Lake Cowichan	15	1	15	8.98	1.67	0.04	
	75 Mission	26	1	29	17.85	1.63	0.04	

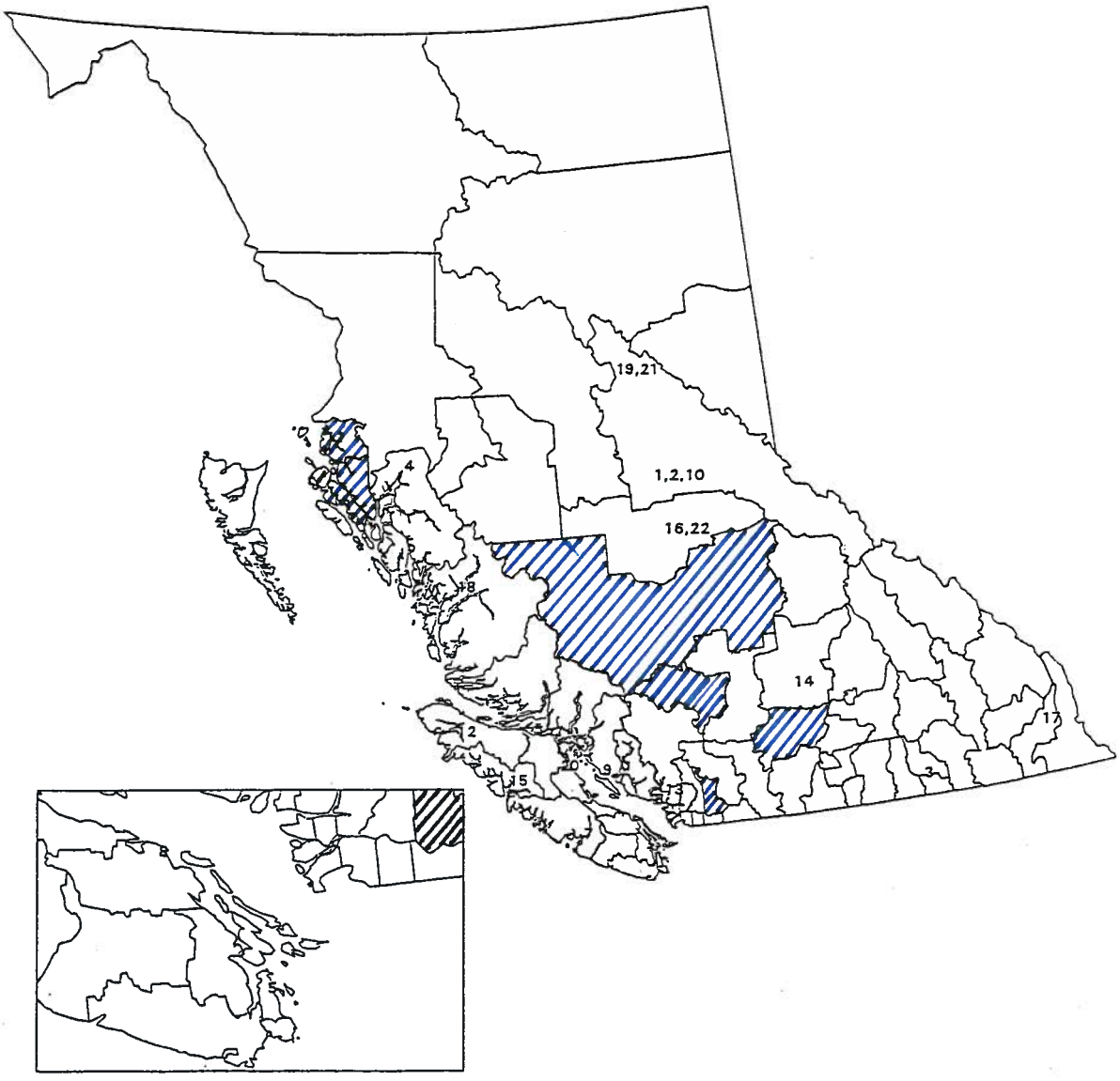
Map courtesy John Smith & MapInfo.

Table 7.31: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
31 Other Sites	12 Grand Forks	10	0	12	5.10	2.35	0.04	0.655
	13 Kettle Valley	12	1	15	6.72	2.23	0.04	

Table 7.32: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
32 Primary Unknown	27 Cariboo-Chilcotin	22	0	22	14.08	1.56	0.03	0.088
	29 Lillooet	17	2	17	10.31	1.65	0.03	
	31 Merritt	9	0	11	4.56	2.41	0.04	
	52 Prince Rupert	12	0	12	6.73	1.78	0.04	
	75 Mission	23	0	24	15.48	1.55	0.04	



Map courtesy John Smith & MapInfo.

Table 7.34: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
34 Ovary	86 Creston-Kaslo	16	0	17	9.91	1.72	0.05	0.895

Table 7.35: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
35 Cervix	17 Princeton	5	0	5	1.65	3.03	0.03	0.535
	28 Quesnel	13	0	16	7.17	2.23	0.03	
	49 Central Coast	13	2	13	7.29	1.78	0.04	

Table 7.36: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
36 Colo-Rectal	17 Princeton	13	0	16	7.30	2.19	0.04	0.314
	46 Sunshine Coast	48	0	56	36.50	1.53	0.04	

Table 7.39: Female General Results 1983–89

Site	School District	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
39 Endometrium	45 W Vancouver	57	0	75	44.75	1.68	0.04	0.221
	48 Howe Sound	64	1	80	51.20	1.56	0.05	
	64 Gulf Islands	19	0	22	11.78	1.87	0.03	
	77 Summerland	16	0	16	9.91	1.61	0.05	

Table 8: Combined Year Male Focused Results by Site 1983–89

Site	Mill Location	NSD	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
1 Lip	Quesnel	28	9	2	9	4.59	1.96	0.04	0.303
	Skookumchuck	3	8	2	9	3.56	2.53	0.03	
2 Oral Cavity	Castlegar	9	10	1	14	4.78	2.93	0.02	0.446
3 Esophagus	Quesnel	28	13	2	15	7.65	1.96	0.05	0.605
4 Stomach	Port Alberni	70	19	1	22	12.37	1.78	0.05	0.001
	Prince Rupert	52	14	2	14	7.86	1.78	0.03	
	Port Alice	85	7	1	7	2.96	2.37	0.03	
	Ocean Falls	49	8	2	8	3.76	2.13	0.04	
	Campbell River	72	17	1	17	10.37	1.64	0.04	
8 Pancreas	Prince George	57	21	1	21	13.32	1.58	0.03	0.070
	Crofton	65	22	1	28	14.76	1.90	0.05	
	MacKenzie	57	21	1	21	13.32	1.58	0.03	
9 Larynx	Prince George	57	18	1	18	11.57	1.56	0.05	0.234
	MacKenzie	57	18	1	18	11.57	1.56	0.05	
10 Lung Squamous	Squamish	48	13	1	13	7.61	1.71	0.05	0.017
	Gold River	84	27	2	30	18.62	1.61	0.04	
	Campbell River	72	26	1	29	17.59	1.65	0.04	
11 Lung Adenosquamous	Nanaimo	68	5	1	6	1.92	3.13	0.05	0.386
13 Lung Small Cell	Nanaimo	68	37	1	44	27.03	1.63	0.04	0.466
14 Lung Others	Prince George	57	40	1	51	29.86	1.71	0.04	0.011
	Prince Rupert	52	18	2	19	11.23	1.69	0.04	
	MacKenzie	57	40	1	51	29.86	1.71	0.04	
20 Prostate	Prince George	57	134	1	178	115.13	1.55	0.05	0.001
	MacKenzie	57	134	1	178	115.13	1.55	0.05	
21 Testis	Powell River	47	15	2	17	9.19	1.85	0.05	0.242
	Port Alice	85	7	1	8	2.95	2.71	0.03	
22 Bladder	Gold River	84	22	2	34	14.38	2.36	0.04	0.096
	Campbell River	72	21	1	32	13.53	2.36	0.04	
23 Kidney	Kitimat	80	7	1	7	2.62	2.68	0.02	0.048
	Prince Rupert	52	13	2	13	7.06	1.84	0.03	
	Ocean Falls	49	8	2	9	3.51	2.56	0.03	
27 Multiple Myeloma	Prince George	57	15	2	15	8.69	1.73	0.03	0.044
	Gold River	84	8	2	8	3.82	2.09	0.04	
	MacKenzie	57	15	2	15	8.69	1.73	0.03	
	Campbell River	72	8	1	8	3.60	2.22	0.03	
28 Leukemia	Crofton	65	27	1	32	18.56	1.72	0.04	0.143
	Port Alice	85	8	1	9	3.63	2.48	0.03	
29 Acute Leukemia	Nanaimo	68	19	2	21	11.73	1.79	0.03	0.541
30 Chronic Leukemia	Crofton	65	21	1	27	13.39	2.02	0.03	0.183
	Port Alice	85	6	1	6	2.12	2.82	0.02	
31 Other Sites	Powell River	47	15	1	15	9.12	1.64	0.05	0.413
32 Primary Unknown	Prince Rupert	52	16	1	17	9.73	1.75	0.04	0.318

Table 9: Combined Year Female Focused Results by Site 1983–89

Site	Mill Location	NSD	k	ℓ	O	λ	O/λ	p	$\mathcal{P}$
2 Oral Cavity	Port Alberni	70	10	1	12	5.26	2.28	0.04	0.575
3 Esophagus	Prince George	57	7	1	7	2.85	2.46	0.03	0.266
	MacKenzie	57	7	1	7	2.85	2.46	0.03	
4 Stomach	Campbell River	72	9	1	9	4.69	1.92	0.05	0.585
5 Colon	Port Mellon	46	33	1	40	23.70	1.69	0.04	0.226
6 Rectum	Powell River	47	18	1	18	10.93	1.65	0.03	0.361
8 Pancreas	Castlegar	9	16	2	20	9.95	2.01	0.05	0.201
	Crofton	65	19	1	20	12.25	1.63	0.04	
10 Lung Squamous	Nanaimo	68	27	1	37	18.32	2.02	0.03	0.027
	Powell River	47	21	2	25	13.60	1.84	0.04	
	Quesnel	28	7	1	7	3.24	2.16	0.05	
	Campbell River	72	21	2	27	13.99	1.93	0.05	
11 Lung Adenosquamous	Prince George	57	5	7	5	1.28	3.89	0.01	0.019
	Kitimat	80	5	12	5	1.47	3.39	0.02	
	Nanaimo	68	5	3	5	1.33	3.77	0.01	
	Prince Rupert	52	5	15	5	1.72	2.90	0.03	
	MacKenzie	57	5	9	5	1.49	3.35	0.02	
12 Lung Adenocarcinoma	Kamloops	24	37	1	42	27.04	1.55	0.04	0.433
13 Lung Small Cell	Powell River	47	19	2	23	12.32	1.87	0.05	0.100
	Kamloops	24	22	2	22	14.28	1.54	0.03	
	Campbell River	72	20	2	21	12.90	1.63	0.04	
14 Lung Others	Port Mellon	46	14	1	14	8.32	1.68	0.04	0.148
	Quesnel	28	10	1	11	4.73	2.33	0.02	
18 Melanoma	Crofton	65	26	1	27	17.82	1.52	0.04	0.052
	Port Mellon	46	41	2	51	30.60	1.67	0.04	
	Squamish	48	38	2	45	27.91	1.61	0.04	
22 Bladder	Port Mellon	46	26	2	29	18.09	1.60	0.05	0.262
	Squamish	48	23	2	23	15.14	1.52	0.04	
24 Brain	Castlegar	9	5	1	5	1.95	2.56	0.05	0.125
	Crofton	65	13	1	13	7.31	1.78	0.04	
	Port Mellon	46	20	2	20	12.64	1.58	0.03	
27 Multiple Myeloma	Prince George	57	11	2	12	5.68	2.11	0.03	0.291
	MacKenzie	57	11	2	12	5.68	2.11	0.03	
28 Leukemia	Crofton	65	24	2	25	15.94	1.57	0.04	0.497
29 Acute Leukemia	Gold River	84	7	2	7	2.64	2.65	0.02	0.256
	Campbell River	72	6	1	7	2.37	2.95	0.03	
30 Chronic Leukemia	Crofton	65	14	1	15	8.22	1.83	0.04	0.503
32 Primary Unknown	Prince Rupert	52	12	1	12	6.73	1.78	0.04	0.355
35 Cervix	Quesnel	28	13	1	16	7.17	2.23	0.03	0.448
36 Colo-Rectal	Port Mellon	46	48	1	56	36.50	1.53	0.04	0.137
39 Endometrium	Port Mellon	46	75	2	94	61.02	1.54	0.05	0.099
	Squamish	48	64	2	80	51.20	1.56	0.05	

Table 10.1: Male General Yearly Results Site 1 Lip 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
12 Grand Forks	k	3	3	2	2	3	3	3	0.01
	ℓ	5	10	0	0	5	5	5	
	O/λ	1.88	0.56	8.95*	10.64*	2.34	2.03	2.12	
13 Kettle Valley	k	3	3	2	2	3	3	3	0.03
	ℓ	5	10	1	1	5	5	5	
	O/λ	1.88	0.56	6.46*	7.75*	2.34	2.03	2.12	
24 Kamloops	k	4	4	5	4	4	4	4	0.12
	ℓ	2	1	6	3	6	11	6	
	O/λ	2.93*	3.04*	0.80	2.52	0.99	1.33	1.14	
30 S Cariboo	k	4	2	5	4	4	4	4	0.04
	ℓ	2	0	11	5	11	11	10	
	O/λ	3.11*	15.30*	0.97	2.38	1.08	0.97	1.54	
32 Hope	k	4	4	5	4	4	3	3	0.01
	ℓ	6	4	5	2	4	2	7	
	O/λ	1.14	2.22	2.01	3.50*	3.06*	3.68*	1.23	
33 Chilliwack	k	5	5	5	4	4	3	4	0.00
	ℓ	6	3	3	0	2	1	6	
	O/λ	1.36	1.79	2.18	4.39*	3.49*	4.11*	1.26	
59 Peace River S	k	2	2	5	4	4	4	4	0.08
	ℓ	0	0	7	13	16	19	13	
	O/λ	6.13*	8.68*	2.05	1.02	1.09	1.07	1.38	
60 Peace River N	k	3	3	5	4	4	4	4	0.05
	ℓ	1	1	8	16	18	19	16	
	O/λ	5.12*	4.81*	1.94	0.96	1.06	1.06	1.30	
76 Agassiz-Harrison	k	4	4	5	4	4	3	3	0.01
	ℓ	5	4	4	1	3	1	6	
	O/λ	1.17	1.70	2.08	3.96*	3.21*	4.11*	1.26	
81 Fort Nelson	k	3	3	3	3	3	3	3	0.06
	ℓ	2	2	7	15	12	12	14	
	O/λ	4.83*	4.54*	1.35	0.97	1.33	1.33	1.32	
86 Creston-Kaslo	k	4	4	4	3	4	3	3	0.01
	ℓ	8	15	8	0	2	12	11	
	O/λ	1.66	0.67	1.41	10.51*	4.80*	1.92	1.54	

Table 10.2: Male General Yearly Results Site 2 Oral Cavity 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
9 Castlegar	k	3	8	7	7	7	3	3	0.12
	ℓ	0	11	11	10	10	0	0	
	O/λ	4.49*	0.65	0.72	0.72	0.98	3.73*	4.31*	
38 Richmond	k	46	49	44	45	46	57	51	0.00
	ℓ	2	2	2	3	2	3	2	
	O/λ	1.79*	1.66*	1.40*	1.41	1.36*	1.09	1.55*	
39 Vancouver	k	36	38	35	34	36	63	39	0.00
	ℓ	0	0	0	0	0	5	0	
	O/λ	1.98*	2.06*	1.60*	1.36*	1.48*	1.10	1.72*	
40 New Westminster	k	24	25	23	6	6	7	19	0.03
	ℓ	4	4	4	0	0	0	1	
	O/λ	1.45	1.46	1.05	3.00*	2.36*	3.88*	1.62*	
41 Burnaby	k	49	51	47	14	49	59	19	0.00
	ℓ	2	2	4	0	2	2	1	
	O/λ	1.67*	1.64*	1.15	1.84*	1.33*	1.30*	1.62*	
44 N Vancouver	k	43	45	41	44	42	56	46	0.00
	ℓ	1	1	1	3	1	4	1	
	O/λ	1.84*	1.92*	1.52*	1.36	1.32*	1.10	1.48*	
45 W Vancouver	k	46	48	44	44	46	56	50	0.01
	ℓ	2	2	2	3	3	4	2	
	O/λ	1.71*	1.81*	1.45*	1.36	1.12	0.96	1.37*	
52 Prince Rupert	k	6	4	3	6	6	7	6	0.38
	ℓ	10	1	0	10	9	13	9	
	O/λ	0.70	3.15*	4.41*	0.71	0.82	0.59	0.99	

Table 10.3: Male General Yearly Results Site 3 Esophagus 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
26 N Thompson	k	7	2	7	7	5	7	2	0.00
	ℓ	13	0	5	10	1	7	0	
	O/λ	0.85	23.65*	1.75	0.78	2.63*	1.44	28.10*	
27 Cariboo-Chilcotin	k	4	4	4	4	4	3	4	0.00
	ℓ	4	2	4	6	5	0	2	
	O/λ	2.85	3.65*	2.59	1.03	1.75	4.31*	4.30*	
39 Vancouver	k	28	20	29	26	31	30	27	0.03
	ℓ	4	0	8	1	5	3	8	
	O/λ	1.25	1.83*	0.97	1.47*	1.12	1.30	0.97	

Table 10.4: Male General Yearly Results Site 4 Stomach 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
50 Queen Charlotte	k	5	4	5	4	4	4	4	0.04
	ℓ	6	10	4	2	1	7	4	
	O/λ	1.42	0.72	1.60	3.06*	4.66*	1.13	1.41	
52 Prince Rupert	k	6	6	6	4	3	6	6	0.09
	ℓ	8	10	6	1	0	9	9	
	O/λ	1.29	0.76	1.63	3.59*	4.38*	0.85	1.20	
85 Van Isl North	k	6	5	6	5	5	6	6	0.13
	ℓ	5	3	4	2	2	5	3	
	O/λ	1.11	1.38	1.16	2.61*	2.64*	1.14	1.22	

Table 10.6: Male General Yearly Results Site 6 Rectum 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	20	25	26	27	27	18	19	0.33
	ℓ	4	4	4	3	4	1	1	
	O/λ	0.88	1.02	1.07	1.21	0.93	1.67*	1.66*	
59 Peace River S	k	12	5	15	15	15	14	15	0.24
	ℓ	7	0	2	7	7	8	12	
	O/λ	1.28	2.62*	1.84*	0.94	1.19	0.90	0.78	
66 Lake Cowichan	k	17	21	22	23	23	22	23	0.16
	ℓ	6	5	5	3	5	2	2	
	O/λ	0.90	1.17	0.86	1.40	1.04	1.61*	1.65*	
68 Nanaimo	k	18	22	23	15	24	15	15	0.08
	ℓ	7	5	6	0	5	0	0	
	O/λ	0.82	1.01	0.94	1.66*	1.12	1.97*	1.75*	
72 Campbell River	k	13	15	16	16	16	6	13	0.14
	ℓ	5	5	5	4	6	0	1	
	O/λ	1.13	1.09	0.96	1.32	0.99	2.74*	1.78*	
84 Van Isl West	k	10	12	13	13	13	7	13	0.07
	ℓ	3	4	4	3	6	1	2	
	O/λ	1.31	1.02	1.05	1.23	0.78	2.94*	1.87*	
86 Creston-Kaslo	k	5	6	13	13	13	12	13	0.42
	ℓ	0	0	11	8	11	9	7	
	O/λ	2.57*	2.48*	0.77	1.01	0.71	0.78	1.03	

Table 10.7: Male General Yearly Results Site 7 Liver 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
38 Richmond	k	5	16	18	22	20	22	22	0.00
	ℓ	0	3	2	3	2	3	2	
	O/λ	3.39*	1.62	1.78*	1.40	1.69*	1.49	1.90*	
39 Vancouver	k	15	14	15	25	17	18	18	0.00
	ℓ	0	0	0	4	0	0	0	
	O/λ	1.67*	1.77*	2.21*	1.31	1.99*	1.58*	2.21*	
40 New Westminster	k	10	9	10	12	11	9	4	0.07
	ℓ	4	3	3	3	3	1	0	
	O/λ	1.25	1.29	1.23	1.43	1.38	1.95*	3.53*	
41 Burnaby	k	20	18	19	23	22	9	23	0.00
	ℓ	2	2	2	2	2	1	2	
	O/λ	1.68*	1.81*	1.90*	1.53*	1.70*	1.95*	2.08*	
44 N Vancouver	k	18	16	17	22	19	21	20	0.00
	ℓ	3	1	1	3	1	1	1	
	O/λ	1.56	1.73*	1.96*	1.29	2.02*	1.57*	1.86*	
45 W Vancouver	k	18	17	18	22	20	22	22	0.00
	ℓ	3	3	2	3	2	2	2	
	O/λ	1.56	1.69	1.97*	1.29	1.85*	1.57*	1.83*	

Table 10.9: Male General Yearly Results Site 9 Larynx 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
43 Coquitlam	k	17	15	13	9	9	17	15	0.26
	ℓ	3	6	4	1	1	3	6	
	O/λ	1.36	0.79	0.95	2.19*	2.15*	1.08	0.94	

Table 10.10: Male General Yearly Results Site 10 Lung Squamous 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
32 Hope	k	14	14	15	14	14	13	13	0.11
	ℓ	4	5	5	6	3	2	3	
	O/λ	1.29	0.70	0.78	0.77	1.69*	1.70*	1.60	
33 Chilliwack	k	17	17	17	16	12	12	16	0.43
	ℓ	4	5	5	5	1	1	3	
	O/λ	0.91	0.84	0.82	0.79	1.75*	1.76*	0.92	
47 Powell River	k	16	16	16	12	12	15	15	0.08
	ℓ	3	4	3	1	1	3	3	
	O/λ	1.17	1.09	1.62	1.92*	1.95*	1.26	1.59	
71 Courtenay	k	16	16	16	9	9	15	15	0.09
	ℓ	4	4	3	0	0	3	4	
	O/λ	1.02	1.09	1.28	2.43*	2.01*	1.26	1.44	
72 Campbell River	k	16	16	16	13	13	15	15	0.07
	ℓ	5	5	4	1	1	4	5	
	O/λ	1.01	1.13	1.27	2.28*	1.87*	1.25	1.42	
76 Agassiz-Harrison	k	14	14	15	14	12	12	13	0.33
	ℓ	3	4	5	5	1	1	4	
	O/λ	1.27	0.72	0.82	0.79	1.75*	1.76*	0.94	
84 Van Isl West	k	13	13	14	13	13	13	12	0.06
	ℓ	6	3	3	2	2	4	5	
	O/λ	0.97	1.23	1.28	2.24*	1.83*	1.25	1.06	

Table 10.11: Male General Yearly Results Site 11 Lung Adenosquamous 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
47 Powell River	k	3	3	2	2	2	2	2	0.05
	ℓ	3	6	12	6	6	6	13	
	O/λ	5.25*	1.75	1.06	2.09	2.10	4.53	1.95	
66 Lake Cowichan	k	3	4	2	3	3	2	2	0.06
	ℓ	8	9	12	5	4	2	15	
	O/λ	1.58	1.04	0.80	4.24	4.24*	8.70*	1.27	
68 Nanaimo	k	3	4	2	2	3	2	2	0.03
	ℓ	8	8	8	0	4	0	11	
	O/λ	0.96	1.02	1.13	6.69*	4.10*	9.51*	1.90	
69 Qualicum	k	2	4	2	3	3	2	2	0.04
	ℓ	0	10	10	10	7	1	12	
	O/λ	11.47*	1.02	1.12	0.93	2.82	6.24*	1.91	
70 Alberni	k	2	3	2	3	3	2	2	0.03
	ℓ	1	6	14	12	8	3	15	
	O/λ	6.49*	1.88	0.95	2.40	2.61	6.11	1.78	

Table 10.12: Male General Yearly Results Site 12 Lung Adenocarcinoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
31 Merritt	k	11	3	11	12	12	12	10	0.13
	ℓ	5	0	1	5	6	6	6	
	O/λ	1.45	4.35*	2.05*	1.44	1.15	1.45	0.89	
38 Richmond	k	12	13	64	68	65	70	59	0.16
	ℓ	0	0	3	4	3	3	3	
	O/λ	1.75*	2.46*	1.16	0.96	1.08	1.03	1.03	
43 Coquitlam	k	17	17	32	34	33	35	30	0.38
	ℓ	1	1	3	4	3	3	3	
	O/λ	1.69*	1.61*	1.10	0.92	1.06	1.02	1.25	
72 Campbell River	k	12	12	12	13	12	10	11	0.31
	ℓ	7	5	5	5	3	1	7	
	O/λ	0.94	1.08	1.16	1.32	1.74*	1.86*	0.97	

Table 10.13: Male General Yearly Results Site 13 Lung Small Cell 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
18 Golden	k	3	4	4	3	3	3	3	0.07
	ℓ	7	7	8	1	2	1	6	
	O/λ	0.49	0.65	0.70	5.65*	3.67*	6.66*	0.74	
55 Burns Lake	k	4	4	4	2	4	4	4	0.06
	ℓ	4	5	1	0	8	5	5	
	O/λ	2.01	1.08	4.85*	7.80*	0.67	0.75	1.35	
72 Campbell River	k	8	8	9	9	9	4	7	0.24
	ℓ	7	6	6	7	5	0	1	
	O/λ	0.96	1.00	0.94	0.98	1.38	2.97*	2.49*	

Table 10.14: Male General Yearly Results Site 14 Lung Others 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
18 Golden	k	4	3	5	5	5	5	5	0.16
	ℓ	1	0	6	4	4	4	4	
	O/λ	5.18*	6.61*	0.74	0.83	0.71	0.82	0.96	
24 Kamloops	k	12	14	13	12	12	12	14	0.36
	ℓ	5	5	5	5	0	0	3	
	O/λ	1.10	0.80	0.97	0.97	2.00*	1.74*	1.44	
28 Quesnel	k	13	15	14	13	15	15	15	0.04
	ℓ	11	8	5	3	2	8	2	
	O/λ	0.65	1.12	1.44	1.65	2.07*	1.35	1.71*	
29 Lillooet	k	5	6	5	3	5	6	6	0.19
	ℓ	3	3	2	0	3	3	3	
	O/λ	0.98	0.97	3.30*	8.44*	1.78	1.68	1.37	
30 S Cariboo	k	12	13	13	4	13	14	14	0.02
	ℓ	10	9	3	1	2	3	5	
	O/λ	0.99	0.73	1.68	4.22*	1.83*	1.68	1.36	
31 Merritt	k	12	13	3	12	13	14	4	0.01
	ℓ	6	6	0	6	1	1	0	
	O/λ	0.85	0.90	3.92*	0.83	1.91*	1.80*	4.75*	
36 Surrey	k	36	41	32	38	37	47	40	0.07
	ℓ	5	5	1	3	1	3	1	
	O/λ	0.86	0.93	1.46*	1.13	1.41*	1.06	1.36*	
40 New Westminster	k	36	41	10	10	43	46	13	0.11
	ℓ	4	3	0	0	3	3	0	
	O/λ	0.96	0.93	2.75*	2.04*	1.18	1.02	1.76*	
50 Queen Charlotte	k	5	6	2	2	5	6	6	0.06
	ℓ	7	8	0	0	3	8	4	
	O/λ	1.04	0.90	7.36*	8.49*	2.04	0.86	1.42	
56 Nechako	k	10	11	11	9	11	12	11	0.02
	ℓ	15	3	6	1	2	6	1	
	O/λ	0.59	1.44	1.24	2.50*	1.84*	1.09	1.97*	
57 Prince George	k	11	13	12	8	9	13	9	0.01
	ℓ	14	4	4	0	0	4	0	
	O/λ	0.68	1.29	1.26	2.80*	2.23*	1.21	1.96*	
59 Peace River S	k	12	5	13	12	14	14	14	0.01
	ℓ	11	0	7	2	4	5	2	
	O/λ	0.89	2.68*	1.25	2.21*	1.44	1.25	1.79*	
60 Peace River N	k	12	14	13	12	14	14	14	0.01
	ℓ	14	2	8	2	5	5	2	
	O/λ	0.91	1.81*	1.26	2.21*	1.42	1.25	1.79*	
80 Kitimat	k	7	7	7	6	7	3	7	0.13
	ℓ	8	8	8	5	2	0	7	
	O/λ	0.79	1.34	0.82	1.80	2.22*	5.04*	1.34	

Table 10.15: Male General Yearly Results Site 15 All Lungs 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
24 Kamloops	k	35	37	34	35	31	32	35	0.10
	ℓ	3	4	1	3	0	0	3	
	O/λ	1.01	0.83	1.41*	1.19	1.48*	1.55*	1.21	
26 N Thompson	k	47	50	50	48	32	33	47	0.11
	ℓ	5	7	5	3	1	1	5	
	O/λ	1.01	0.87	1.08	1.26	1.45*	1.52*	1.05	
29 Lillooet	k	12	13	12	5	12	12	11	0.10
	ℓ	3	3	2	0	3	3	2	
	O/λ	1.15	0.94	1.77*	3.60*	1.32	1.54	2.01*	
30 S Cariboo	k	33	36	35	34	35	36	33	0.09
	ℓ	5	5	3	3	2	2	5	
	O/λ	0.97	0.80	1.39	1.29	1.38*	1.48*	1.17	
31 Merritt	k	34	36	7	35	34	35	6	0.00
	ℓ	4	6	0	4	1	1	0	
	O/λ	1.16	0.99	2.42*	1.19	1.39*	1.61*	3.49*	
33 Chilliwack	k	39	42	41	40	41	30	41	0.49
	ℓ	3	3	3	3	2	0	3	
	O/λ	0.88	0.97	0.82	0.91	1.38*	1.44*	0.79	
36 Surrey	k	113	121	121	119	124	132	104	0.45
	ℓ	3	3	3	4	3	2	1	
	O/λ	1.15	1.08	1.01	0.87	1.09	1.17*	1.23*	
38 Richmond	k	38	264	258	246	260	278	269	0.56
	ℓ	0	2	3	3	3	3	3	
	O/λ	1.39*	1.17*	1.04	0.98	1.00	1.03	0.95	
39 Vancouver	k	202	211	297	283	299	320	310	0.52
	ℓ	0	0	4	4	4	4	5	
	O/λ	1.17*	1.20*	0.99	0.97	0.97	0.96	0.92	
40 New Westminster	k	26	120	26	114	121	129	125	0.15
	ℓ	0	2	0	3	3	3	3	
	O/λ	1.48*	1.17*	1.53*	0.82	0.99	1.03	1.01	
41 Burnaby	k	85	289	281	268	284	304	296	0.10
	ℓ	1	2	2	4	3	3	4	
	O/λ	1.26*	1.17*	1.11*	1.00	1.06	1.02	0.92	
42 Maple Ridge	k	71	76	20	20	77	82	77	0.55
	ℓ	3	3	0	0	3	3	3	
	O/λ	1.11	1.05	1.52*	1.65*	1.10	1.15	1.04	
43 Coquitlam	k	55	38	119	114	121	129	125	0.53
	ℓ	1	0	3	3	3	3	3	
	O/λ	1.33*	1.41*	1.00	0.82	0.99	1.03	1.01	
44 N Vancouver	k	233	245	260	247	262	281	273	0.56
	ℓ	1	1	3	3	3	3	4	
	O/λ	1.12*	1.12*	1.01	0.98	1.01	0.95	0.89	
47 Powell River	k	37	40	30	38	30	31	38	0.09
	ℓ	3	3	1	3	1	1	3	
	O/λ	1.14	1.01	1.40*	1.20	1.41*	1.45*	1.25	
71 Courtenay	k	37	40	30	38	22	22	38	0.05
	ℓ	4	3	1	3	0	0	3	
	O/λ	1.03	1.18	1.40*	1.24	1.55*	1.56*	1.15	
72 Campbell River	k	37	40	14	30	31	32	38	0.01
	ℓ	5	4	0	1	1	1	4	
	O/λ	1.02	1.19	1.89*	1.41*	1.45*	1.52*	1.19	
84 Van Isl West	k	30	32	14	31	32	33	14	0.01
	ℓ	4	3	1	3	2	2	1	
	O/λ	0.82	1.18	1.77*	1.36	1.46*	1.48*	1.72*	

Table 10.16: Male General Yearly Results Site 16 Lungs: non-small cells 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
24 Kamloops	k	31	33	30	31	27	27	30	0.10
	ℓ	3	4	1	3	0	0	3	
	O/λ	0.97	0.83	1.43*	1.18	1.50*	1.53*	1.22	
26 N Thompson	k	41	44	43	42	28	29	41	0.23
	ℓ	5	7	5	5	1	1	5	
	O/λ	1.00	0.86	1.12	1.14	1.48*	1.50*	1.06	
31 Merritt	k	30	6	30	30	30	30	6	0.00
	ℓ	5	0	1	4	1	1	0	
	O/λ	1.19	2.37*	1.43*	1.24	1.43*	1.50*	3.66*	
33 Chilliwack	k	35	37	36	35	36	26	36	0.51
	ℓ	3	3	3	3	2	0	3	
	O/λ	0.88	1.03	0.83	0.90	1.40*	1.58*	0.90	
36 Surrey	k	98	107	104	103	109	114	90	0.40
	ℓ	3	3	3	4	3	2	1	
	O/λ	1.11	1.04	1.05	0.92	1.13	1.18*	1.26*	
39 Vancouver	k	176	186	254	245	261	275	267	0.49
	ℓ	0	0	4	4	4	4	5	
	O/λ	1.15*	1.19*	0.99	0.97	0.97	0.96	0.94	
40 New Westminster	k	98	105	23	99	106	111	26	0.14
	ℓ	2	3	0	3	3	3	0	
	O/λ	1.19*	1.04	1.67*	0.82	1.02	1.04	1.54*	
41 Burnaby	k	240	254	241	233	248	262	255	0.09
	ℓ	2	2	2	4	3	3	4	
	O/λ	1.16*	1.17*	1.13*	1.02	1.07	1.04	0.94	
43 Coquitlam	k	98	51	50	99	106	111	108	0.19
	ℓ	2	1	1	3	3	3	3	
	O/λ	1.19*	1.33*	1.35*	0.82	1.02	1.04	1.02	
47 Powell River	k	33	35	34	33	35	27	33	0.02
	ℓ	3	3	2	2	2	1	3	
	O/λ	1.23	1.05	1.49*	1.41*	1.43*	1.55*	1.14	
71 Courtenay	k	33	35	34	19	35	19	33	0.02
	ℓ	4	3	2	0	2	0	4	
	O/λ	1.13	1.19	1.49*	1.69*	1.43*	1.69*	1.14	
72 Campbell River	k	33	35	12	27	27	28	33	0.01
	ℓ	5	4	0	1	1	1	4	
	O/λ	1.11	1.20	2.09*	1.65*	1.47*	1.49*	1.06	
84 Van Isl West	k	26	28	13	27	28	28	27	0.01
	ℓ	4	3	1	2	2	2	4	
	O/λ	0.86	1.22	1.96*	1.61*	1.49*	1.46*	1.06	

Table 10.17: Male General Yearly Results Site 17 Soft Tissue Sarcoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
12 Grand Forks	k	4	4	4	4	2	4	2	0.04
	ℓ	9	5	4	6	0	8	0	
	O/λ	0.85	1.46	2.15	1.23	9.77*	0.96	6.42*	
38 Richmond	k	23	24	27	26	25	30	38	0.00
	ℓ	6	3	2	3	2	2	2	
	O/λ	1.06	1.52	1.58*	1.36	2.34*	1.98*	1.80*	
39 Vancouver	k	25	20	21	20	20	23	29	0.00
	ℓ	6	0	0	0	0	0	0	
	O/λ	1.11	1.60*	1.86*	1.70*	2.56*	2.41*	2.30*	
41 Burnaby	k	24	8	28	27	26	31	39	0.00
	ℓ	5	0	2	2	2	2	2	
	O/λ	1.08	2.10*	1.57*	1.59*	1.93*	2.11*	1.73*	
44 N Vancouver	k	22	24	25	24	23	27	35	0.00
	ℓ	3	3	1	1	1	1	1	
	O/λ	1.21	1.50	1.71*	1.52*	2.51*	1.97*	2.20*	
45 W Vancouver	k	22	24	27	25	24	29	37	0.00
	ℓ	3	3	2	2	2	2	2	
	O/λ	1.21	1.50	1.59*	1.47*	2.39*	1.93*	2.16*	

Table 10.18: Male General Yearly Results Site 18 Melanoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	13	12	15	14	16	12	14	0.50
	ℓ	4	4	4	4	2	1	4	
	O/λ	0.74	1.21	0.85	1.02	1.88*	1.97*	1.00	
63 Saanich	k	10	6	8	7	12	13	11	0.07
	ℓ	3	0	1	0	3	3	3	
	O/λ	0.78	2.84*	2.15*	2.97*	0.80	1.17	0.83	

Table 10.20*a*: Male General Yearly Results Site 20 Prostate 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
14 S Okanagan	k	41	43	18	19	59	28	64	0.00
	ℓ	2	3	0	0	2	1	2	
	O/λ	1.44*	1.26	1.55*	1.86*	1.42*	1.56*	1.25*	
15 Penticton	k	26	47	30	32	38	70	41	0.00
	ℓ	0	3	0	0	0	2	0	
	O/λ	1.49*	1.26	1.44*	1.74*	1.70*	1.28*	1.39*	
16 Keremeos	k	41	43	47	23	59	9	64	0.00
	ℓ	2	3	2	1	2	0	2	
	O/λ	1.44*	1.26	1.43*	1.59*	1.42*	2.51*	1.25*	
24 Kamloops	k	34	30	37	35	48	49	47	0.12
	ℓ	3	0	1	0	3	3	3	
	O/λ	1.28	1.44*	1.41*	1.45*	0.82	1.20	1.26	
26 N Thompson	k	29	31	4	37	67	69	67	0.00
	ℓ	1	1	0	1	7	3	4	
	O/λ	1.40*	1.41*	3.14*	1.49*	0.72	1.20	1.13	
27 Cariboo-Chilcotin	k	21	14	25	26	29	18	26	0.01
	ℓ	4	0	3	4	5	0	1	
	O/λ	1.22	1.81*	1.40	1.20	0.78	1.59*	1.60*	

Table 10.20*b*: Male General Yearly Results Site 20 Prostate 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
28 Quesnel	k	34	36	41	44	49	27	13	0.00
	ℓ	4	2	3	5	2	1	0	
	O/λ	1.23	1.99*	1.19	1.18	1.33*	1.42*	1.84*	
29 Lillooet	k	12	12	9	9	15	15	15	0.52
	ℓ	3	3	1	1	3	3	3	
	O/λ	1.11	1.13	2.06*	1.98*	0.83	1.18	1.20	
30 S Cariboo	k	33	34	7	9	46	47	45	0.08
	ℓ	5	5	0	1	5	3	3	
	O/λ	1.30	1.21	2.92*	1.98*	0.79	1.18	1.20	
31 Merritt	k	33	35	37	39	47	48	47	0.05
	ℓ	5	4	1	1	5	3	4	
	O/λ	1.05	1.20	1.41*	1.50*	0.94	1.21	1.15	
34 Abbotsford	k	34	71	41	86	99	53	53	0.03
	ℓ	0	3	0	3	3	0	0	
	O/λ	1.41*	1.07	1.34*	1.05	0.95	1.28*	1.48*	
44 N Vancouver	k	272	259	45	48	354	61	434	0.01
	ℓ	3	1	0	0	1	0	3	
	O/λ	1.04	1.12*	1.40*	1.47*	1.13*	1.52*	0.90	
45 W Vancouver	k	60	281	72	36	93	101	434	0.00
	ℓ	1	2	1	0	1	1	3	
	O/λ	1.26*	1.13*	1.35*	1.58*	1.24*	1.38*	0.90	
47 Powell River	k	37	31	14	46	53	55	42	0.14
	ℓ	4	1	0	3	4	3	1	
	O/λ	0.80	1.52*	1.78*	0.92	0.72	1.11	1.54*	
48 Howe Sound	k	63	67	76	40	97	105	107	0.01
	ℓ	2	3	2	1	3	2	3	
	O/λ	1.25*	1.17	1.34*	1.45*	1.23	1.35*	1.10	
49 Central Coast	k	9	9	10	10	4	11	11	0.14
	ℓ	4	4	4	4	0	2	4	
	O/λ	1.17	1.12	1.68	1.22	3.72*	1.86*	1.62	
55 Burns Lake	k	13	13	14	15	17	6	16	0.08
	ℓ	3	3	3	3	2	0	3	
	O/λ	1.12	1.31	1.08	1.37	1.69*	3.47*	1.10	
56 Nechako	k	26	25	8	31	32	33	9	0.00
	ℓ	3	1	0	3	1	1	0	
	O/λ	1.15	2.35*	2.18*	1.10	1.85*	1.45*	2.16*	
57 Prince George	k	30	21	35	37	27	28	32	0.01
	ℓ	4	0	4	4	0	0	1	
	O/λ	1.21	2.61*	1.18	1.06	2.01*	1.43*	1.55*	
59 Peace River S	k	32	33	12	39	44	45	43	0.01
	ℓ	4	2	0	4	2	3	3	
	O/λ	1.13	2.00*	1.74*	1.09	1.63*	1.29	1.35	
60 Peace River N	k	32	33	19	39	44	45	43	0.01
	ℓ	5	2	1	5	2	4	4	
	O/λ	1.11	2.00*	1.66*	1.07	1.63*	1.27	1.33	
75 Mission	k	59	16	53	75	86	91	67	0.14
	ℓ	3	0	1	3	3	3	1	
	O/λ	1.11	1.79*	1.36*	1.05	1.00	1.05	1.33*	
77 Summerland	k	85	12	100	41	15	133	53	0.00
	ℓ	4	0	6	1	0	3	1	
	O/λ	1.17	2.04*	0.89	1.56*	1.64*	1.18	1.28*	

Table 10.21: Male General Yearly Results Site 21 Testis 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
35 Langley	k	5	5	12	13	13	15	17	0.02
	ℓ	0	0	2	8	6	4	5	
	O/λ	3.36*	3.26*	1.80*	0.91	1.12	1.17	1.00	
42 Maple Ridge	k	10	6	6	11	11	12	14	0.29
	ℓ	6	1	1	6	5	3	3	
	O/λ	1.10	2.37*	2.87*	0.84	0.93	1.02	1.01	
47 Powell River	k	6	3	5	4	5	6	7	0.02
	ℓ	4	0	6	1	11	8	4	
	O/λ	1.85	6.98*	1.05	3.23*	0.93	1.22	1.74	
71 Courtenay	k	6	4	5	4	5	6	7	0.04
	ℓ	4	1	7	1	12	10	3	
	O/λ	1.85	3.91*	1.03	3.23*	0.67	1.18	2.01	
72 Campbell River	k	6	6	5	5	5	6	7	0.03
	ℓ	5	3	7	2	12	10	4	
	O/λ	1.78	2.81*	1.03	2.54*	0.89	1.25	1.93	
85 Van Isl North	k	4	4	4	4	4	3	5	0.04
	ℓ	7	5	3	3	14	0	3	
	O/λ	1.56	2.29	1.97	2.37	0.81	9.46*	1.79	

Table 10.22: Male General Yearly Results Site 22 Bladder 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
30 S Cariboo	k	3	12	11	12	11	12	11	0.05
	ℓ	0	5	9	5	7	2	3	
	O/λ	4.17*	1.26	0.77	1.06	0.94	1.92*	1.70	
44 N Vancouver	k	81	74	68	14	14	77	75	0.27
	ℓ	4	4	3	0	0	5	8	
	O/λ	0.97	1.04	1.07	1.74*	1.81*	0.86	0.80	
66 Lake Cowichan	k	19	9	17	19	18	18	18	0.09
	ℓ	4	1	2	4	5	4	4	
	O/λ	1.19	2.44*	1.70*	1.13	0.89	1.14	1.14	
72 Campbell River	k	14	5	12	5	5	13	5	0.01
	ℓ	5	0	4	0	0	5	0	
	O/λ	0.99	3.58*	1.64	3.05*	2.72*	1.13	3.22*	
84 Van Isl West	k	11	6	5	6	5	11	6	0.00
	ℓ	6	1	1	1	1	6	1	
	O/λ	1.02	3.33*	2.54*	3.35*	2.59*	1.09	3.03*	
85 Van Isl North	k	7	7	6	7	6	7	3	0.00
	ℓ	5	2	2	2	3	4	0	
	O/λ	1.02	2.60*	2.39*	3.04*	1.03	1.10	5.96*	

Table 10.23: Male General Yearly Results Site 23 Kidney 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
50 Queen Charlotte	k	4	4	4	4	4	4	4	0.12
	ℓ	10	3	8	10	6	2	2	
	O/λ	0.88	1.75	1.15	1.25	1.42	2.97*	2.98*	
80 Kitimat	k	5	6	5	5	5	6	3	0.11
	ℓ	8	11	8	8	8	2	0	
	O/λ	0.96	0.90	1.26	1.35	1.16	2.80*	7.16*	

Table 10.24: Male General Yearly Results Site 24 Brain 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
26 N Thompson	k	8	10	8	6	2	9	7	0.06
	ℓ	15	7	15	1	0	4	10	
	O/λ	0.67	1.16	0.54	2.54*	13.41*	1.80	1.28	
42 Maple Ridge	k	12	16	8	12	13	5	8	0.06
	ℓ	6	4	1	3	3	0	1	
	O/λ	0.92	0.85	2.17*	1.27	1.22	3.34*	2.62*	

Table 10.26: Male General Yearly Results Site 26 Non-Hodgkins Lymphoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
35 Langley	k	25	27	29	30	30	31	10	0.15
	ℓ	4	3	4	5	6	1	0	
	O/λ	0.98	1.44	0.97	0.90	0.90	1.44*	2.03*	
36 Surrey	k	26	23	29	31	31	25	33	0.12
	ℓ	5	1	4	4	6	0	2	
	O/λ	1.12	1.55*	1.07	0.96	0.77	1.55*	1.37*	
38 Richmond	k	53	57	59	60	12	71	65	0.04
	ℓ	3	4	2	2	0	3	3	
	O/λ	1.13	0.99	1.27*	1.29*	1.88*	1.05	1.15	
47 Powell River	k	4	11	11	12	9	13	12	0.04
	ℓ	0	2	4	4	1	6	5	
	O/λ	3.13*	2.08*	1.07	1.20	2.38*	0.78	1.10	
70 Alberni	k	12	12	13	6	13	15	14	0.12
	ℓ	5	3	3	0	2	6	4	
	O/λ	1.12	1.25	1.14	2.88*	1.80*	0.90	1.02	
71 Courtenay	k	8	11	11	12	7	13	7	0.01
	ℓ	1	2	4	4	0	7	0	
	O/λ	2.17*	2.08*	1.07	1.20	3.20*	0.77	2.33*	

Table 10.27: Male General Yearly Results Site 27 Multiple Myeloma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
57 Prince George	k	5	4	4	5	5	5	5	0.07
	ℓ	20	0	1	18	9	20	5	
	O/λ	0.85	3.48*	3.47*	0.72	1.62	0.56	1.99	

Table 10.28: Male General Yearly Results Site 28 Leukemia 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
65 Cowichan	k	6	13	11	6	13	12	12	0.04
	ℓ	0	5	4	0	5	4	4	
	O/λ	2.42*	1.11	1.44	3.08*	1.10	1.50	1.36	
66 Lake Cowichan	k	7	15	12	7	14	13	13	0.00
	ℓ	1	4	5	1	4	3	3	
	O/λ	2.54*	1.26	1.16	2.77*	1.43	1.62	1.72	
68 Nanaimo	k	13	15	12	13	14	13	9	0.04
	ℓ	4	4	7	4	2	4	0	
	O/λ	1.83	1.21	0.81	1.45	1.67*	1.45	2.08*	

Table 10.29: Male General Yearly Results Site 29 Acute Leukemia 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
39 Vancouver	k	17	23	17	12	14	19	17	0.21
	ℓ	10	5	8	0	0	10	15	
	O/λ	0.87	1.22	0.94	1.76*	1.78*	0.84	0.80	
44 N Vancouver	k	15	20	15	14	16	17	16	0.20
	ℓ	8	3	6	1	1	9	15	
	O/λ	0.84	1.25	1.08	1.67*	1.89*	0.75	0.67	
69 Qualicum	k	6	7	6	6	3	6	5	0.03
	ℓ	7	10	10	10	0	3	1	
	O/λ	1.48	1.14	1.31	1.21	6.04*	2.38*	3.32*	

Table 10.30: Male General Yearly Results Site 30 Chronic Leukemia 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
2 Cranbrook	k	5	5	5	5	5	4	3	0.05
	ℓ	6	7	7	3	12	1	0	
	O/λ	1.50	0.98	1.10	2.03	0.70	3.93*	4.47*	
3 Kimberley	k	5	5	5	5	5	4	5	0.04
	ℓ	7	8	8	3	12	1	2	
	O/λ	1.42	1.10	1.05	2.03	0.70	3.93*	3.29*	
14 S Okanagan	k	4	8	7	7	8	7	8	0.34
	ℓ	1	2	6	6	6	8	6	
	O/λ	3.89*	2.21*	1.03	0.88	0.96	0.68	1.01	
16 Keremeos	k	2	8	7	7	8	7	8	0.29
	ℓ	0	2	5	5	5	10	5	
	O/λ	11.10*	2.21*	1.05	0.89	0.88	0.73	1.02	
61 Greater Victoria	k	21	18	18	21	24	22	24	0.04
	ℓ	8	0	2	4	4	4	7	
	O/λ	0.81	1.64*	1.55*	1.50	1.43	1.27	1.05	
62 Sooke	k	21	20	18	21	24	22	24	0.02
	ℓ	8	1	2	3	3	4	7	
	O/λ	0.90	1.60*	1.55*	1.50	1.44	1.27	1.05	
66 Lake Cowichan	k	10	11	9	6	11	10	10	0.01
	ℓ	3	5	5	1	4	3	3	
	O/λ	1.80	1.10	1.24	3.27*	1.45	1.74	1.63	

Table 10.32: Male General Yearly Results Site 32 Primary Unknown 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
28 Quesnel	k	16	15	18	19	11	5	20	0.04
	ℓ	8	6	2	8	1	0	8	
	O/λ	1.04	1.29	1.94*	1.15	1.96*	2.69*	1.12	
38 Richmond	k	86	85	100	98	102	18	116	0.01
	ℓ	3	3	3	2	2	0	2	
	O/λ	1.05	1.10	1.28	1.23*	1.22*	1.63*	1.22*	
39 Vancouver	k	98	97	79	77	80	78	92	0.00
	ℓ	4	3	0	0	0	0	0	
	O/λ	1.02	1.13	1.35*	1.30*	1.30*	1.33*	1.22*	
41 Burnaby	k	94	92	29	106	110	28	126	0.00
	ℓ	3	3	0	2	2	0	2	
	O/λ	1.14	1.13	1.66*	1.26*	1.19*	1.54*	1.21*	
44 N Vancouver	k	86	85	92	90	93	91	116	0.02
	ℓ	3	3	1	1	1	1	3	
	O/λ	1.06	1.13	1.26*	1.22*	1.22*	1.28*	1.09	
47 Powell River	k	6	12	17	17	17	16	18	0.33
	ℓ	0	1	5	5	5	6	5	
	O/λ	2.76*	2.08*	0.87	0.88	0.81	0.67	0.92	

Table 10.36: Male General Yearly Results Site 36 Colo-Rectal 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
22 Vernon	k	53	59	64	21	22	57	63	0.33
	ℓ	5	5	5	0	0	4	3	
	O/λ	0.91	0.90	0.84	1.51*	1.52*	1.01	1.07	
36 Surrey	k	79	89	97	96	66	57	100	0.32
	ℓ	3	3	3	3	0	0	3	
	O/λ	0.97	1.15	1.01	1.10	1.25*	1.26*	1.04	
68 Nanaimo	k	41	28	50	49	51	27	30	0.08
	ℓ	6	0	6	4	4	0	0	
	O/λ	0.81	1.60*	0.89	1.10	1.10	1.47*	1.78*	
69 Qualicum	k	41	47	50	50	51	38	42	0.03
	ℓ	6	2	5	4	3	1	1	
	O/λ	0.92	1.33*	0.96	1.08	1.09	1.41*	1.63*	
72 Campbell River	k	27	30	31	31	32	10	24	0.28
	ℓ	5	5	4	4	5	0	1	
	O/λ	0.95	0.89	1.07	1.05	0.99	1.92*	1.47*	
75 Mission	k	39	44	48	47	49	11	36	0.47
	ℓ	4	4	4	3	5	0	1	
	O/λ	0.76	0.86	0.94	1.26	0.92	1.89*	1.38*	
84 Van Isl West	k	21	24	25	25	26	11	25	0.19
	ℓ	3	4	4	3	4	1	2	
	O/λ	1.10	0.93	1.07	1.08	0.94	1.99*	1.55*	

Table 10.38: Male General Yearly Results Site 38 All Cancers Except Lung 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
14 S Okanagan	k	130	135	51	145	156	163	164	0.00
	ℓ	2	3	0	2	2	2	3	
	O/λ	1.18*	1.11	1.31*	1.16*	1.22*	1.19*	1.06	
15 Penticton	k	80	148	155	159	98	103	182	0.01
	ℓ	0	3	4	2	0	0	4	
	O/λ	1.29*	1.11	0.88	1.16*	1.39*	1.28*	0.96	
16 Keremeos	k	130	135	62	145	156	163	164	0.00
	ℓ	2	3	1	2	2	2	3	
	O/λ	1.18*	1.11	1.25*	1.16*	1.22*	1.19*	1.06	
28 Quesnel	k	150	161	167	170	174	175	170	0.05
	ℓ	5	2	2	6	2	3	3	
	O/λ	0.97	1.17*	1.14*	0.94	1.18*	1.11	1.08	
38 Richmond	k	1023	1060	1094	1103	1193	1259	296	0.04
	ℓ	2	2	2	3	3	3	1	
	O/λ	1.06*	1.09*	1.10*	1.02	1.00	1.02	1.12*	
39 Vancouver	k	816	836	857	857	930	1446	1464	0.01
	ℓ	0	0	0	0	0	3	3	
	O/λ	1.08*	1.16*	1.13*	1.06*	1.07*	1.03	0.98	
41 Burnaby	k	329	1157	1190	1196	1299	1375	1395	0.04
	ℓ	1	2	2	2	3	3	3	
	O/λ	1.14*	1.09*	1.09*	1.07*	1.02	0.99	0.97	
44 N Vancouver	k	148	976	1004	167	1093	189	1282	0.00
	ℓ	0	1	1	0	1	0	3	
	O/λ	1.16*	1.15*	1.13*	1.25*	1.08*	1.15*	0.98	
45 W Vancouver	k	1027	1061	1093	263	1195	1264	1282	0.01
	ℓ	2	2	2	1	2	3	3	
	O/λ	1.07*	1.14*	1.11*	1.20*	1.07*	1.03	0.98	
46 Sunshine Coast	k	244	259	272	280	53	54	53	0.15
	ℓ	3	3	3	3	0	0	0	
	O/λ	0.94	0.98	0.96	0.97	1.30*	1.43*	1.41*	
56 Nechako	k	110	108	111	122	115	126	123	0.14
	ℓ	4	1	1	3	1	3	3	
	O/λ	0.95	1.25*	1.32*	0.93	1.24*	1.15	1.11	
57 Prince George	k	127	91	94	142	97	147	143	0.03
	ℓ	4	0	0	4	0	3	3	
	O/λ	0.96	1.37*	1.32*	0.93	1.28*	1.15	1.11	
59 Peace River S	k	138	146	151	153	156	158	154	0.12
	ℓ	4	2	2	4	2	4	3	
	O/λ	0.92	1.20*	1.17*	0.93	1.15*	1.04	1.06	
60 Peace River N	k	138	146	151	153	156	158	154	0.14
	ℓ	5	2	2	5	2	5	4	
	O/λ	0.92	1.20*	1.17*	0.92	1.15*	1.02	1.06	
77 Summerland	k	288	303	318	327	126	133	365	0.49
	ℓ	4	4	6	4	1	1	4	
	O/λ	0.98	0.98	0.88	1.02	1.34*	1.25*	0.96	

Table 10.46: Male General Yearly Results Site 46 All Cancers 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
14 S Okanagan	k	158	166	61	175	187	196	196	0.09
	ℓ	3	3	0	2	2	3	3	
	O/λ	1.05	1.07	1.31*	1.16*	1.15*	1.11	1.01	
15 Penticton	k	97	182	188	192	116	122	218	0.02
	ℓ	0	3	4	2	0	0	4	
	O/λ	1.19*	1.07	0.87	1.15*	1.26*	1.17*	0.95	
16 Keremeos	k	158	166	171	175	187	196	196	0.34
	ℓ	3	3	3	2	2	3	3	
	O/λ	1.05	1.07	0.97	1.16*	1.15*	1.11	1.01	
28 Quesnel	k	180	194	201	201	206	208	199	0.07
	ℓ	6	2	2	5	2	3	3	
	O/λ	0.95	1.16*	1.23*	0.99	1.20*	1.10	1.10	
31 Merritt	k	153	23	157	168	175	167	23	0.00
	ℓ	3	0	1	3	3	1	0	
	O/λ	1.08	1.69*	1.15*	1.09	1.06	1.18*	1.59*	
38 Richmond	k	1254	1304	1332	1328	1432	222	351	0.01
	ℓ	2	2	2	3	3	0	1	
	O/λ	1.08*	1.11*	1.09*	1.02	1.00	1.12*	1.12*	
39 Vancouver	k	1000	1028	1042	1033	1117	1742	1751	0.01
	ℓ	0	0	0	0	0	3	4	
	O/λ	1.09*	1.16*	1.13*	1.06*	1.08*	1.02	0.98	
40 New Westminster	k	110	113	595	113	645	682	685	0.17
	ℓ	0	0	3	0	3	3	3	
	O/λ	1.29*	1.20*	0.94	1.30*	0.97	0.98	1.00	
41 Burnaby	k	305	1424	1450	1442	1561	1656	1668	0.04
	ℓ	0	2	2	2	3	3	3	
	O/λ	1.12*	1.10*	1.10*	1.06*	1.02	1.00	0.96	
42 Maple Ridge	k	339	362	89	218	408	428	425	0.57
	ℓ	3	3	0	1	3	3	3	
	O/λ	0.93	1.02	1.24*	1.16*	1.04	1.01	1.03	
43 Coquitlam	k	547	272	595	597	645	682	685	0.59
	ℓ	2	1	3	3	3	3	3	
	O/λ	1.10*	1.14*	0.94	0.95	0.97	0.98	1.00	
44 N Vancouver	k	1161	1201	1222	200	1312	1523	1534	0.01
	ℓ	1	1	1	0	1	3	3	
	O/λ	1.09*	1.15*	1.11*	1.23*	1.08*	1.02	0.96	
45 W Vancouver	k	1260	1306	1332	316	1436	1523	1534	0.01
	ℓ	2	2	2	1	2	3	3	
	O/λ	1.07*	1.14*	1.09*	1.15*	1.07*	1.02	0.96	
46 Sunshine Coast	k	300	318	331	338	62	64	63	0.17
	ℓ	3	3	3	3	0	0	0	
	O/λ	0.96	0.95	0.97	0.98	1.25*	1.35*	1.30*	
56 Nechako	k	131	129	133	144	136	150	144	0.15
	ℓ	4	1	1	3	1	3	3	
	O/λ	0.92	1.25*	1.38*	0.97	1.27*	1.16	1.10	
57 Prince George	k	153	109	112	168	114	174	167	0.01
	ℓ	4	0	0	4	0	2	2	
	O/λ	0.93	1.36*	1.41*	0.97	1.31*	1.14*	1.14*	
59 Peace River S	k	165	176	181	180	185	188	180	0.08
	ℓ	4	2	2	4	2	3	3	
	O/λ	0.88	1.20*	1.20*	0.95	1.14*	1.03	1.05	
60 Peace River N	k	165	176	181	180	185	188	180	0.10
	ℓ	5	2	2	5	2	4	4	
	O/λ	0.89	1.20*	1.20*	0.95	1.14*	1.02	1.05	
68 Nanaimo	k	264	280	292	298	315	325	183	0.59
	ℓ	4	4	4	4	4	2	0	
	O/λ	1.03	0.89	0.94	0.95	0.95	1.11*	1.26*	

Table 11.1: Female General Yearly Results Site 1 Lip 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
35 Langley	k	4	3	4	3	4	4	3	0.08
	ℓ	10	10	2	2	6	10	12	
	O/λ	0.85	1.08	3.10*	4.52*	2.26	1.07	1.44	

Table 11.2: Female General Yearly Results Site 2 Oral Cavity 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
36 Surrey	k	9	16	17	13	16	13	12	0.08
	ℓ	0	5	5	5	7	2	0	
	O/λ	2.17*	1.00	0.82	0.97	0.69	1.94*	1.80*	
38 Richmond	k	25	31	33	26	31	24	33	0.08
	ℓ	6	3	3	2	2	4	7	
	O/λ	1.08	1.12	1.25	1.55*	1.46*	1.14	0.99	

Table 11.3: Female General Yearly Results Site 3 Esophagus 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
38 Richmond	k	15	13	16	14	14	16	19	0.04
	ℓ	5	8	2	5	4	2	4	
	O/λ	1.15	1.02	1.82*	1.22	1.37	1.70*	1.19	
39 Vancouver	k	17	15	13	16	16	14	22	0.01
	ℓ	6	15	0	6	5	0	2	
	O/λ	1.21	0.94	1.87*	1.37	1.31	1.87*	1.55*	
41 Burnaby	k	17	14	17	15	16	18	21	0.01
	ℓ	4	8	5	3	4	2	4	
	O/λ	1.38	1.02	1.29	1.65	1.41	1.78*	1.40	
44 N Vancouver	k	16	13	16	14	15	16	5	0.00
	ℓ	5	5	3	3	4	1	0	
	O/λ	1.30	1.22	1.43	1.40	1.33	1.72*	3.86*	

Table 11.4: Female General Yearly Results Site 4 Stomach 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
37 Delta	k	12	9	15	13	5	14	11	0.04
	ℓ	3	1	3	3	0	3	1	
	O/λ	1.15	2.80*	1.16	1.09	2.59*	1.13	2.21*	
38 Richmond	k	34	7	43	35	36	37	11	0.03
	ℓ	4	0	3	5	3	3	1	
	O/λ	1.05	3.38*	1.15	0.93	1.18	1.22	2.21*	
65 Cowichan	k	7	8	9	8	5	9	9	0.41
	ℓ	6	6	6	2	0	7	6	
	O/λ	0.98	0.46	0.77	2.18*	3.26*	0.40	0.94	

Table 11.5: Female General Yearly Results Site 5 Colon 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	7	8	35	34	33	36	38	0.36
	ℓ	0	0	4	4	4	4	4	
	O/λ	2.54*	2.40*	0.99	1.12	0.97	0.86	0.86	

Table 11.6: Female General Yearly Results Site 6 Rectum 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
17 Princeton	k	5	5	3	5	6	6	3	0.04
	ℓ	3	3	0	3	5	3	0	
	O/λ	1.26	1.48	7.27*	1.36	0.82	0.98	8.07*	
40 New Westminster	k	25	10	39	37	37	10	34	0.10
	ℓ	1	0	3	3	3	0	4	
	O/λ	1.57*	2.00*	1.00	0.90	1.08	2.19*	0.99	

Table 11.7: Female General Yearly Results Site 7 Liver 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
69 Qualicum	k	4	4	4	4	2	5	6	0.46
	ℓ	10	10	10	1	0	10	10	
	O/λ	1.16	1.05	1.17	3.63*	5.97*	1.56	0.99	

Table 11.8: Female General Yearly Results Site 8 Pancreas 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
9 Castlegar	k	6	4	6	5	6	7	5	0.02
	ℓ	11	1	10	2	5	10	1	
	O/λ	0.83	3.12*	1.05	2.63*	1.89	0.67	3.33*	
11 Trail	k	6	4	6	3	6	7	4	0.03
	ℓ	11	1	9	0	6	9	0	
	O/λ	0.74	3.12*	1.14	3.77*	1.50	0.72	3.95*	

Table 11.9: Female General Yearly Results Site 9 Larynx 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
24 Kamloops	k	3	3	2	2	3	2	3	0.03
	ℓ	32	19	0	3	19	0	6	
	O/λ	0.61	0.88	9.43*	8.15*	0.95	6.97*	1.34	
26 N Thompson	k	3	3	2	2	3	2	3	0.03
	ℓ	37	26	1	2	23	1	10	
	O/λ	0.73	0.77	9.00*	8.94*	0.96	6.65*	1.20	
27 Cariboo-Chilcotin	k	2	2	2	2	2	2	2	0.03
	ℓ	22	0	5	8	20	5	14	
	O/λ	0.69	11.79*	5.25	4.25	0.57	3.84	1.29	
30 S Cariboo	k	2	3	2	2	3	2	3	0.04
	ℓ	23	15	2	5	17	2	11	
	O/λ	0.81	1.04	8.27*	7.72*	0.97	6.08*	1.18	
61 Greater Victoria	k	4	6	4	3	6	5	6	0.03
	ℓ	0	5	12	9	10	12	0	
	O/λ	3.73*	2.07	0.72	1.84	1.03	1.00	2.96*	

Table 11.10: Female General Yearly Results Site 10 Lung Squamous 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	10	7	3	12	8	8	13	0.01
	ℓ	4	1	0	4	1	1	4	
	O/λ	1.31	2.78*	4.86*	1.23	2.29*	2.46*	0.94	
47 Powell River	k	6	3	5	7	7	7	7	0.00
	ℓ	2	0	1	5	3	6	3	
	O/λ	2.91*	5.31*	3.13*	1.29	1.74	1.61	1.41	
68 Nanaimo	k	9	6	8	10	7	7	11	0.00
	ℓ	6	0	4	4	0	0	6	
	O/λ	1.33	2.72*	1.61	1.57	2.98*	3.24*	0.95	
69 Qualicum	k	9	8	8	10	8	9	11	0.01
	ℓ	6	3	5	3	1	1	6	
	O/λ	1.30	1.73	1.79	1.63	2.27*	2.40*	1.14	
71 Courtenay	k	4	5	5	7	4	7	7	0.00
	ℓ	0	1	1	6	0	7	4	
	O/λ	3.48*	3.64*	3.13*	1.29	2.99*	1.61	1.33	
72 Campbell River	k	3	6	6	7	6	7	7	0.00
	ℓ	0	2	2	6	1	7	5	
	O/λ	4.68*	3.13*	2.75*	1.29	2.89*	1.61	1.33	
84 Van Isl West	k	3	5	5	6	6	6	6	0.03
	ℓ	1	4	3	6	2	7	6	
	O/λ	4.51*	2.34	2.09	1.08	2.85*	1.75	1.29	

Table 11.12: Female General Yearly Results Site 12 Lung Adenocarcinoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
36 Surrey	k	21	28	18	26	25	31	29	0.03
	ℓ	4	3	0	4	1	4	2	
	O/λ	1.21	1.26	1.96*	1.06	1.48*	1.07	1.42*	
40 New Westminster	k	22	30	28	27	8	30	28	0.08
	ℓ	3	2	3	3	0	2	3	
	O/λ	1.21	1.58*	1.39	0.95	2.36*	1.40*	1.19	
41 Burnaby	k	48	64	58	57	64	18	59	0.06
	ℓ	3	3	4	4	2	0	5	
	O/λ	1.23	1.28	1.01	1.08	1.39*	1.56*	0.99	
43 Coquitlam	k	22	11	28	27	16	30	28	0.07
	ℓ	3	0	3	3	1	2	3	
	O/λ	1.21	1.90*	1.39	0.95	1.76*	1.40*	1.19	

Table 11.13: Female General Yearly Results Site 13 Lung Small Cell 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
47 Powell River	k	5	6	6	6	6	7	3	0.01
	ℓ	3	3	8	4	1	6	0	
	O/λ	2.12	1.80	0.69	2.12	2.93*	1.31	4.17*	
66 Lake Cowichan	k	6	8	8	2	5	9	10	0.03
	ℓ	8	6	5	0	1	6	4	
	O/λ	0.60	1.18	1.24	16.50*	3.46*	0.96	1.68	
72 Campbell River	k	5	6	6	6	6	7	7	0.05
	ℓ	4	5	11	4	1	7	5	
	O/λ	2.21	1.45	0.66	2.15	2.77*	1.30	1.60	
84 Van Isl West	k	4	5	5	5	6	6	6	0.03
	ℓ	4	5	7	3	2	4	4	
	O/λ	2.21	1.53	0.80	2.19	2.73*	1.61	1.46	

Table 11.14: Female General Yearly Results Site 14 Lung Others 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	14	4	3	15	14	17	19	0.08
	ℓ	4	0	0	3	3	4	4	
	O/λ	0.95	3.96*	3.72*	1.42	1.56	0.91	1.01	
57 Prince George	k	7	6	6	7	5	8	9	0.04
	ℓ	6	4	5	5	0	6	6	
	O/λ	1.40	1.64	2.10	1.75	2.91*	1.22	1.14	
59 Peace River S	k	7	7	6	3	7	8	9	0.02
	ℓ	7	4	7	0	3	7	7	
	O/λ	1.38	1.87	1.87	3.86*	2.12	1.21	1.13	
60 Peace River N	k	7	7	6	8	7	8	9	0.04
	ℓ	8	5	8	5	4	8	8	
	O/λ	1.30	1.84	1.77	1.77	2.09	1.14	1.06	

Table 11.15: Female General Yearly Results Site 15 All Lungs 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	33	8	8	39	41	44	47	0.10
	ℓ	3	0	0	3	3	4	4	
	O/λ	1.21	2.34*	2.63*	1.21	1.14	0.92	0.94	
47 Powell River	k	18	8	19	21	22	24	9	0.01
	ℓ	2	0	4	3	2	4	0	
	O/λ	1.56*	2.70*	0.93	1.33	1.55*	1.08	2.20*	
65 Cowichan	k	24	28	25	29	31	15	16	0.40
	ℓ	5	5	5	4	5	0	0	
	O/λ	0.89	0.86	0.98	1.07	1.15	1.64*	1.63*	
69 Qualicum	k	28	32	30	34	30	38	41	0.12
	ℓ	5	5	5	2	1	5	5	
	O/λ	1.04	1.28	1.11	1.38*	1.40*	1.11	1.20	
70 Alberni	k	22	25	23	18	10	10	31	0.07
	ℓ	3	3	3	1	0	0	3	
	O/λ	1.34	1.15	0.93	1.65*	2.08*	2.35*	1.00	
71 Courtenay	k	18	12	19	21	13	24	25	0.02
	ℓ	2	0	4	3	0	3	3	
	O/λ	1.56*	1.86*	0.93	1.23	2.06*	1.32	1.18	
72 Campbell River	k	15	17	19	21	18	24	25	0.02
	ℓ	1	1	5	4	1	4	4	
	O/λ	1.74*	1.88*	0.93	1.27	1.86*	1.31	1.17	
84 Van Isl West	k	15	17	16	17	18	19	21	0.03
	ℓ	2	2	4	3	2	3	4	
	O/λ	1.82*	1.85*	0.98	1.23	1.84*	1.31	1.17	

Table 11.16: Female General Yearly Results Site 16 Lungs: non-small cells 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
27 Cariboo-Chilcotin	k	10	11	7	11	11	12	12	0.09
	ℓ	5	5	0	2	5	5	1	
	O/λ	0.96	1.11	2.46*	1.84*	0.74	1.08	2.33*	
46 Sunshine Coast	k	29	7	7	34	35	38	40	0.08
	ℓ	3	0	0	3	3	4	4	
	O/λ	1.29	2.52*	3.24*	1.26	1.13	0.94	0.96	
65 Cowichan	k	21	24	22	25	26	13	14	0.49
	ℓ	5	5	5	5	5	0	0	
	O/λ	0.96	0.82	0.92	1.10	0.91	1.72*	1.74*	
70 Alberni	k	19	21	19	23	8	9	27	0.33
	ℓ	3	3	3	3	0	0	3	
	O/λ	1.38	1.10	0.96	1.32	2.31*	2.13*	0.87	
71 Courtenay	k	10	14	16	19	19	21	22	0.08
	ℓ	0	1	4	4	3	3	4	
	O/λ	2.12*	2.22*	0.97	1.23	1.57	1.26	1.10	
72 Campbell River	k	13	14	16	19	15	21	22	0.05
	ℓ	1	1	5	5	1	4	5	
	O/λ	1.90*	1.79*	0.96	1.26	1.65*	1.25	1.09	
84 Van Isl West	k	13	15	13	15	15	17	18	0.04
	ℓ	2	2	4	4	2	3	4	
	O/λ	1.86*	1.76*	0.97	1.12	1.62*	1.25	1.11	

Table 11.18: Female General Yearly Results Site 18 Melanoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
35 Langley	k	21	7	9	8	29	35	31	0.06
	ℓ	5	0	0	0	5	4	5	
	O/λ	0.96	2.37*	2.02*	2.64*	0.93	0.97	0.89	
41 Burnaby	k	17	13	62	52	58	70	61	0.39
	ℓ	1	0	5	5	4	5	6	
	O/λ	1.67*	1.72*	0.95	0.96	1.13	0.88	0.84	
45 W Vancouver	k	6	41	8	7	17	20	58	0.00
	ℓ	0	3	0	0	1	1	5	
	O/λ	2.90*	1.06	2.84*	2.73*	1.59*	1.60*	0.86	
46 Sunshine Coast	k	12	12	16	4	15	18	16	0.44
	ℓ	4	4	2	0	4	4	4	
	O/λ	1.08	0.83	1.67*	3.75*	1.12	0.87	0.81	
48 Howe Sound	k	7	14	9	8	18	22	19	0.00
	ℓ	1	4	1	1	2	3	4	
	O/λ	2.33*	0.89	2.52*	2.19*	1.56*	1.40	0.91	

Table 11.22: Female General Yearly Results Site 22 Bladder 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
45 W Vancouver	k	32	33	5	30	10	33	9	0.03
	ℓ	6	4	0	6	1	4	1	
	O/λ	0.95	1.07	3.64*	0.92	2.06*	1.09	1.92*	

Table 11.23: Female General Yearly Results Site 23 Kidney 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
50 Queen Charlotte	k	3	2	3	3	2	3	3	0.03
	ℓ	15	1	10	11	0	4	10	
	O/λ	0.74	6.76*	1.01	1.07	21.04*	2.77	0.95	
86 Creston-Kaslo	k	4	5	5	5	5	5	3	0.03
	ℓ	6	13	5	3	9	8	0	
	O/λ	1.71	0.78	1.74	2.54*	1.19	1.39	5.24*	
87 Stikine	k	2	2	2	2	3	2	2	0.05
	ℓ	7	8	2	11	5	2	4	
	O/λ	1.73	1.57	6.82*	0.53	2.02	7.04*	1.95	

Table 11.26: Female General Yearly Results Site 26 Non-Hodgkins Lymphoma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
35 Langley	k	7	6	23	22	25	25	31	0.23
	ℓ	0	0	7	7	7	4	3	
	O/λ	2.61*	2.40*	0.78	0.87	0.78	1.16	1.18	
37 Delta	k	19	6	18	17	20	20	24	0.10
	ℓ	2	0	3	4	3	3	2	
	O/λ	1.79*	2.72*	0.89	0.85	1.00	1.08	1.58*	
56 Nechako	k	7	6	7	7	7	8	3	0.04
	ℓ	6	6	2	6	10	8	0	
	O/λ	1.25	1.37	2.41*	1.40	0.81	1.10	4.70*	

Table 11.27: Female General Yearly Results Site 27 Multiple Myeloma 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
14 S Okanagan	k	5	5	5	4	4	6	5	0.05
	ℓ	8	10	5	3	6	2	8	
	O/λ	1.17	0.81	2.47	2.89	1.66	3.84*	0.99	
16 Keremeos	k	5	5	5	4	4	6	5	0.05
	ℓ	10	12	4	3	5	2	10	
	O/λ	1.12	0.83	2.54	2.89	1.68	3.84*	0.95	
55 Burns Lake	k	2	2	2	2	2	3	2	0.10
	ℓ	2	1	5	8	14	9	9	
	O/λ	6.28*	9.61*	1.48	1.46	0.89	1.09	0.92	
56 Nechako	k	3	2	4	3	3	4	4	0.16
	ℓ	1	0	17	18	18	17	17	
	O/λ	4.98*	14.17*	0.87	0.80	0.88	0.71	0.89	
59 Peace River S	k	4	4	4	4	4	5	4	0.32
	ℓ	3	3	13	23	20	24	16	
	O/λ	3.16*	3.00*	1.04	0.77	0.98	0.45	0.86	
60 Peace River N	k	4	4	4	4	4	5	4	0.26
	ℓ	4	4	16	23	22	19	16	
	O/λ	3.11*	2.95*	0.99	0.84	0.95	0.80	1.01	
77 Summerland	k	8	8	8	4	6	5	9	0.05
	ℓ	13	18	11	1	6	1	18	
	O/λ	1.25	0.82	1.18	4.19*	1.65	3.51*	0.86	

Table 11.28: Female General Yearly Results Site 28 Leukemia 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
85 Van Isl North	k	4	5	4	4	2	4	5	0.23
	ℓ	5	5	9	7	0	2	7	
	O/λ	1.12	1.27	0.66	0.67	7.21*	3.73*	0.77	

Table 11.29: Female General Yearly Results Site 29 Acute Leukemia 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
46 Sunshine Coast	k	4	5	5	5	5	5	6	0.29
	ℓ	1	1	4	4	4	4	4	
	O/λ	3.94*	3.61*	1.29	0.95	0.72	0.87	0.68	
68 Nanaimo	k	4	4	5	4	4	5	5	0.18
	ℓ	0	0	8	8	8	7	7	
	O/λ	3.98*	3.66*	1.34	0.99	0.70	1.46	1.07	

Table 11.31: Female General Yearly Results Site 31 Other Sites 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
12 Grand Forks	k	7	6	3	3	7	3	7	0.01
	ℓ	4	5	1	0	4	0	2	
	O/λ	1.71	0.93	3.70*	4.04*	1.29	3.94*	2.15*	
44 N Vancouver	k	73	13	62	15	82	15	76	0.00
	ℓ	4	0	1	0	3	0	1	
	O/λ	0.95	1.71*	1.33*	1.76*	1.07	1.80*	1.25*	
45 W Vancouver	k	73	67	19	76	82	22	82	0.05
	ℓ	4	3	1	3	3	1	2	
	O/λ	1.01	1.06	1.66*	1.10	1.07	1.55*	1.22*	
56 Nechako	k	10	3	9	11	12	11	12	0.10
	ℓ	5	0	1	7	6	17	6	
	O/λ	1.37	4.20*	2.39*	1.04	1.45	0.62	1.02	
68 Nanaimo	k	16	14	15	11	19	17	19	0.32
	ℓ	5	7	2	0	6	6	6	
	O/λ	1.14	0.75	1.70*	1.96*	0.98	1.04	0.96	

Table 11.32: Female General Yearly Results Site 32 Primary Unknown 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
39 Vancouver	k	89	79	72	95	74	76	110	0.06
	ℓ	4	6	0	4	0	0	5	
	O/λ	1.11	1.00	1.24*	1.03	1.23*	1.29*	0.95	
42 Maple Ridge	k	22	7	16	25	28	29	30	0.39
	ℓ	3	0	1	3	3	3	3	
	O/λ	0.93	2.52*	1.81*	0.97	1.09	1.13	1.29	
75 Mission	k	17	16	20	19	6	7	24	0.08
	ℓ	4	3	3	4	0	0	3	
	O/λ	1.08	1.35	1.14	0.93	2.83*	2.67*	1.14	

Table 11.33: Female General Yearly Results Site 33 Breast 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
32 Hope	k	36	38	43	43	43	52	52	0.43
	ℓ	2	2	5	5	4	4	5	
	O/λ	1.37*	1.41*	0.72	1.01	1.01	1.07	0.92	
33 Chilliwack	k	31	32	52	52	52	64	64	0.51
	ℓ	0	0	3	3	3	3	3	
	O/λ	1.48*	1.45*	0.72	1.02	1.01	0.99	0.97	
44 N Vancouver	k	56	58	390	386	380	81	462	0.20
	ℓ	0	0	3	3	3	0	3	
	O/λ	1.31*	1.37*	1.08	1.02	1.02	1.36*	1.01	
45 W Vancouver	k	325	37	390	386	42	123	462	0.15
	ℓ	3	0	3	3	0	1	3	
	O/λ	1.06	1.53*	1.08	1.02	1.35*	1.19*	1.01	
76 Agassiz-Harrison	k	33	34	43	43	43	52	52	0.40
	ℓ	1	1	4	4	3	3	4	
	O/λ	1.49*	1.45*	0.73	0.99	0.98	1.09	0.94	

Table 11.35: Female General Yearly Results Site 35 Cervix 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
36 Surrey	k	26	18	25	23	22	19	29	0.26
	ℓ	4	5	3	4	2	0	5	
	O/λ	1.10	0.94	1.39	0.91	1.51*	1.87*	0.85	
38 Richmond	k	53	36	50	46	42	50	52	0.01
	ℓ	2	3	2	3	4	2	2	
	O/λ	1.32*	1.34	1.36*	1.18	1.05	1.31*	1.70*	
39 Vancouver	k	41	28	38	35	46	56	39	0.00
	ℓ	0	0	0	0	4	4	0	
	O/λ	1.39*	1.53*	1.38*	1.43*	1.14	1.17	1.93*	
41 Burnaby	k	16	38	52	47	43	52	53	0.00
	ℓ	0	2	2	3	4	3	2	
	O/λ	1.66*	1.44*	1.30*	1.20	1.05	1.14	1.73*	
44 N Vancouver	k	49	33	45	44	41	49	47	0.01
	ℓ	1	1	1	3	3	3	1	
	O/λ	1.36*	1.38*	1.31*	1.10	1.15	1.14	1.67*	
49 Central Coast	k	4	3	3	2	4	4	4	0.06
	ℓ	5	7	1	0	9	4	5	
	O/λ	1.34	0.79	5.31*	22.71*	1.42	2.20	1.10	
70 Alberni	k	11	8	10	9	6	7	10	0.22
	ℓ	13	8	3	3	1	1	13	
	O/λ	0.48	0.79	1.21	1.09	2.50*	2.77*	0.61	

Table 11.36: Female General Yearly Results Site 36 Colo-Rectal 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
27 Cariboo-Chilcotin	k	12	14	15	9	9	15	15	0.22
	ℓ	3	5	5	0	0	5	5	
	O/λ	1.84	0.85	0.69	1.99*	1.99*	1.06	0.93	
32 Hope	k	21	23	7	23	23	24	25	0.02
	ℓ	5	3	1	4	2	5	3	
	O/λ	0.81	1.38	2.93*	1.07	1.71*	1.11	1.46	
40 New Westminster	k	63	23	94	92	88	70	91	0.18
	ℓ	1	0	3	3	3	1	3	
	O/λ	1.26*	1.73*	1.07	0.97	0.99	1.28*	1.07	
46 Sunshine Coast	k	9	10	52	10	49	52	53	0.11
	ℓ	0	0	4	0	4	4	4	
	O/λ	2.13*	2.17*	0.98	1.96*	0.94	0.94	0.93	
80 Kitimat	k	10	11	8	11	11	11	11	0.09
	ℓ	8	8	1	2	7	8	2	
	O/λ	0.95	0.87	2.15*	1.98*	1.05	0.88	1.80*	

Table 11.38: Female General Yearly Results Site 38 All Cancers Except Lung 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
13 Kettle Valley	k	9	9	65	63	67	75	76	0.38
	ℓ	0	0	3	3	3	3	3	
	O/λ	2.73*	2.43*	0.85	0.86	1.03	0.97	1.06	
32 Hope	k	104	109	119	115	121	135	136	0.57
	ℓ	2	2	4	4	4	4	4	
	O/λ	1.21*	1.21*	0.85	0.97	1.07	1.04	1.01	
35 Langley	k	92	427	111	477	442	130	586	0.04
	ℓ	0	3	0	3	1	0	3	
	O/λ	1.28*	1.04	1.27*	1.03	1.08*	1.16*	1.07	
36 Surrey	k	432	460	517	507	435	606	612	0.04
	ℓ	2	3	3	3	1	2	2	
	O/λ	1.10*	1.02	1.00	0.98	1.13*	1.08*	1.07*	
37 Delta	k	321	103	116	277	386	431	429	0.04
	ℓ	3	0	0	1	3	3	2	
	O/λ	1.02	1.21*	1.18*	1.17*	1.08	1.04	1.09*	
38 Richmond	k	1043	1087	282	175	1185	1317	1303	0.57
	ℓ	3	3	1	0	3	3	3	
	O/λ	1.06	1.02	1.13*	1.16*	1.01	1.03	1.02	
39 Vancouver	k	974	1264	925	1323	1364	1510	1489	0.15
	ℓ	1	3	0	3	3	2	3	
	O/λ	1.06*	1.05	1.10*	1.04	1.04	1.05*	1.01	
40 New Westminster	k	346	491	541	525	109	435	599	0.18
	ℓ	1	3	3	3	0	1	3	
	O/λ	1.15*	1.00	0.99	0.97	1.32*	1.11*	1.03	
41 Burnaby	k	260	1199	1298	1248	1286	329	1404	0.19
	ℓ	0	3	2	3	3	0	3	
	O/λ	1.17*	1.00	1.08*	1.01	1.01	1.11*	1.00	
44 N Vancouver	k	164	171	1097	1153	1190	1318	1301	0.04
	ℓ	0	0	1	3	2	3	3	
	O/λ	1.15*	1.26*	1.09*	1.04	1.05*	1.05	1.01	
45 W Vancouver	k	253	107	1198	1153	118	1318	1301	0.04
	ℓ	1	0	2	3	0	3	3	
	O/λ	1.11*	1.20*	1.09*	1.04	1.18*	1.05	1.01	
76 Agassiz-Harrison	k	94	109	119	115	121	135	136	0.56
	ℓ	1	2	4	3	3	3	3	
	O/λ	1.23*	1.21*	0.87	0.95	1.06	1.06	1.00	

Table 11.39: Female General Yearly Results Site 39 Endometrium 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
38 Richmond	k	69	15	90	84	25	100	86	0.06
	ℓ	3	0	2	3	1	3	3	
	O/λ	1.04	1.75*	1.22*	1.07	1.67*	1.06	0.99	
45 W Vancouver	k	10	81	91	12	12	101	87	0.01
	ℓ	0	3	2	0	0	3	4	
	O/λ	2.25*	1.03	1.22*	2.53*	2.24*	1.10	1.02	
48 Howe Sound	k	11	24	27	13	13	30	26	0.13
	ℓ	1	4	4	1	1	4	4	
	O/λ	1.99*	1.06	1.23	2.35*	1.96*	1.11	0.89	
57 Prince George	k	7	12	9	12	9	14	13	0.10
	ℓ	0	13	0	15	0	14	5	
	O/λ	2.15*	0.77	1.97*	0.54	2.22*	0.83	1.11	
64 Gulf Islands	k	14	17	5	11	19	22	20	0.17
	ℓ	4	3	0	1	3	3	3	
	O/λ	0.79	1.06	3.37*	2.13*	1.34	1.08	1.21	

Table 11.46: Female General Yearly Results Site 46 All Cancers 1983–89

School District		1983	1984	1985	1986	1987	1988	1989	p_c
3 Kimberley	k	68	71	77	76	25	27	84	0.49
	ℓ	3	3	3	3	0	0	3	
	O/λ	1.11	0.94	0.87	0.90	1.48*	1.46*	0.80	
13 Kettle Valley	k	9	9	71	70	75	84	85	0.56
	ℓ	0	0	3	3	3	3	3	
	O/λ	2.89*	2.15*	0.85	0.88	0.99	0.97	1.02	
32 Hope	k	115	17	130	128	135	150	152	0.57
	ℓ	2	0	4	4	4	4	4	
	O/λ	1.19*	1.60*	0.88	1.01	1.04	1.04	1.02	
35 Langley	k	101	477	120	530	565	638	652	0.18
	ℓ	0	3	0	3	2	3	3	
	O/λ	1.25*	1.03	1.29*	1.02	1.08*	1.05	1.07	
36 Surrey	k	478	514	565	564	484	672	551	0.04
	ℓ	2	3	3	3	1	2	1	
	O/λ	1.10*	1.01	1.02	0.98	1.13*	1.08*	1.08*	
37 Delta	k	355	114	307	306	428	476	476	0.20
	ℓ	3	0	1	1	3	3	3	
	O/λ	1.03	1.18*	1.11*	1.14*	1.07	1.05	1.07	
38 Richmond	k	1154	1214	307	193	1319	1463	1454	0.60
	ℓ	3	3	1	0	3	3	3	
	O/λ	1.06	1.01	1.11*	1.15*	1.01	1.04	1.01	
39 Vancouver	k	1078	1413	1014	1474	1520	1679	1663	0.16
	ℓ	1	3	0	3	3	2	3	
	O/λ	1.06*	1.04	1.09*	1.04	1.04	1.04*	1.00	
40 New Westminster	k	383	548	592	583	121	483	667	0.18
	ℓ	1	3	3	3	0	1	3	
	O/λ	1.16*	1.00	1.01	0.98	1.33*	1.12*	1.03	
41 Burnaby	k	287	1340	1422	1392	1435	365	1569	0.20
	ℓ	0	3	2	3	3	0	3	
	O/λ	1.17*	1.00	1.08*	1.02	1.02	1.12*	0.99	
44 N Vancouver	k	1078	190	1201	1285	1326	1466	1453	0.04
	ℓ	1	0	1	3	2	3	3	
	O/λ	1.06*	1.24*	1.08*	1.04	1.05*	1.04	1.00	
45 W Vancouver	k	280	297	1312	1285	328	1466	1453	0.04
	ℓ	1	1	2	3	1	3	3	
	O/λ	1.11*	1.21*	1.08*	1.04	1.12*	1.04	1.00	
76 Agassiz-Harrison	k	104	121	130	128	135	150	152	0.57
	ℓ	1	2	3	3	3	3	3	
	O/λ	1.20*	1.20*	0.88	0.99	1.04	1.06	1.02	

Table 12*a*: Male Focused Yearly Results by Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
2	Castlegar	k	3	8	7	7	7	3	3	0.12
		ℓ	1	12	12	11	11	1	1	
		O/λ	4.49*	0.65	0.72	0.72	0.98	3.73*	4.31*	
	Port Mellon	k	41	43	39	39	41	49	4	0.00
		ℓ	3	3	3	4	3	5	1	
		O/λ	1.78*	1.85*	1.48*	1.19	1.36*	1.04	3.11*	
	Prince Rupert	k	6	4	3	6	6	7	6	0.38
		ℓ	11	2	1	11	10	14	10	
		O/λ	0.70	3.15*	4.41*	0.71	0.82	0.59	0.99	
4	Prince Rupert	k	6	6	6	4	3	6	6	0.09
		ℓ	9	11	7	2	1	10	10	
		O/λ	1.29	0.76	1.63	3.59*	4.38*	0.85	1.20	
	Port Alice	k	6	5	6	5	5	6	6	0.13
		ℓ	6	4	5	3	3	6	4	
		O/λ	1.11	1.38	1.16	2.61*	2.64*	1.14	1.22	
	Ocean Falls	k	5	5	5	5	5	3	5	0.03
		ℓ	6	11	8	4	4	2	11	
		O/λ	1.55	1.08	1.45	2.22	2.37	5.89*	0.82	
6	Nanaimo	k	18	22	23	15	24	15	15	0.08
		ℓ	8	6	7	1	6	1	1	
		O/λ	0.82	1.01	0.94	1.66*	1.12	1.97*	1.75*	
	Gold River	k	10	12	13	13	13	7	13	0.18
		ℓ	6	6	6	6	7	2	3	
		O/λ	1.10	0.96	0.99	1.25	0.78	2.94*	1.87*	
	Campbell River	k	13	15	16	16	16	6	13	0.14
		ℓ	6	6	6	5	7	1	2	
		O/λ	1.13	1.09	0.96	1.32	0.99	2.74*	1.78*	
7	Port Mellon	k	17	15	16	20	18	20	20	0.00
		ℓ	4	3	3	5	3	3	3	
		O/λ	1.43	1.65*	2.10*	1.30	1.72*	1.51*	2.14*	
10	Powell River	k	16	16	16	12	12	15	15	0.08
		ℓ	4	5	4	2	2	4	4	
		O/λ	1.17	1.09	1.62	1.92*	1.95*	1.26	1.59	
	Gold River	k	13	13	14	13	13	13	12	0.11
		ℓ	7	6	5	3	3	6	6	
		O/λ	0.97	1.10	1.28	2.24*	1.83*	1.19	1.06	
	Campbell River	k	16	16	16	13	13	15	15	0.07
		ℓ	6	6	5	2	2	5	6	
		O/λ	1.01	1.13	1.27	2.28*	1.87*	1.25	1.42	
11	Crofton	k	3	3	2	3	3	2	2	0.09
		ℓ	10	9	10	5	5	3	15	
		O/λ	0.74	0.96	0.86	5.08*	3.84*	6.14*	1.15	
	Port Alberni	k	2	3	2	3	3	2	2	0.03
		ℓ	2	7	15	13	9	4	16	
		O/λ	6.49*	1.88	0.95	2.40	2.61	6.11	1.78	
	Nanaimo	k	3	4	2	2	3	2	2	0.03
		ℓ	9	9	9	1	5	1	12	
		O/λ	0.96	1.02	1.13	6.69*	4.10*	9.51*	1.90	
	Powell River	k	3	3	2	2	2	2	2	0.05
		ℓ	4	7	13	7	7	7	14	
		O/λ	5.25*	1.75	1.06	2.09	2.10	4.53	1.95	
12	Gold River	k	10	10	10	11	10	11	9	0.10
		ℓ	8	6	4	6	3	4	7	
		O/λ	0.95	1.03	1.70	1.18	1.88*	1.81*	0.92	
	Campbell River	k	12	12	12	13	12	10	11	0.31
		ℓ	8	6	6	6	4	2	8	
		O/λ	0.94	1.08	1.16	1.32	1.74*	1.86*	0.97	

Table 12*b*: Male Focused Yearly Results by Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
13	Campbell River	k	8	8	9	9	9	4	7	0.24
		ℓ	8	7	7	8	6	1	2	
		O/λ	0.96	1.00	0.94	0.98	1.38	2.97*	2.49*	
14	Prince George	k	11	13	12	8	9	13	9	0.01
		ℓ	15	5	5	1	1	5	1	
		O/λ	0.68	1.29	1.26	2.80*	2.23*	1.21	1.96*	
	Kitimat	k	7	7	7	6	7	3	7	0.13
		ℓ	9	9	9	6	3	1	8	
		O/λ	0.79	1.34	0.82	1.80	2.22*	5.04*	1.34	
	Kamloops	k	16	18	17	17	12	12	20	0.30
		ℓ	6	7	6	7	1	1	6	
		O/λ	1.10	0.87	0.97	0.83	2.00*	1.74*	1.22	
	Quesnel	k	13	15	14	13	15	15	15	0.04
		ℓ	12	9	6	4	3	9	3	
		O/λ	0.65	1.12	1.44	1.65	2.07*	1.35	1.71*	
	MacKenzie	k	11	12	12	8	9	13	9	0.03
		ℓ	17	4	9	1	1	6	1	
		O/λ	0.73	1.72	1.15	2.80*	2.23*	1.21	1.96*	
15	Powell River	k	37	40	30	38	30	31	38	0.09
		ℓ	4	4	2	4	2	2	4	
		O/λ	1.14	1.01	1.40*	1.20	1.41*	1.45*	1.25	
	Kamloops	k	48	52	34	50	31	32	49	0.05
		ℓ	6	6	2	6	1	1	5	
		O/λ	0.99	0.89	1.41*	1.20	1.48*	1.55*	1.18	
	Gold River	k	30	32	14	31	32	33	14	0.00
		ℓ	6	5	2	4	3	3	2	
		O/λ	0.80	1.09	1.77*	1.30	1.46*	1.48*	1.72*	
	Campbell River	k	37	40	14	30	31	32	38	0.01
		ℓ	6	5	1	2	2	2	5	
		O/λ	1.02	1.19	1.89*	1.41*	1.45*	1.52*	1.19	
16	Powell River	k	33	35	34	33	35	27	33	0.02
		ℓ	4	4	3	3	3	2	4	
		O/λ	1.23	1.05	1.49*	1.41*	1.43*	1.55*	1.14	
	Kamloops	k	43	46	30	43	27	27	42	0.06
		ℓ	6	6	2	6	1	1	5	
		O/λ	0.97	0.88	1.43*	1.15	1.50*	1.53*	1.19	
	Gold River	k	26	28	13	27	28	28	27	0.01
		ℓ	6	5	2	3	3	3	5	
		O/λ	0.84	1.11	1.96*	1.61*	1.49*	1.46*	1.04	
	Campbell River	k	33	35	12	27	27	28	33	0.01
		ℓ	6	5	1	2	2	2	5	
		O/λ	1.11	1.20	2.09*	1.65*	1.47*	1.49*	1.06	
17	Port Mellon	k	20	22	24	22	22	26	32	0.00
		ℓ	4	4	3	3	3	3	3	
		O/λ	1.44	1.32	1.70*	1.56*	2.47*	2.24*	2.16*	

Table 12c: Male Focused Yearly Results by Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
20	Prince George	k	30	21	35	37	27	28	32	0.01
		ℓ	5	1	5	5	1	1	2	
		O/λ	1.21	2.61*	1.18	1.06	2.01*	1.43*	1.55*	
	Port Mellon	k	252	260	284	49	58	21	398	0.02
		ℓ	4	3	4	2	2	1	5	
		O/λ	1.02	1.12*	1.04	1.48*	1.32*	2.01*	0.93	
	Powell River	k	37	31	14	46	53	55	42	0.14
		ℓ	5	2	1	4	5	4	2	
		O/λ	0.80	1.52*	1.78*	0.92	0.72	1.11	1.54*	
	Squamish	k	63	67	76	40	97	105	107	0.01
		ℓ	3	4	3	2	4	3	4	
		O/λ	1.25*	1.17	1.34*	1.45*	1.23	1.35*	1.10	
	Kamloops	k	48	30	37	35	69	72	69	0.00
		ℓ	3	1	2	1	6	4	3	
		O/λ	1.34*	1.44*	1.41*	1.45*	0.77	1.20	1.26*	
	Quesnel	k	34	36	41	44	49	27	13	0.00
		ℓ	5	3	4	6	3	2	1	
		O/λ	1.23	1.99*	1.19	1.18	1.33*	1.42*	1.84*	
	MacKenzie	k	29	21	34	35	27	28	32	0.00
		ℓ	4	1	3	4	1	1	2	
		O/λ	1.12	2.61*	1.41*	1.13	2.01*	1.43*	1.55*	
21	Powell River	k	6	3	5	4	5	6	7	0.02
		ℓ	5	1	7	2	12	9	5	
		O/λ	1.85	6.98*	1.05	3.23*	0.93	1.22	1.74	
	Port Alice	k	4	4	4	4	4	3	5	0.04
		ℓ	8	6	4	4	15	1	4	
		O/λ	1.56	2.29	1.97	2.37	0.65	9.46*	1.79	
	Campbell River	k	6	6	5	5	5	6	7	0.03
		ℓ	6	4	8	3	13	11	5	
		O/λ	1.78	2.81*	1.03	2.54*	0.89	1.25	1.93	
22	Port Alice	k	7	7	6	7	6	7	3	0.00
		ℓ	6	3	3	3	4	5	1	
		O/λ	1.02	2.60*	2.39*	3.04*	1.03	1.10	5.96*	
	Gold River	k	11	6	5	6	5	11	6	0.00
		ℓ	7	2	2	2	2	7	2	
		O/λ	1.02	3.33*	2.54*	3.35*	2.59*	1.09	3.03*	
	Campbell River	k	14	5	12	5	5	13	5	0.01
		ℓ	6	1	5	1	1	6	1	
		O/λ	0.99	3.58*	1.64	3.05*	2.72*	1.13	3.22*	
23	Kitimat	k	5	6	5	5	5	6	3	0.11
		ℓ	9	12	9	9	9	3	1	
		O/λ	0.96	0.90	1.26	1.35	1.16	2.80*	7.16*	
	Ocean Falls	k	4	5	4	4	4	3	3	0.07
		ℓ	12	11	9	11	5	2	2	
		O/λ	0.65	0.86	1.15	1.15	1.72	5.19*	5.34*	
26	Port Alberni	k	12	12	13	6	13	15	14	0.12
		ℓ	6	4	4	1	3	7	5	
		O/λ	1.12	1.25	1.14	2.88*	1.80*	0.90	1.02	
	Powell River	k	4	11	11	12	9	13	12	0.04
		ℓ	1	3	5	5	2	7	6	
		O/λ	3.13*	2.08*	1.07	1.20	2.38*	0.78	1.10	
27	Prince George	k	5	4	4	5	5	5	5	0.07
		ℓ	21	1	2	19	10	21	6	
		O/λ	0.85	3.48*	3.47*	0.72	1.62	0.56	1.99	
	MacKenzie	k	5	4	4	5	5	5	5	0.07
		ℓ	26	1	2	21	13	26	6	
		O/λ	0.67	3.48*	3.47*	0.69	1.41	0.54	2.19	

Table 12*d*: Male Focused Yearly Results by Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
28	Nanaimo	k	13	15	12	13	14	13	9	0.04
		ℓ	5	5	8	5	3	5	1	
		O/λ	1.83	1.21	0.81	1.45	1.67*	1.45	2.08*	
30	Skookumchuck	k	5	5	5	5	5	4	5	0.05
		ℓ	8	9	9	5	13	2	3	
		O/λ	1.42	1.10	1.05	1.83	0.70	3.93*	3.29*	
32	Port Mellon	k	79	77	91	89	92	90	105	0.01
		ℓ	5	3	3	4	3	3	4	
		O/λ	0.96	1.22*	1.26*	1.14	1.22*	1.21*	1.11	
	Powell River	k	6	12	17	17	17	16	18	0.33
		ℓ	1	2	6	6	6	7	6	
		O/λ	2.76*	2.08*	0.87	0.88	0.81	0.67	0.92	
	Quesnel	k	16	15	18	19	11	5	20	0.04
		ℓ	9	7	3	9	2	1	9	
		O/λ	1.04	1.29	1.94*	1.15	1.96*	2.69*	1.12	
36	Nanaimo	k	41	28	50	49	51	27	30	0.08
		ℓ	7	1	7	5	5	1	1	
		O/λ	0.81	1.60*	0.89	1.10	1.10	1.47*	1.78*	
	Gold River	k	21	24	25	25	26	11	25	0.22
		ℓ	6	6	5	5	6	2	3	
		O/λ	0.96	0.91	1.10	1.08	0.99	1.99*	1.55*	
	Campbell River	k	27	30	31	31	32	10	24	0.28
		ℓ	6	6	5	5	6	1	2	
		O/λ	0.95	0.89	1.07	1.05	0.99	1.92*	1.47*	
38	Prince George	k	127	91	94	142	97	147	143	0.03
		ℓ	5	1	1	5	1	4	4	
		O/λ	0.96	1.37*	1.32*	0.93	1.28*	1.15	1.11	
	Port Mellon	k	931	958	985	990	53	54	53	0.00
		ℓ	4	3	3	3	1	1	1	
		O/λ	1.07	1.14*	1.10*	1.06*	1.30*	1.43*	1.41*	
	Quesnel	k	150	161	167	170	174	175	170	0.05
		ℓ	6	3	3	7	3	4	4	
		O/λ	0.97	1.17*	1.14*	0.94	1.18*	1.11	1.08	
	MacKenzie	k	125	91	94	138	97	144	140	0.13
		ℓ	5	1	1	5	1	4	4	
		O/λ	0.94	1.37*	1.32*	0.89	1.28*	1.02	1.06	
46	Prince George	k	153	109	112	168	114	174	167	0.01
		ℓ	5	1	1	5	1	3	3	
		O/λ	0.93	1.36*	1.41*	0.97	1.31*	1.14*	1.14*	
	Port Mellon	k	1142	1180	1201	1194	62	64	63	0.00
		ℓ	3	3	3	3	1	1	1	
		O/λ	1.06*	1.14*	1.10*	1.05*	1.25*	1.35*	1.30*	
	Nanaimo	k	264	280	292	298	315	325	183	0.59
		ℓ	5	5	5	5	5	3	1	
		O/λ	1.03	0.89	0.94	0.95	0.95	1.11*	1.26*	
	Quesnel	k	180	194	201	201	206	208	199	0.07
		ℓ	7	3	3	6	3	4	4	
		O/λ	0.95	1.16*	1.23*	0.99	1.20*	1.10	1.10	
	MacKenzie	k	149	109	112	163	114	170	164	0.14
		ℓ	5	1	1	4	1	4	4	
		O/λ	0.90	1.36*	1.41*	0.92	1.31*	1.03	1.05	

Table 13*a*: Female Focused Yearly Results Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
2	Port Mellon	k	5	29	30	23	28	21	30	0.05
		ℓ	2	4	4	5	3	6	6	
		O/λ	2.60*	1.24	1.28	1.31	1.61*	0.97	0.90	
4	Crofton	k	7	8	9	8	5	9	9	0.32
		ℓ	8	8	8	3	1	9	7	
		O/λ	1.02	1.48	0.83	2.18*	3.26*	0.46	1.17	
5	Port Mellon	k	7	8	123	122	113	123	129	0.07
		ℓ	1	1	5	3	5	6	5	
		O/λ	2.54*	2.40*	0.93	1.18*	1.00	0.96	0.97	
7	Port Mellon	k	10	12	11	13	12	14	16	0.04
		ℓ	12	5	5	6	7	3	5	
		O/λ	0.97	1.48	1.52	1.31	1.17	1.77*	1.41	
8	Castlegar	k	6	4	6	5	6	7	5	0.02
		ℓ	12	2	11	3	6	11	2	
		O/λ	0.83	3.12*	1.05	2.63*	1.89	0.67	3.33*	
9	Kamloops	k	3	3	2	2	3	2	3	0.02
		ℓ	33	20	1	3	20	1	7	
		O/λ	0.61	0.88	9.43*	8.59*	0.95	6.97*	1.34	
10	Nanaimo	k	9	6	8	10	7	7	11	0.00
		ℓ	7	1	5	5	1	1	7	
		O/λ	1.33	2.72*	1.61	1.57	2.98*	3.24*	0.95	
	Powell River	k	6	3	5	7	7	7	7	0.00
		ℓ	3	1	2	6	4	7	4	
		O/λ	2.91*	5.31*	3.13*	1.29	1.74	1.61	1.41	
	Gold River	k	3	5	5	6	6	6	6	0.01
		ℓ	2	5	4	7	3	8	7	
		O/λ	4.51*	2.92	2.75*	1.08	2.85*	1.75	1.29	
	Campbell River	k	3	6	6	7	6	7	7	0.00
		ℓ	1	3	3	7	2	8	6	
		O/λ	4.68*	3.13*	2.75*	1.29	2.89*	1.61	1.33	
13	Powell River	k	5	6	6	6	6	7	3	0.01
		ℓ	4	4	9	5	2	7	1	
		O/λ	2.12	1.80	0.69	2.12	2.93*	1.31	4.17*	
	Gold River	k	4	5	5	5	6	6	6	0.01
		ℓ	5	4	8	6	3	6	5	
		O/λ	2.20	2.59*	0.80	2.06	2.73*	1.54	1.80	
	Campbell River	k	5	6	6	6	6	7	7	0.05
		ℓ	5	6	12	5	2	8	6	
		O/λ	2.21	1.45	0.66	2.15	2.77*	1.30	1.60	
14	Prince George	k	7	6	6	7	5	8	9	0.04
		ℓ	7	5	6	6	1	7	7	
		O/λ	1.40	1.64	2.10	1.75	2.91*	1.22	1.14	
	Port Mellon	k	46	4	3	47	45	54	59	0.12
		ℓ	6	1	1	6	4	5	5	
		O/λ	0.99	3.96*	3.72*	0.90	1.17	1.05	1.00	
	MacKenzie	k	6	6	5	7	5	8	9	0.04
		ℓ	5	6	6	6	1	8	9	
		O/λ	1.72	1.79	1.66	1.72	2.91*	1.24	0.97	

Table 13*b*: Female Focused Yearly Results Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
15	Crofton	k	24	28	25	29	31	15	16	0.46
		ℓ	5	6	5	5	5	1	1	
		O/λ	0.89	0.86	1.01	1.12	1.02	1.64*	1.63*	
	Port Mellon	k	117	8	8	133	138	149	153	0.25
		ℓ	4	1	1	5	4	5	5	
		O/λ	1.04	2.34*	2.63*	1.00	1.07	0.99	0.93	
	Port Alberni	k	22	25	23	18	10	10	31	0.07
		ℓ	4	4	4	2	1	1	4	
		O/λ	1.34	1.15	0.93	1.65*	2.08*	2.35*	1.00	
	Powell River	k	18	8	19	21	22	24	9	0.01
		ℓ	3	1	5	4	3	5	1	
		O/λ	1.56*	2.70*	0.93	1.33	1.55*	1.08	2.20*	
	Gold River	k	15	17	16	17	18	19	21	0.03
		ℓ	3	3	6	5	3	6	5	
		O/λ	1.82*	1.85*	1.04	1.19	1.84*	1.34	1.28	
	Campbell River	k	15	17	19	21	18	24	25	0.02
		ℓ	2	2	6	5	2	5	5	
		O/λ	1.74*	1.88*	0.93	1.27	1.86*	1.31	1.17	
16	Crofton	k	21	24	22	25	26	13	14	0.40
		ℓ	5	6	5	5	6	1	1	
		O/λ	0.95	0.82	0.91	1.08	0.91	1.72*	1.74*	
	Port Mellon	k	102	7	7	115	115	127	129	0.16
		ℓ	4	1	1	4	4	5	5	
		O/λ	1.06	2.52*	3.24*	1.03	1.12	1.03	0.97	
	Port Alberni	k	19	21	19	23	8	9	27	0.33
		ℓ	4	4	4	4	1	1	4	
		O/λ	1.38	1.10	0.96	1.32	2.31*	2.13*	0.87	
	Gold River	k	13	15	13	15	15	17	18	0.03
		ℓ	3	3	6	5	3	6	5	
		O/λ	1.86*	1.76*	1.06	1.16	1.62*	1.30	1.17	
	Campbell River	k	13	14	16	19	15	21	22	0.05
		ℓ	2	2	6	6	2	5	6	
		O/λ	1.90*	1.79*	0.96	1.26	1.65*	1.25	1.09	
18	Port Mellon	k	8	36	10	4	48	58	51	0.03
		ℓ	2	6	2	1	4	5	6	
		O/λ	2.43*	1.06	2.30*	3.75*	1.18	0.96	0.87	
	Squamish	k	7	14	9	8	18	22	19	0.00
		ℓ	2	5	2	2	3	4	5	
		O/λ	2.33*	0.89	2.52*	2.19*	1.56*	1.40	0.91	
25	MacKenzie	k	5	5	3	4	4	4	5	0.29
		ℓ	22	28	2	3	26	23	28	
		O/λ	1.05	0.62	3.99*	3.08*	0.82	0.99	0.70	
27	MacKenzie	k	3	4	4	3	3	4	4	0.17
		ℓ	1	3	17	18	24	17	17	
		O/λ	4.48*	3.82*	0.97	0.83	0.81	0.79	0.99	
28	Port Alice	k	4	5	4	4	2	4	5	0.23
		ℓ	6	6	10	8	1	3	8	
		O/λ	1.12	1.27	0.66	0.67	7.21*	3.73*	0.77	
29	Nanaimo	k	4	4	5	4	4	5	5	0.18
		ℓ	1	1	9	9	9	8	8	
		O/λ	3.98*	3.66*	1.34	0.99	0.70	1.46	1.07	

Table 13*c*: Female Focused Yearly Results Site 1983–89

Site No.	Mill Location		1983	1984	1985	1986	1987	1988	1989	p_c
31	Nanaimo	k	16	14	15	11	19	17	19	0.32
		ℓ	6	8	3	1	7	7	7	
		O/λ	1.14	0.75	1.70*	1.96*	0.98	1.04	0.96	
35	Port Mellon	k	46	31	43	39	35	43	44	0.02
		ℓ	4	3	4	4	4	4	3	
		O/λ	1.23	1.39*	1.26	1.16	1.29	1.12	1.73*	
	Port Alberni	k	11	8	10	9	6	7	10	0.22
		ℓ	14	9	4	4	2	2	14	
		O/λ	0.48	0.79	1.21	1.09	2.50*	2.77*	0.61	
36	Kitimat	k	10	11	8	11	11	11	11	0.09
		ℓ	9	9	2	3	8	9	3	
		O/λ	0.95	0.87	2.15*	1.98*	1.05	0.88	1.80*	
	Port Mellon	k	9	10	188	10	174	181	183	0.11
		ℓ	1	1	5	1	5	5	5	
		O/λ	2.13*	2.17*	0.96	1.96*	0.94	0.95	0.98	
39	Prince George	k	7	12	9	12	9	14	13	0.10
		ℓ	1	14	1	16	1	15	6	
		O/λ	2.15*	0.77	1.97*	0.54	2.22*	0.83	1.11	
	Port Mellon	k	12	72	82	15	15	90	78	0.02
		ℓ	2	4	4	2	2	4	5	
		O/λ	1.81*	1.07	1.21	2.44*	2.18*	1.11	0.97	
	Squamish	k	11	24	27	13	13	30	26	0.13
		ℓ	2	5	5	2	2	5	5	
		O/λ	1.99*	1.06	1.23	2.35*	1.96*	1.11	0.89	
	MacKenzie	k	7	12	9	12	9	14	13	0.11
		ℓ	1	10	1	18	1	13	8	
		O/λ	2.15*	0.84	1.97*	0.52	2.22*	0.73	1.01	
46	Port Mellon	k	1045	155	48	1138	1176	1301	1291	0.55
		ℓ	4	2	1	4	4	4	4	
		O/λ	1.06	1.15*	1.34*	1.04	1.05	1.02	1.00	
	Skookumchuck	k	68	71	77	76	25	27	84	0.52
		ℓ	5	5	5	5	1	1	5	
		O/λ	1.09	0.91	0.87	0.90	1.48*	1.46*	0.81	