

Low Birthweights: Spatial and Socioeconomic Patterns in Kamloops

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This study examines the spatial patterns and socioeconomic correlates of low weight births (infants who weigh less than 2500 grams at birth) in Kamloops, BC between 1990 and 1995. "Natural" zones of low birthweight risk were identified by interpolating geocoded birth data to create a continuous surface map of low birthweight values. The zones were used in turn used to aggregate birth and socioeconomic data. Analysis indicates that low birthweight rates differ significantly across Kamloops, with the highest rates occurring in neighbourhoods on the North Shore. However, low birthweight rates were only moderately correlated with socioeconomic characteristics, with occupation being the strongest predictor. The results suggest, in line with other studies, that low birthweight is the product of a complex of factors, several of which are not captured by socioeconomic characteristics. Social networks, community resources, and the forces that shape them also appear to affect the risk for low birthweight.

Low birthweight is a key medical statistic. It is a proven predictor of infant mortality and childhood disabilities, including mental development (Köhler, 1991). Children who were low birth weight babies have smaller builds, more behavioural problems, and weaker language and cognitive abilities than their normal weight counterparts. A strong association with poor nutrition and high risk adult health behaviours (smoking, drug use, and physical inactivity) also links low birthweight to poor maternal health and poor adult health in general (Aber et al, 1997). Health officials closely monitor low birthweight rates, using them to gauge the average health and health needs of a community.

Low birthweight rates are widely recognized to be inversely correlated with socioeconomic status (Williams and Collins, 1995). However, the strength and character of the relationship is far from clear (Aber et al, 1997). Some studies indicate, for example, that the relationship is not linear while others suggest that a pregnant woman's risk for low birthweight is affected by her current and antecedent socioeconomic status (Starfield et al, 1991; Bell and Lumley, 1992). The relationship also appears to be modified and complicated by race (Aber et al, 1997), health behaviours (Cornelius et al, 1995), occupational hazards (Homer, 1990), access to health care (Baldwin, 1998), environmental and social stress (Lantz et al, 1998), and community networks (Roberts, 1997). Collectively this research suggests that variations in low birthweight rates cannot be explained by a simple socioeconomic model (Aber et al, 1997: 472).

This study is a modest test of the relationship between low birthweight rates and socioeconomic status. It examines the spatial pattern of low birthweight rates in Kamloops, British Columbia and compares their distribution to the socioeconomic pattern of its neighbourhoods. In contrast to most studies, this study uses natural areas rather than census tracts to aggregate birth and socioeconomic data. The procedures associated with this method are described as are general issues surrounding the analysis of low probability events like low weight births. The study concludes with a discussion of several alternative explanations for variations in low birthweight rates. The relevance of these explanations for Kamloops are weighed and directions for future research identified.

Low Birthweight and Socioeconomic Status

Many studies have reported strong inverse correlations between low birthweight and socioeconomic status (Binsacca et al, 1987; Mackenback, 1992; Mustard and Noralou, 1994; Williams and Collins, 1995). Measures of income, education, housing, and occupation in particular have shown strong correlations. Related family status variables have also proven significant, as have race and ethnicity (Binsacca et al, 1987; Polednak, 1991; Collins et al, 1997; Roberts, 1997). Crosse et al's (1997) ecological analysis of low birthweight rates in London, Ontario, for example, identified significant correlations for rates of low income, unemployment, low education, and unwed and teenage mothers. Unwed mothers was the most significant of these variables, accounting for almost two-

thirds of the variation in low birthweight rates. The authors also argue that low income ($r^2 = 0.54$) "could be used on its own as a reasonably good ecologic indicator of low birthweight" (1997: 60). This conclusion is supported by Binsacca et al's study of 3,978 birth records at an inner city hospital in California. After controlling for pregnancy complications, prenatal health care, health behaviours, and race, the researchers found that differences in financial problems experienced by the mother or her household during pregnancy were associated with a "six-fold increase in the risk of low birthweight" (1987: 505). Financial problems included unemployment, inadequate medical insurance, and insufficient funds for rent, food, or transportation.

The strong relationship between low birthweight and socioeconomic status generally, and low income specifically, is a logical one. Low birthweight is physiologically linked to poor maternal health which in turn is associated with poverty. Besides the connections noted in Binsacca et al's study, poverty may also increase the risk for low birthweight through stressful living and work conditions, greater substance abuse, and higher rates of teenage pregnancy (Aber et al, 1997). Teenage mothers typically have a higher risk of low birthweight than their older counterparts (Hardy and Zabin, 1991).

While the relationship between low birthweight and socioeconomic status is well documented, several recent studies and reviews have suggested that the relationship is more complex than acknowledged (Williams, 1990; Williams and Collins, 1995; Aber et al, 1997). This work argues that the character of the relationship can vary between populations and that contextual forces can affect the risk for low birthweight in ways that a simple socioeconomic equation often overlooks. Bell and Lumley's (1992) ecological study of low weight births in the state of Victoria, Australia, for example, suggests the relationship may not be linear. They grouped over 300,000 births into deciles using a postal code based measure of socioeconomic status. Only the lowest ranked decile had significantly higher rates of low birthweight. Differences between rates for the rest of the ranks were small and inconsistent. This result suggests the "marginal returns" of additional income on low birthweight diminish rapidly once a basic standard of living is achieved. The absence of a socioeconomic-health gradient among middle and upper income populations has also been detected in research on other health issues (Williams and Collins, 1995). American researchers have also noted weak low birthweight-income differences among Blacks. The low birthweight rate for Blacks is consis-

tently higher than white and Hispanic populations' at all socioeconomic levels. However, while white and Hispanic rates decline with income, Black low birthweight rates vary little by socioeconomic status (Starfield et al, 1991). This pattern has caused researchers to speculate that higher rates among Blacks are the product of historical and structural inequalities in American society (Lantz et al, 1998). More education, better jobs, and higher incomes apparently do not compensate for the adverse impacts of residential segregation and racial discrimination (Collins et al, 1997). Interesting geographic differences have also been reported. Collins et al (1997), for instance, have identified spatial association effects within neighbourhoods of Chicago. In particular, they found that low income mothers living in higher income areas have a lower risk for low birthweight than their counterparts in less affluent areas. This difference they believe is attributable to the varying strength of social networks within neighbourhoods. Other studies have come to similar conclusions, resulting in calls for greater exploration of the influence of social class, public policy, and the marketplace on low birthweight (Starfield et al, 1991: 601; Roberts, 1997; Wallace and Wallace, 1997). These arguments and their applicability to Kamloops are discussed in greater detail at the end of the paper.

Methodology

Most ecological studies of health and disease aggregate data into census tracts, postal zones, or health wards. This strategy results in efficient geocoding and provides for ready statistical comparison with a wealth of demographic, social, and economic data. Rushton et al (1995; 1996) have recently demonstrated, however, that these generic units may not provide the best method for identifying the real patterns in the data. Census tracts and their like can hide peaks and valleys in the data because their boundaries rarely correspond to the data's "natural" patterns. In their place, Rushton et al outline a method of spatial averaging and interpolation that transform the original point data into a continuous spatial distribution with values demarcated by isolines or choropleth shading. The techniques involved are not new (see Cole and King, 1968: 203-206). But they are ones that have only become feasible for large data sets with recent improvements in geographic information systems software.

The method used in this study combines the strengths of Rushton's method with the data advantages of census areas.

Rushton's procedures are used to create a continuous surface of low birthweight probabilities across Kamloops. This surface is used in turn as a guide for aggregating Enumeration Areas into low birthweight zones. Some of the accuracy of the continuous surface was thus sacrificed to increase analytical utility of the zones. Zone boundaries follow closely but not perfectly the contours of low birthweight probabilities in the city. The zones provide, nevertheless, a more detailed and meaningful spatial classification of the low birthweight data than census tracts can (Harvey, 1971; Openshaw and Taylor, 1981).

To construct the continuous surface, the birth data was geocoded by street address. Records of births to mothers residing in Kamloops between 1990 and 1995 were obtained from the British Columbia Ministry of Health. The data identified the year of the birth, birthweight, mother's age and home address. Of the 5278 births recorded, 5.3% had birthweights less than 2500 grams (the standard definition of a low weight birth). This rate is on par with the Thompson Health Region's but above the provincial average of 4.9% (British Columbia, 1996). The Thompson Health Region has the highest low birthweight rate in the southern interior. Only the Vancouver, Burnaby, Northern Interior, and Cariboo Health Regions have higher low birthweight rates in the province (British Columbia, 1995). Approximately 92% of the births were successfully geocoded on the first attempt. Corrections to misspelled street names increased the success rate to 98%.

A grid of 2,475 cells (0.25 km by 0.25 km) was placed over populated areas of the city to establish a sampling frame (Figure 1). The grid includes a buffer of cells about the periphery to reduce interpolation errors. Circular sampling areas with radii of 0.5 kilometres were centred about each cell (Figure 2). Each sampling area encloses approximately 0.75 square kilometres and overlaps with eight other sampling areas. The overlap helps to smooth the data in the same way a running average reduces noise and highlights trends in a time series (Olsen et al, 1996; Rushton and Lolonis, 1996). The number of births and low weight births in each sampling area were counted with GIS query commands (Figure 3).

The proper method for calculating the relative frequency and significance of health events, especially when small populations are involved, is an area of much experimentation. A variety of methods have been used in similar studies: rates and percentages, Bayesian estimates, chi-square values, and Poisson, binomial and Monte Carlo probabilities (Thomas, 1991; Devine et al, 1994; Olsen et al, 1996; Rushton and Lolonis, 1996; Crosse et al, 1997; Morphet,

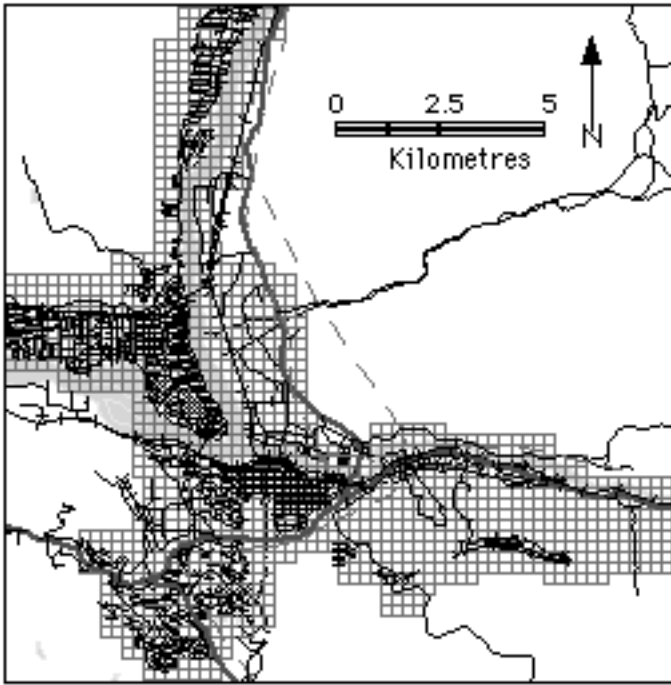


Figure 1 Sampling Frame

1997). For this study, a “difference from expectations” measure was created using binomial probabilities. It was assumed that the probability of low weight births follows a binomial distribution and that the probability that any single birth was less than 2500 grams was equivalent to Kamloops’ low birthweight rate (5.3%). Treating the number of births in a sampling area as equivalent to the number of trials in a binomial test, the expected number of low births was defined as the lowest number of low weight births (successful trials) for which the cumulative binomial distribution was greater than or equal to a critical probability value. Theoretically, the critical probability can be any value between 0 and 1 (0 and 100%). The value 0.5 was chosen because it represents an average result in the sense that 50% of the tests for a given sample size are expected to equal or exceed the number of successful trials (low weight births). The relative frequency and significance of low weight births was calculated by comparing the actual and expected numbers in each sampling area. This procedure moderates the influence that small sample sizes (birth counts). The continuous surface map was

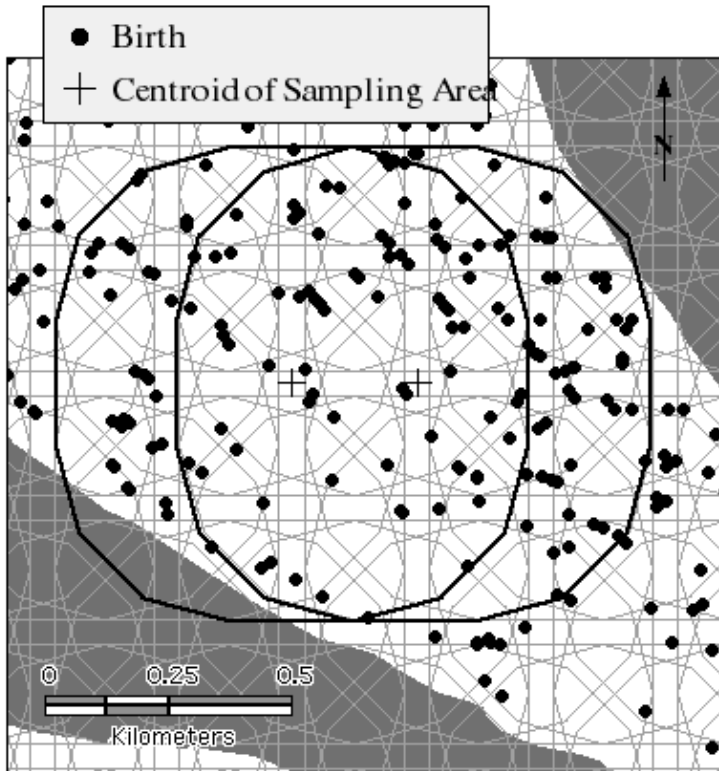


Figure 2 Sampling Areas Example

completed by interpolating the difference from expectations results in raster software. The results were assigned to 50 metre by 50 metre cells identified by the latitude and longitude of the sampling area's centroid. The values of cells between those with known values were established by inverse square interpolation. This method spatially limits the influence of extraneous values. In trials of different methods, inverse square interpolation produced the most accurate estimates of low birthweight values (Nelson, 1998).

Adjacent Enumeration Areas¹ with similar low birthweight values were grouped together to form zones approximately the size of a census tract (population between 3000 and 4000). The shape and variation in low birthweight values within some Enumeration Areas made it difficult to honour the low birthweight patterns precisely in all areas. Enumeration Areas that contained a range of low birthweight probabilities were assigned to zones

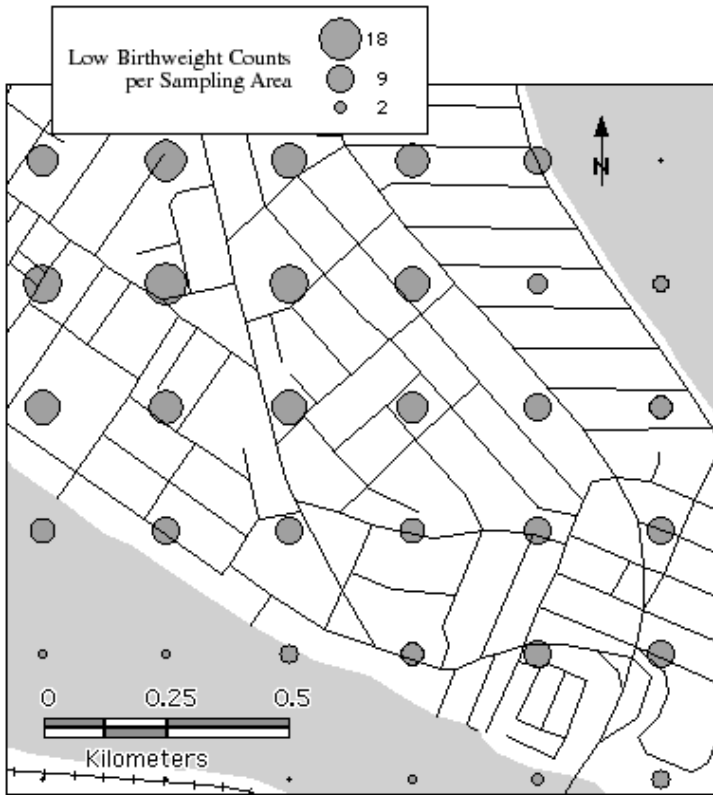


Figure 3 Low Birthweight Counts

according to their average "difference from expected" value. Physical boundaries such as highways, ravines, changes in elevation, and nonresidential land were respected where possible. Low birthweight and birth events within each zone were counted and converted to chi-square values. Chi-square values are recommended when working with proportions based on small samples (Jones and Kirby, 1980; Morphet, 1992). The chi-square conversion weights proportions by their sample size (the denominator in a rate), effectively discounting high rates based on small samples. Cumulative binomial probabilities for the low birthweight zones were also calculated and graphed.

Eight variables were selected on the basis of previous studies and in light of research on Kamloops' housing stock (Nelson et al, 1996) and patterns of teenage pregnancy (Nelson and Lu, 1997). The selected variables are average household income, occupation,

education, unemployment, housing quality, housing affordability, lone parent families, and aboriginal status. Occupation was defined as the percentage of employed persons working in white collar jobs (management, business, science, health, education, and government), education as the percentage that does not hold a high school diploma, and housing quality as the percentage of dwellings that requires major repairs (as identified by residents and not including renovations). The proportion of households spending more than 30% of their income on shelter was used to assess housing affordability and was interpreted as a measure of economic hardship. Enumeration Area level data were collected from the 1996 Census of Canada and aggregated by the low birthweight zones (Statistics Canada, 1996). The 1996 was used because it reflects the growth and structural changes the city has experienced recently. Kamloops' population increased by almost 10,000 or 14% between 1991 and 1996. Most of this growth has been concentrated in one quadrant of the city and is associated with the expansion of the region's tertiary and quaternary rather than resource sectors. The relationship between the low birthweight values and the socioeconomic variables was assessed using Spearman's rank correlation coefficient. A nonparametric test was used because of concerns about the unequal influence of small sample sizes. This concern is addressed shortly.

Results

The continuous spatial pattern of low birthweight probabilities is shown in Figure 4. Also shown are the fifteen low birthweight zones derived from this surface. Enumeration Areas within the Kamloops Indian Band Reserve were not included because of geocoding concerns and small sample sizes. The low birthweight and birth counts, cumulative binomial probabilities, chi square values, and rates for each zone are shown in Table 1. The statistical significance of the binomial probabilities is shown in the accompanying needle chart (Figure 5). The horizontal line running through the centre identifies the overall low birthweight probability for Kamloops. The points on the vertical lines that stem from the centre line show the low birthweight rate for each zone. The short, dashed horizontal lines on either side of the centre line are the Upper and Lower Control Limits. They identify sample size adjusted significance levels. Low birthweight rates that cross these levels are significantly different from the Kamloops average.

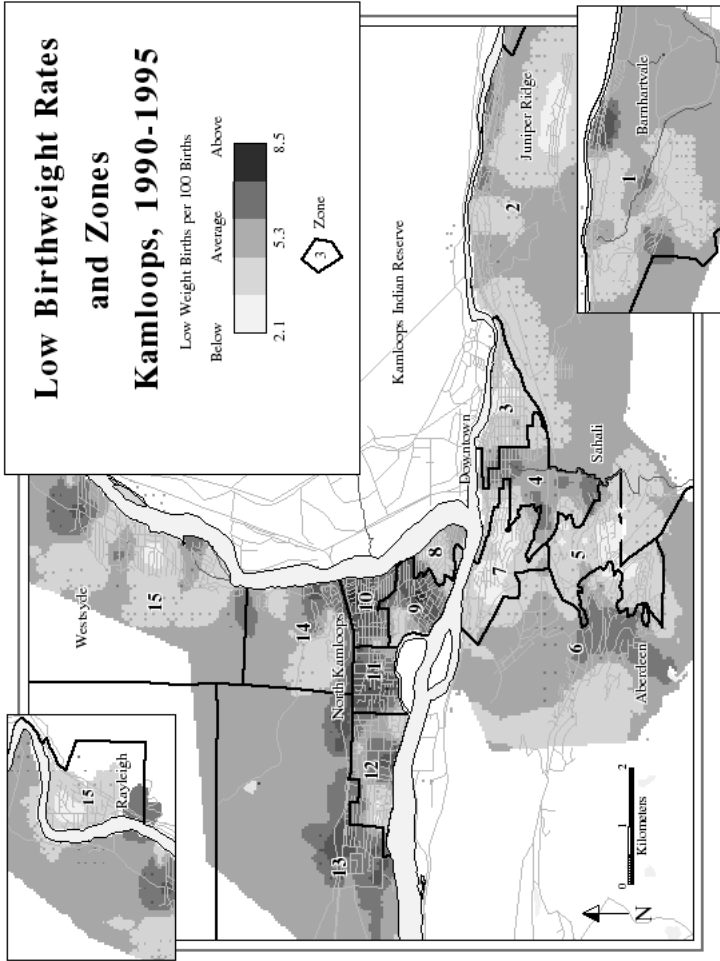


Figure 4 Low Birthweight Rates and Zones

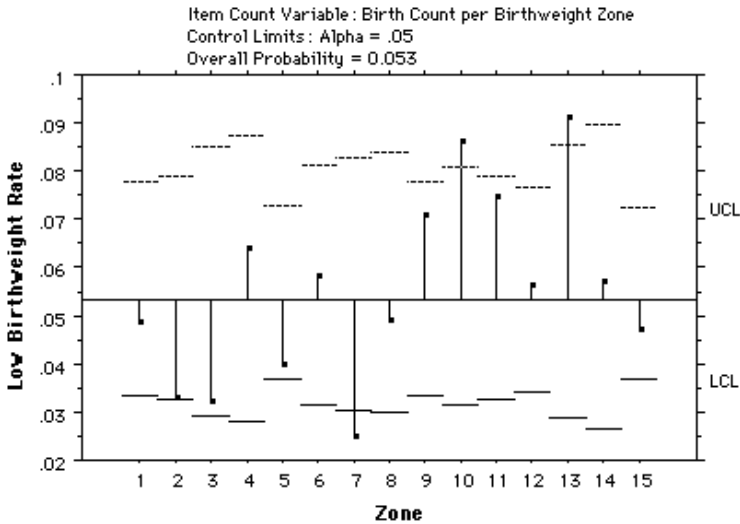


Figure 5 Needle Chart Showing the Statistical Significance of Low Birthweight Proportions per Low Birthweight Zone

The results clearly show that the low weight births vary dramatically across Kamloops. Most noticeably, there is a sharp discrepancy between low birthweight statistics north and south of the Thompson River. The highest values are found about Bert Edwards Elementary in North Kamloops (zone 10) and along Ord Road and in the western sections of Brocklehurst (zone 13). The binomial probabilities are statistically significant for these areas. Two other high value zones are located to the south and west of zone 10. Zone 11 is centred on Singh Street while zone 9 cuts across Tranquille Road and Fortune Drive, the major thoroughfares on the North Shore. The cumulative binomial probabilities for zone 11 exceeds 0.95 but falls short of the sample size adjusted critical levels. The low birthweight rates for these zones vary from 7.12 to 9.17 per hundred births. These rates are high but not extreme. Only one of the thirteen areas in a recent Vancouver study had a rate greater than 7.5% while 5 of the 31 in a study of London, Ontario exceeded this level (British Columbia, 1995; Crosse et al, 1997). Rates in inner city neighbourhoods in large American cities, by comparison, can approach 20% (Roberts, 1997). The pattern of high rates on the north shore is broken up by average values in zones 8 and 12. Zones 14 and 15 contain a mixture of values.

Table 1 Low Birthweight Counts, Probabilities, Indexes and Rates for Low Birthweight Zones, Kamloops, BC, 1990 to 1995

<i>Low Birthweight Zone</i>	<i>Low Weight Births</i>	<i>Total Births</i>	<i>Low Birthweight Measures</i>		
			<i>Cumulative Binomial Probability</i>	<i>Chi-Square Value</i>	<i>Rate</i>
1	19	387	0.326	-0.20	4.91
2	12	361	0.028	-2.83	3.32
3	8	245	0.048	-2.07	3.27
4	14	217	0.731	0.37	6.45
5	24	594	0.063	-1.98	4.04
6	18	307	0.628	0.08	5.86
7	7	278	0.007**	-4.19	2.52
8	13	262	0.357	-0.12	4.96
9	28	393	0.925	1.84	7.12
10	27	312	0.990 *	5.48	8.65
11	27	359	0.953	2.60	7.52
12	24	423	0.595	0.03	5.67
13	22	240	0.990 *	5.75	9.17
14	11	191	0.561	0.03	5.76
15	29	610	0.240	-0.50	4.75

* = Statistically Significant High Probability

** = Statistically Significant Low Probability

Low birthweight rates are, with two exceptions, less than the Kamloops average in zones south of the Thompson River. Values are particularly low in the West End-College Heights-Lower Sahali (zone 7) and Valleyview-Juniper Heights (zone 2) neighbourhoods. The binomial probability level for zone 7 is statistically significant while zone 2 is borderline. Low birthweight values are also low in zones 3 and 5 (Upper Sahali-Western Aberdeen). Low birthweight proportions are just below or above average elsewhere on the south shore.

The immense spatial variability of low birthweights across Kamloops was not unexpected. The revealed pattern is very similar to those for teenage pregnancy and housing problems (Thompson Health Region, 1997; Nelson et al, 1996). The pattern also reflects the substantial social discrepancies and geographical isolation of the city's neighbourhoods. These similarities are partially substantiated by the Spearman rank correlation results (Table 2). The per-

cent white collar occupation and average household income were both significantly and inversely correlated with the low birthweight values. However, the correlations for the other independent variables range from mild to weak. The small number of significant correlations is interesting considering the collinearity of the independent variables. Unemployment, major repairs, aboriginal status, and average income are significantly correlated with all of the other independent variables (not including low birthweight), lone parent and occupation with all but one, and education and unaffordable housing with all but two. A stepwise regression indicated that occupation was the only critical independent variable, explaining 43% of the variation in low birthweight rates. Overall, these results suggest, in line with arguments by Roberts (1997) and Aber et al (1997), that the relationship between low birthweight and socioeconomic status is complex and that other factors are at play.

Table 2 Spearman Rank Correlations Coefficients

χ^2 Low Birthweight versus	<i>Rho</i>	<i>p value</i>
Average Income	-0.606	0.023*
White Collar Occupations	-0.658	0.014*
No High School Diploma	0.483	0.071
Unemployed	0.463	0.083
Poor Housing	0.397	0.138
Unaffordable Housing	0.332	0.214
Lone Parent	0.324	0.324
Aboriginal	0.372	0.164

* = Significant at $p = 0.05$

Methodological Concerns

The probability and correlation results must be interpreted cautiously for a couple of reasons. Most notably, the sample sizes—the number of births per low birthweight zone—are small in statistical terms. The median standard error is +/- 45% of the zones' rates at the 95% probability level. Real rates could thus vary considerably from those calculated. This problem is a function of the relatively low rate of low birthweight events (less than 10%) and is thus not unique to this study. All low birthweight studies that use census tract sized zones have large standard errors. In large cities, the obvious solution is to aggregate spatial units until adequate sample sizes are reached. Unfortunately this solution is not feasible in smaller or even mid-sized (500,000) urban areas. Using the over-

all rate of 5.3%, zones containing approximately 3500 births are required for reliable estimates (standard errors of +/- 10% of the rate). This requirement is more than half the total sample (N = 5278). The sample size could be increased by extending the time frame. However, this option risks confusing spatial differences with longitudinal changes.

The use of natural spatial units may also affect the results. Low and high rates and probabilities should be more extreme for natural areas than for areas identified by other criteria. However, in this case, the impact of the spatial units does not appear to be severe. The boundaries of the low birthweight zones and Kamloops census tracts are generally similar, with those for two of the highest zones on the North corresponding exactly to census tract boundaries (Figure 6). The most significant discrepancies between boundaries are found in areas of low birthweight rates on the south shore. The use of natural areas may also affect the correlation results. Natural areas minimize the variance of low birthweight rates within zones. The opposite should be true, in contrast, for socioeconomic variables, especially in comparison to Census Tracts. The impact of the spatial units was checked by aggregating the data by Census Tracts and recalculating the descriptive and analytical statistics. Variances for the dependent and independent measures varied as expected. However, none of the correlation coefficients changed dramatically: occupation and average household income were the only significantly correlated variables.

Another potential source of error is the ecological design of the study. The backgrounds of the mothers of low birthweight babies were assumed to be equivalent to the character of Enumeration Areas in which they live. This assumption may not be valid. The correlation results suggest that their socioeconomic status is probably lower than average. It is not clear, however, how this possibility may affect the results since it should apply in all areas. If low birthweight rates are associated with social status then the link should be evident in the general character of the Enumeration areas.

Alternative Explanations for Variations in Low Birthweight Rates

If the methodology and results of this study are sound, what other factors may contribute the spatial pattern of low birthweight rates in Kamloops? The literature suggests four key possibilities: health risk behaviours, prenatal care, occupational health risks, and

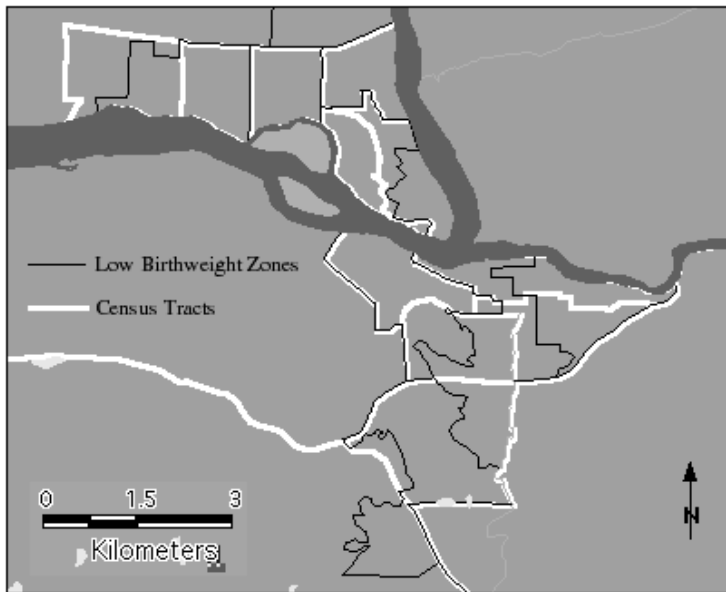


Figure 6 Low Birthweight Zones and Census Tracts

neighbourhood effects. The connection between these factors and low birth weight is explored below. Environmental factors such as air (Berry and Bove, 1997) and water quality (Foster, 1992; Bove, 1996) and diet (Godfrey et al 1997), especially zinc consumption (Neggers et al, 1991), may also affect the pattern of low birthweights but are not addressed.

Many studies have identified a link between the low birthweight and physical inactivity and tobacco, alcohol, and drug consumption (Kramer, 1987; Bakketeig et al, 1993; Cornelius et al, 1995). These health risk behaviours are commonly assumed to be related to socioeconomic status (Williams and Collins, 1995; Marmot et al, 1995). If true, their influence should be reflected in the independent variables. There is some evidence, nevertheless, that the relationship may not be linear. As cited earlier, a study by Bell and Lumley (1992) found that smoking, socioeconomic status, and low birthweight rates were connected only for women from impoverished backgrounds. The link here may be the use of tobacco as an appetite suppressant: smoking reflects and amplifies the effect of inadequate income on nutrition. Other studies that control for health risk behaviours have also documented a weak relationship with socioeconomic status. Binsacca et al (1987) and Lantz et al

(1998), for example, found that the explanatory value of socioeconomic status is largely unaffected by, and only modestly augmented by, behavioural variables. Williams and Collins (1995) similarly note that Blacks have higher low birthweight but lower smoking rates than whites. Taken together, these studies suggest that health risk behaviours may inflate high rates in areas of lower socioeconomic status, but that their contribution to the broader pattern is probably marginal.

Access to prenatal care services has also been identified as a low birthweight risk factor. Yet, like the research on health behaviours, the evidence is mixed. On the positive side, a study of the impact of prenatal care in Washington State found that low birthweight rates decreased after services were expanded (Baldwin et al, 1998). The decrease was most noticeable for mothers in high risk categories (including teenagers). This finding is supported by Gortmaker (1979), Roberts (1997) and Binsacca et al's (1987) analyses of low birthweight rates, and by general studies of the relationship between socioeconomic status and the use of health care (Williams, 1990). These studies draw attention to the relative lack of quality health services, transportation, and social-care networks in poorer neighbourhoods (Collins et al, 1997). Other research suggests, however, that the impact of health care is overstated. For example, a comparative study of prenatal care in Washington state and British Columbia "found little relationship between the utilization of prenatal care (as expressed by the timing and number of visits) and low birthweight" (Katz et al, 1994: 989). In a study of low birthweight in Winnipeg, mothers of lower socioeconomic status used prenatal care services less frequently than their more affluent counterparts (Mustard and Noralou, 1994). The authors were unable to prove, however, that this difference affected low birthweight rates or weights. After controlling for socioeconomic differences, health behaviours, and other risks (demographic, health), prenatal care added little to the explanatory model, even for complicated pregnancies. The authors suggest this finding may indicate that many health risks (poor nutrition, occupational stress and activity) associated with low birthweight are "beyond the reach of prenatal medical care" (1994: 1465). If these arguments hold for Kamloops, a small city in a country with universal health care, differences in prenatal care probably do not contribute significantly to its low birthweight pattern.

Occupation was the most important independent variable in this study, accounting for 43% of the variation in low birthweight rates. This result supports health studies that use occupation as a

stand alone measure of socioeconomic status (Marmot et al, 1995). Occupation reflects education and is a strong predictor of income and social and cultural status. In this study, occupation was significantly correlated with every variable except unaffordable housing. It is also thought that occupational differences in physical activity, stress, and working conditions may affect low birthweight rates (Homer et al, 1990; Williams and Collins, 1995; Aber et al, 1997). Lower skilled and paid occupations, especially those in the personal service and manufacturing industries, can require prolonged standing, repetitive movements, heavy labour, exposure to toxins, and irregular shifts. They may also provide less job security and be more inflexible about maternity leaves. The collective impact of these factors is difficult to gauge. Only a few known studies have directly weighed their influence. These studies indicate, nonetheless, that occupational stress and physical exertion are significant predictors of pre-term, low weight births (Homer, 1990). The data used in this study cannot confirm these results since they describe the prevalence of occupational category in a zone, not the occupation of women who gave birth to low weight infants. Still, the strong correlation and theoretical suggestions recommend greater investigation of the link between low birthweight and occupation in Kamloops.

The fourth possibility—neighbourhood effects—offers the broadest explanation of variations in health. Neighbourhood effects refer to the influence of a neighbourhood's social networks, employment base, political policies, resources (including medical services), and environment (housing stock, pollution, maintenance) on the economic well being, educational attainment, and health of its residents (Corcoran, 1995). Recent research into neighbourhood effects is stimulated by Wilson's (1987) and Jencks and Peterson's (1991) much debated work on impoverished inner city neighbourhoods. This research tries to explain why poverty persists within some areas to a degree that cannot be satisfactorily explained by the individual characteristics of its residents.

Several medical studies explore the importance of neighbourhood effects. Roberts (1997) study of low birthweight in Chicago, for example, examines the explanatory value of community measures when individual characteristics (including ethnicity, socioeconomic status, health risk behaviours, prenatal care) are held constant. His analysis reveals significant links between low birthweight rates, ethnicity and socioeconomic measures at the community scale. These results cause the author to call for more research into the forces—residential segregation, social stratifica-

tion, and community dynamics—that “mobilize and distribute resources to promote maternal health” (1997: 602). Unemployment and poverty negatively affect low birthweight rates because they “undermine the cultural standards in a community”, erode support networks, and ultimately alter its socioeconomic and ethnic makeup as residents relocate to more stable environments (1997: 601).

Roberts’ findings are supported by Lantz et al’s (1998) longitudinal investigation of the relationship between mortality and socioeconomic characteristics and health behaviours. The authors found that the correlation between health behaviours and socioeconomic status was insufficient to explain mortality differentials between social classes. They subsequently question the impact of health policies that focus on individual risk behaviours, especially for persons of lower socioeconomic status. They speculate that “socioeconomic stratification itself may be a social force that has deleterious health effects for those in the lower strata” (1998: 1707). Critical social forces include little social support, low self-esteem and hostility, and chronic stress, “including the stress of racism, classism, and other phenomena related to the social distribution of power and resources” (1998: 1707). Wallace and Wallace (1997) offer a similar explanation for the results of their analysis of health problems in large American cities. In particular, they point to the impact of a neighbourhood’s “weak ties” on health. Weak ties, as opposed to the strong ties of families and ethnic groups, are “relations of occupation, common interest, and neighbourliness ... [that] bind small groups tightly” in social space. Weak ties are channels through which “information, support, and social control” pass from the larger society to smaller groups and individuals (1997: 1343). Deleterious public policies, economic decline, relocation, social isolation, and other negative forces can sever these ties, destabilizing the community and its support network and increasing stress, antisocial behaviour, and health problems.

The most vigorous test of the relationship between neighbourhood effects and low birthweight is a study by Collins et al (1997). The authors classified over 70,000 births in Chicago by weight, census tract, and the mother’s income incongruity. Income incongruity is a measure the authors develop to determine if a mother’s socioeconomic status differs from the norm in her neighbourhood (controlling for ethnicity, age, and marital status). They use this measure because they feel that traditional measures of socioeconomic status fail to fully assess a neighbourhood’s “community wealth”. Community wealth is similar to the “weak ties”,

social networks, or community resources described earlier. It summarizes the social advantages that accrue to residents from safe environments, well maintained housing, political connections, active community associations, and access to quality medical care and education. Although typically associated with higher socioeconomic groups, persons of lower status acquire these social advantages by living in, or close to, neighbourhoods with greater community wealth. For the study, income incongruity was said to exist if the mother lives in a neighbourhood whose average socioeconomic status is either greater (positive income incongruity) or less (negative) than her own. Critical levels were set at one standard deviation above and below the median family income of the mother's census tract. Analysis of the data confirmed expectations: mothers with positive income incongruity were less likely to have low birthweight infants than those with no or negative income incongruity.

The size and racial composition of Chicago and Kamloops are dramatically different. Nevertheless, the logic behind positive income incongruity, weak ties, and community wealth may help explain some of the lower than expected rates south of the Thompson River and the extreme rates in North Kamloops neighbourhoods. Zone 4 has the highest rate on the south shore. Its rate, nevertheless, is slightly less than its occupation and household income values predict. Zone 4 has the highest percentage of people in unaffordable housing situations. It also contains three of the four Enumeration Areas with the lowest average household incomes in the city, and collectively has one of the highest rates of unemployment in the city (15.7%). The southern end of this zone is sandwiched, however, between two of Kamloops' most affluent neighbourhoods (Figure 7). City planning policies are largely responsible for the wide range and proximity of social classes here (Kamloops, 1997). This area is also well served by schools and medical services and located next to the city's most vibrant commercial area. The northern end of the zone is dominated by high density accommodation—including boarding houses, residential hotels, and seniors' complexes—and commercial and industrial structures. The central business district, regional hospital, law courts, and "zone of transition" are found here. A considerable portion of the housing stock on either side of this zone has been renovated over the past decade. This activity is thought to be indicative of social upgrading in Kamloops' older, inner city neighbourhoods (Stewart and Moore, 1997). It also reflects efforts by city planners to revitalize the area by building on its character and "livability" (Kamloops, 1993). Zone 3

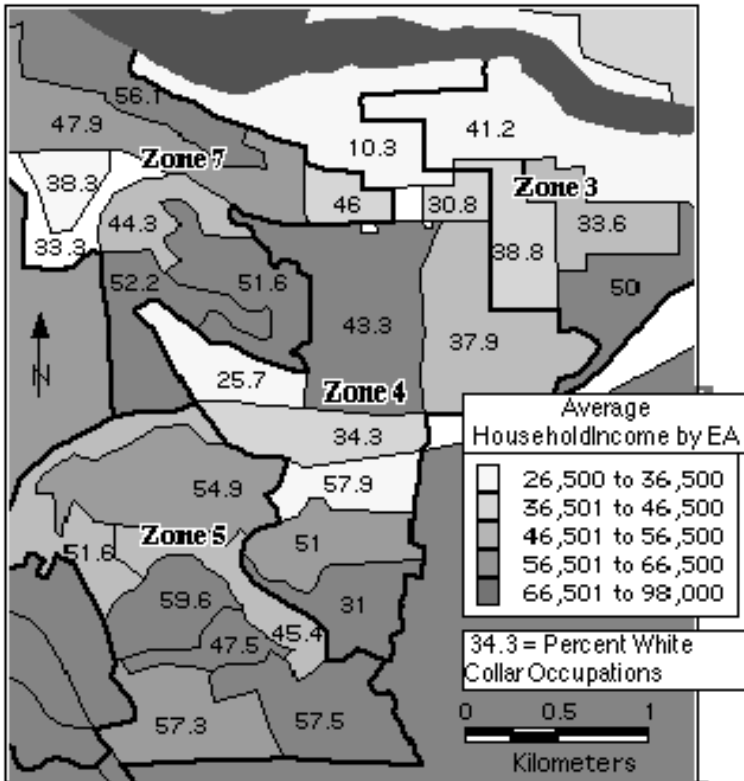


Figure 7 Socioeconomic Status—South Kamloops

is an area popular with young families and professionals. It is close to civic services, cultural amenities, and employment opportunities and offers a varied housing stock in terms of age, style, and price. A number of the homes along its busiest streets have been converted to “store fronts” by doctors, lawyers, accountants, lawyers, and small business owners. This zone has median ranks for most of the independent variables yet has the third lowest low birthweight probability in Kamloops. Zone 7, which has the lowest low birthweight rate in the city, has a higher average social status than zones 3 and 4. This zone has the third highest percentage of people in white collar occupations and the second highest with high school diplomas. Professionals are attracted by its large heritage homes, views, and proximity to quaternary sector employment including the region’s post-secondary institution. This zone also has pockets of multifamily units and an area of older, less desirable homes that

were built outside Kamloops' previous city limits. The Enumeration Areas associated with this housing stock are clearly evident in Figure 7. Like zones 3 and 4, more than one-fifth of the households are headed by a single parent.

From a neighbourhood effects perspective, the diversity of social groups in these zones is critical. Positive income incongruity can only exist by definition, and the filtering of community wealth occur, in areas of mixed social status. Of course, the existence and mechanisms of neighbourhood effects and their influence on low birthweight rates requires empirical verification. From a statistical and geographical standpoint, nevertheless, the theoretical possibilities are attractive. Statistical tests assume that observations (low birthweight events) and subjects (low birthweight zones) are independent of another. This assumption, however, seldom holds. Areas interact with other areas, with the degree of interaction declining with distance. This interaction causes adjacent areas to be more similar than those that are distant. On the south shore, this spatial correlation may be responsible for the lower than expected low birthweight rates and thus for the inconsistencies of the statistical results.

In contrast to the undulations and sharp gradients of the south, the socioeconomic landscape of North Kamloops is flat (Figure 8). Zones 8 through 11 encompass a relatively uniform lower socioeconomic area, unpunctuated nor ringed by higher status neighbourhoods. This area has high rates of teenage pregnancy, welfare dependency, and single parent households (Thompson Health Region, 1997). Smaller, older bungalows and duplexes, interspersed with mobile home parks, and concentrations of subsidized, multifamily housing are common. Property is less well maintained and sidewalks and curbs almost nonexistent. Crime rates are higher. Several schools have closed. Commercial areas have been recently upgraded but are of declining significance within the regional economy (Kamloops, 1995). Second-hand stores, social service agencies, automobile repair shops, and empty lots are common along Tranquille Road in zone 9 while vacancy rates are high in the regional shopping mall. Perhaps the best measure of the economic and social challenges faced in the area is the participation of its four elementary schools in the province's Inner City, Meals, and Community Schools Programs. The first two provide funds and expertise to run learning assistance and breakfast and lunch programs in schools in lower income areas. The objective of the Community Schools initiative is to increase community involvement in the schools through the provision of social, recreational,

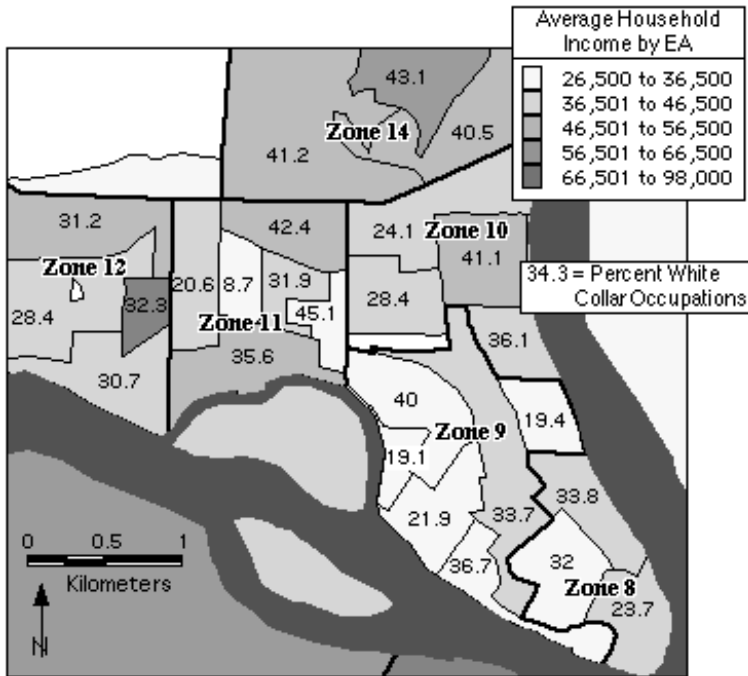


Figure 8 Socioeconomic Status—North Kamloops

and personal development activities. It seeks to raise the profile of education, improve parenting, and strengthen neighbourhoods' social networks. Schools in this area have more socially dysfunctional students, lower achievement records, less parental involvement, and higher rates of absenteeism and student mobility (Bert Edwards Elementary School, 1998). An estimated 67% of single parent families and 19% of two parent families live below the poverty line in the most affluent neighbourhood in this area.

This evidence is consistent with observations offered by Roberts (1997), Collins et al (1997), and Wallace and Wallace (1997) about the relative character of neighbourhoods lacking in community wealth and resources. It also appears to support speculation that insufficient community wealth can negatively affect the health of high socioeconomic status households, causing rates to be lower than expected (Williams and Collins, 1995). Despite the parallels, it must be stressed that residents of the north shore do not constitute an underclass in the way that Wilson (1987) suggests that people living in impoverished and racially segregated neighbourhoods of

large American cities do. The average household income for zone 10, which has the second highest low birthweight probability in the city and the highest in this area, is well above the poverty line and only 10% below the average in zone 4. Two-thirds or more of the population 15 years and older in these zones holds a high school diploma while 30% are employed in white collar occupations. With the exception of zone 9, the proportion of single parent families is on par with zones 3, 4, and 7. It must also be stressed that the relationship between neighbourhood effects and low birthweight rates requires empirical verification. The argument does not account, for example, for the lower than expected rates in zones 8 and 12. These anomalies may be products of random variations in the data or thorns in the side of theoretical explanations.

Community wealth is not solely the property of the affluent and the educated. Several studies of low income Black neighbourhoods have documented the existence of extensive care networks (Roberts, 1997). Jacobs (1961) has made similar arguments about the vitality of inner city neighbourhoods generally, a vitality that is often transparent to outsiders. Obviously, community wealth is not the aggregate of a neighbourhood's socioeconomic characteristics (Collins et al, 1997). Yet neither is it spatially nor historically accidental (Roberts, 1997). Community wealth is the geographical and historical product of a complex of social perceptions and biases as well as economic, political, and infrastructural decisions. Implicated in Kamloops are the legacy of once independent urban entities and their unequal zoning standards², the cyclical economy of the region's resource industries, and recent private and public decisions that have concentrated new residential and commercial development in the southwest quarter of the city. No less important are the topographical isolation of the North Shore, the fragmentation of its residential areas by major thoroughfares, and entrenched public beliefs about the safety of its neighbourhoods. The unequal social and geographical distribution of community wealth and low birthweights may represent patterned responses to these factors (Williams, 1990).

Conclusion

This study has shown that the spatial distribution of low weight births in Kamloops is far from even. Rates are much higher in neighbourhoods on the north shore. In several cases the frequency of low birthweights in its neighbourhoods exceeds the statistical probabilities that could have arisen through random variation. This

study has also shown the spatial distribution of low birthweights is related to, but not entirely explained by variations in socioeconomic status. This result conforms to other research that argues that variations in low birthweight are the complex product of individual and contextual factors. The results of this study must be interpreted cautiously. The standard errors of the low birthweight rates are high. Furthermore, the absence of data about individual mothers limits conclusions.

Of the four additional theories considered, occupational risks and neighbourhood effects seem to have the most explanatory value. Occupational risks include stress, strenuous activity, and exposure to noxious substances. While only a few studies have explicitly examined the link between these risks and low birthweight, health officials may want to study their importance because of the strong correlation between occupation and low birthweight rates. Data for the study should be collected from individuals and should try to control for individual health risk behaviours and the use of prenatal care. The neighbourhood effects perspective is structural. It argues that a neighbourhood's spatial and historical contexts can affect the health of its residents. This perspective thus looks beyond individual risk factors to the collective impacts of social networks, neighbourhood resources, private and public sector policy decisions, and the built environment. Neighbourhood effects reflect but are more than the sum of a community's socioeconomic characteristics. As such, their role is probably greater in neighbourhoods whose low birthweight rates are more or less than their socioeconomic characteristics suggest. Future research could explore the importance of neighbourhood effects by replicating Collins et al (1997) "income incongruity" study. Researchers may also want to consider a strategy for identifying the mechanisms that link individual health to geographical and historical contexts. A comparative ethnography of neighbourhoods with similar socioeconomic characteristics but different low birthweight rates may be one way to proceed.

The importance of socioeconomic conditions and contextual forces legitimizes the need for community and regional health. Community health agencies play a lead role in efforts to reduce low birthweight rates by evaluating prenatal care, cooperating with other agencies, and monitoring and shaping the actions of the private and public sector. The connection between health and planning agencies is particularly key. The evidence and theories examined suggest that the primary cause of the difference in low birthweight rates between the north and south shores is the relative

mix of socioeconomic groups. Community health officials should thus actively support the city's goal of ensuring a broad range of housing in all neighbourhoods (Kamloops, 1997). As Gortmaker (1979) and Williams (1990) argue, the "elimination of inequalities in health status" requires more than advances in medical care; the socioeconomic conditions of the disadvantaged, of the less healthy, must also be addressed.

Notes

1. Enumeration Areas (EAs) were used to simplify the aggregation of census data. However, low birthweight zones could be delimited more precisely. For example, the data for an EA could be assigned to a low birthweight zone in proportion to the area of the EA within the zone. If an EA had one-half of its area in a zone, then one-half of its households, housing, unemployed, etc. would be assigned to that area. This method was not chosen because many EAs in Kamloops contain large chunks of non-urban land that would have reduced the data associated with a zone. This method also assumes that the characteristics of an EA are distributed evenly. This assumption is often incorrect in Kamloops.
2. Kamloops, North Kamloops, Rayleigh, and Valleyview were amalgamated in 1974.

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