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Autumn 1998 Volume 10 No. 2

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Research Articles

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Multiple-risk behaviour in adolescents and young adults

Abstract

Objectives

This article examines the prevalence of four risk behaviours among teenagers and young adults: smoking, binge drinking, sex with multiple partners, and sex without a condom.

Data source

The data are from a Health Canada-sponsored supplement to the 1994/95 National Population Health Survey. The analysis is based on 905 respondents aged 15 to 19 and 1,055 respondents aged 20 to 24.

Analytical techniques

Prevalence estimates of the four risk behaviours were calculated for males and females in each age group. An index of multiple-risk behaviour was derived by summing the four risk behaviours. Hierarchical multiple regression was used to examine how sets of variables are related to multiple-risk behaviour.

Main results

Multiple-risk behaviour was higher among young people who had never married, who were not students, and who did not live with a parent. Feeling distressed was positively linked with multiple-risk behaviour, while regular attendance at religious services was negatively linked with such conduct.

Key words

risk behaviour, adolescence, smoking, drinking behaviour, sexual partners, condoms

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Youth is a time for experimentation, even—and maybe especially—if the activities involve an element of risk. A sense of invincibility, combined with bravado, may increase the appeal of behaviour that is frowned upon by older adults. But not all young people are equally likely to indulge in activities that might jeopardize their health and safety. The circumstances of some teenagers and young adults seem to deter them from taking risks, while the situations of others act to facilitate involvement in potentially hazardous practices.

Risk behaviours, which generally first emerge during adolescence, have important implications for individual psychological and physical health, both in the short- and long-term. Risk behaviour that is tried out during adolescence is not necessarily abandoned in adulthood. As well, some practices, such as driving while intoxicated, present health hazards to others. Because these activities entail substantial economic and social costs to the health and well-being of individuals and also to society, it is important to understand on a national level the extent of young people's involvement in them.

While most young people will experiment with at least one potentially hazardous behaviour, a minority will engage in several. Individuals who engage in multiple-risk behaviour are of special concern, because they are most likely to develop immediate and longer-term health problems. However, relatively little is known about the prevalence of multiple-risk behaviour during adolescence and early adulthood.

Methods

Data source

The analysis in this article is based on the household component of a Health Canada-sponsored supplement to Statistics Canada's 1994/95 National Population Health Survey (NPHS) for the 10 provinces. An institutional component of the survey, which covered residents of long-term health care facilities, was excluded from the analysis.

The household component of the NPHS sample consisted of 27,263 households, of which 88.7% agreed to participate in the survey. After the application of a screening rule to keep the sample representative,[1] 20,725 households remained in scope.

One knowledgeable person in every participating household provided general socio-demographic and health information about each household member. In total, data pertaining to 58,439 individuals were collected. (The data base containing these data is called the General file.) In addition, one randomly selected person in each of the 20,725 participating households was chosen to provide in-depth information about his or her own health. In 18,342 of these households, the selected person was aged 12 or older. The response rate to these in-depth health questions was 96.1% or 17,626 respondents. (The data base containing in-depth health information as well as data from the General file pertaining to these respondents is called the Health file.)

Of the 17,626 randomly selected respondents aged 12 and older, 14,786 were eligible members of the NPHS longitudinal panel. These respondents were also eligible for the Health Canada supplement. The response rate to the Health Canada-sponsored questions was 90.6%. (The data base containing information from the Health Canada supplement as well as data from the General and Health files pertaining to these respondents is called the Supplementary file.)

The analysis of risk behaviour among young adults in this article is based on the supplemental Health Canada-sponsored questions. The data reported here pertain to 905 respondents aged 15 to 19 (431 males and 474 females) and 1,055 respondents aged 20 to 24 (489 males and 566 females).

Data on 1994 motor vehicle accident fatalities are from the Canadian Vital Statistics Data Base. Information on 1996 impaired driving charges is from the Canadian Centre for Justice Statistics at Statistics Canada.

Analytical techniques

Four commonly studied risk behaviours were selected from the NPHS Supplementary file: smoking, binge drinking, sex with multiple partners, and sex without a condom (see *Risk behaviours* and *Limitations)*. Each behaviour was dichotomized as either risk absent (0) or risk present (1). An index of *multiple-risk behaviour* was derived by summing the values for the four behaviours. Scores ranged from 0 (no risk behaviour) to 4 (four risk behaviours). Only respondents with complete data for all four risk behaviours received a score on the multiple-risk index. Scores on this variable were missing for 3.2% of the respondents (4.2% of males and 2.3% of females).

Hierarchical multiple regression was used to examine how sets of variables were related to the index of multiple-risk behaviour. A number of variables that might facilitate or reduce risk behaviour were chosen (see *Appendix A, Independent variables*). After partialling out the socio-demographic variables of cohort in Step 1 and household income in Step 2, social role variables (marital status, student status, employment status, and whether individuals lived with at least one parent) were entered in Step 3. A set of personal risk factors (distress, unhappiness, and low self-esteem), which typically increase the likelihood of engaging in risk behaviour, were entered in Step 4. A set of personal protective factors (sense of mastery, social support, and religious attendance), which typically reduce the likelihood of engaging in risk behaviour, were entered in Step 5. At each step, an F test assesses the significance in the proportion of variance in multiple-risk behaviour accounted for by the variables in that step. The change in the multiple R^2 indicates the amount of variance explained by the variables in that step. Regression coefficients are reported for each variable within the full (non-hierarchical) model and are tested to determine if the variable is a significant predictor of multiple-risk behaviour, controlling for all other independent variables. One-tailed tests of significance are used because the hypotheses are directional.

Given the higher prevalence of multiple-risk behaviour among males, hierarchical regressions were calculated separately for males and females. Standard errors were estimated using the jackknife procedure to take into account the complexity of the sample design. Listwise deletion was used, omitting respondents with information missing for one or more variables. Because of missing data, 113 males (12.3%) and 95 females (9.1%) were excluded from the analysis.

This article uses the 1994/95 National Population Health Survey (NPHS) to examine the prevalence of four risk behaviours among males and females aged 15 to 19 and aged 20 to 24 (see *Methods*). The four risk behaviours are smoking, binge drinking, sex with multiple partners, and sex without a condom.

Risk behaviours

Risk for *smoking* was determined by responses to a single NPHS question: "At the present time, do you smoke cigarettes daily, occasionally or not at all?" A value of 0 was assigned to respondents who indicated not smoking at all. A value of 1 was assigned to those who indicated smoking occasionally or daily. No data were missing.

Two questions were used to form an indicator of *binge drinking*. First, respondents were asked, "During the past 12 months, have you had a drink of beer, wine, liquor, or any other alcoholic beverage?" A value of 0 was assigned to those who had not had a drink in 12 months. Respondents who had had a drink were asked, "How many times in the past 12 months have you had five or more drinks on one occasion?" A value of 0 was assigned to those who reported no occasions of binge drinking. A value of 1 was assigned to respondents who indicated binge drinking at least once in the past 12 months. Data were missing for 22 respondents (1.1% of the sample).

Sex with multiple partners was determined by responses to one question: "How many sexual partners have you had within the past 12 months?" Respondents who indicated one or no sexual partner were assigned a value of 0. Those who indicated two or more sexual partners were assigned a value of 1. Data were missing for 41 respondents (2.1%).

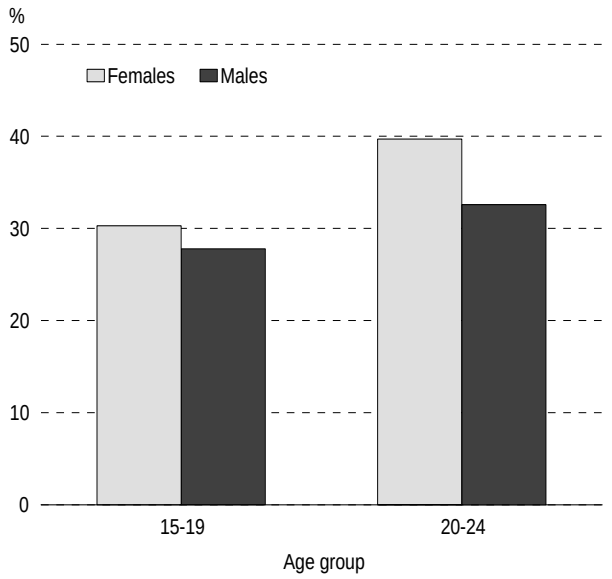
Sex without a condom was determined by responses to two questions. First, a value of 0 was assigned to respondents who had not had any sexual partners in the past 12 months and to those who reported that they had one sexual partner *and* that they were married, living common-law, divorced or widowed (these individuals were not asked about condom use). Second, all other respondents were asked, "In the past year, when you had sexual intercourse, did you/your partner use a condom?" (Each time; Some, but not all, of the time; Never). A value of 0 was assigned to respondents indicating they used a condom each time. A value of 1 was assigned to those indicating that they never or only sometimes used a condom. Data were missing for 41 respondents (2.1%).

With these indicators, it is possible to form an index that reflects multiple-risk behaviour. The multiple-risk-behaviour index moves away from the more common and limited single-variable approach that focuses on only one domain of behaviour. In so doing, it reflects some of the complexity of risk behaviour due to the co-occurrence of these individual behaviours.[2-4] Hierarchical multiple regressions were used to determine how much of the variance in the multiple-risk index can be explained by a set of socio-demographic, role-related, and personal variables. The independent variables were selected because they either tend to increase the likelihood of engaging in multiple-risk behaviour, or are protective factors that decrease its likelihood.

Smoking

A substantial share of young people are daily or occasional smokers. As have previous surveys conducted in Canada and other western countries,[5,6] the 1994/95 NPHS showed that in their late teens and early twenties, females have higher rates of daily or occasional smoking than males (Chart 1). At ages 15 to 19, the smoking rate among females was 30%, compared with 28% for males. Rates were higher

Chart 1
Prevalence of smoking among 15- to 24-year-olds, by age group and sex, Canada excluding territories, 1994/95



Data source: *1994/95 National Population Health Survey, Supplementary file*

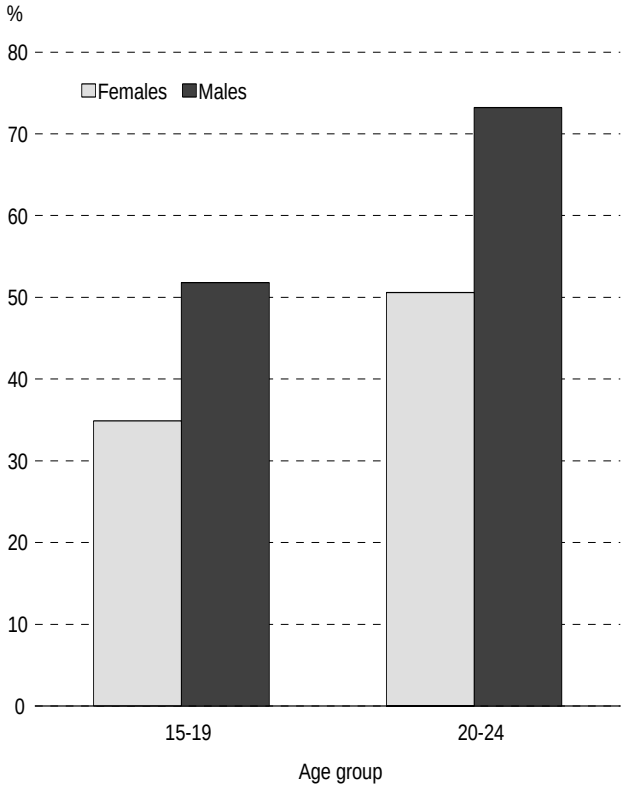
at ages 20 to 24: 40% for females versus 33% for males.

Binge drinking

Binge drinking is even more common than smoking among teenagers and young adults. In fact, binge drinking is "the most ubiquitous problem behaviour during adolescence and young adulthood."[7] However, unlike smoking, binge drinking tends to be more prevalent among young men than young women.

At ages 15 to 19, 52% of males and 35% of females reported consuming five or more alcoholic drinks on a single occasion in the previous year (Chart 2). By ages 20 to 24, the majority of both sexes reported at least one such episode: 73% of males and 51% of females. Moreover, if only those who reported consuming alcohol in the past year are considered, the proportions increase considerably. At ages 15 to 19, 71% of males and 50% of females reported binge drinking; among young adult drinkers, the corresponding figures were 81% and 61%.

Chart 2
Prevalence of binge drinking in past year among 15- to 24-year-olds, by age group and sex, Canada excluding territories, 1994/95



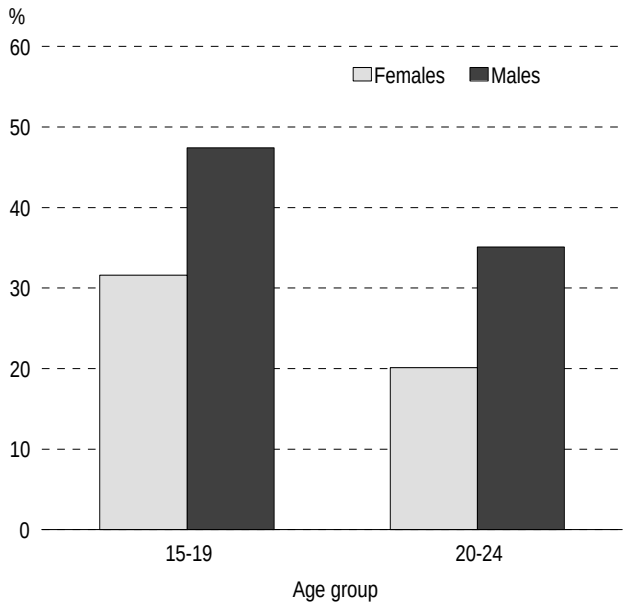
Data source: *1994/95 National Population Health Survey, Supplementary file*

Multiple sex partners

The prevalence of sexual activity among young people was similar for males and females. At ages 15 to 19, 44% of males and 43% of females had had at least one sex partner in the past year. The figures among young adults were higher, but again, not much different for males (78%) and females (81%).

There was, however, a considerable gender difference in having multiple partners. At ages 15 to 19, 21% of males reported having at least two sex partners in the past year, compared with just 13% of females. Among young adults, the disparity persisted: 27% of males versus 16% of females. The higher prevalence of multiple partners among young adults than teenagers is in part due to the generally higher rates of sexual activity among young adults.

Chart 3
Percentage of sexually active† 15- to 24-year-olds with at least two sex partners in past year, by age group and sex, Canada excluding territories, 1994/95



Data source: *1994/95 National Population Health Survey, Supplementary file*
† At least one sex partner in past year

Considering only those who were sexually active, teenagers were more likely than young adults to have multiple partners (Chart 3). Among sexually active males, 47% of 15- to 19-year-olds reported at least two sex partners, whereas at ages 20 to 24, the percentage was just 35%. Among sexually active females, the corresponding percentages were 32% and 20%.

Condom use

Condom use during sexual intercourse is a means of preventing unplanned pregnancies and infection from sexually transmitted diseases.

Not using condoms is reported more frequently by young women than young men. Among sexually active 15- to 19-year-olds (excluding those with a single sex partner *and* who were married, in a common-law relationship, divorced, or widowed) 51% of females, but just 29% of males, reported having had sex without a condom in the past year. At ages 20 to 24, higher proportions reported not using condoms, but the difference between males and females was narrower: 53% and 44% (Chart 4).

These figures suggest that a substantial number of young people may be putting themselves at risk, particularly since many of them may have more than one sex partner. Indeed, 21% of sexually active 20- to 24-year-old males reported multiple sex partners and condom non-use in the past year (Chart 5).

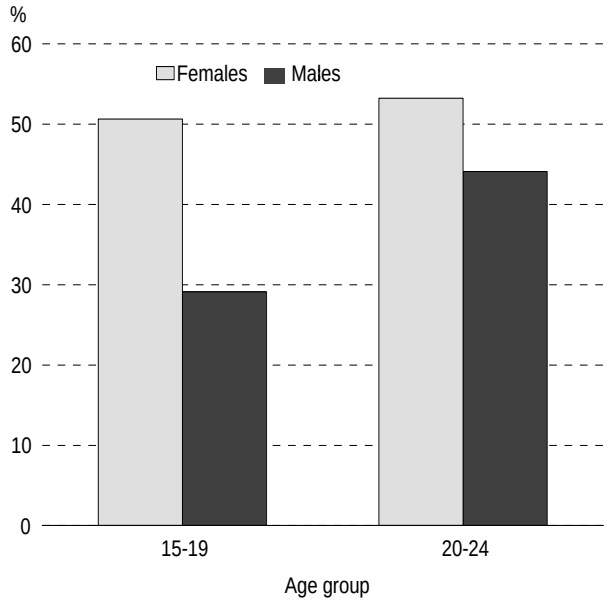
Multiple-risk behaviour

The majority of teenagers and young adults engage in at least one of the four potentially harmful activities, and a considerable percentage are involved in two or more (Chart 6). The prevalence of multiple-risk behaviour rises with age and is more common among males than females.

According to the 1994/95 NPHS, 20- to 24-year-old males were most at risk—22% of them reported engaging in at least three of these risk behaviours in the previous year. A smaller percentage of females in this age range (17%) reported the same level of risk. On the other hand, 19% of males and 31% of females aged 20 to 24 reported none of these activities.

Chart 4

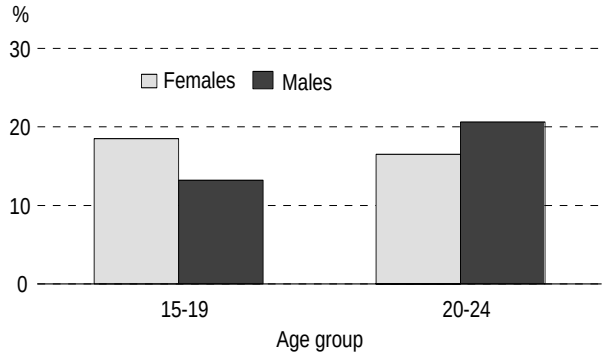
Percentage of sexually active† 15- to 24-year-olds who never or sometimes used a condom in past year, by age group and sex, Canada excluding territories, 1994/95



Data source: *1994/95 National Population Health Survey, Supplementary file*
Note: *Excluded from calculations are married, common-law, divorced, or widowed individuals with a single sex partner.*
† At least one sex partner in past year

Chart 5

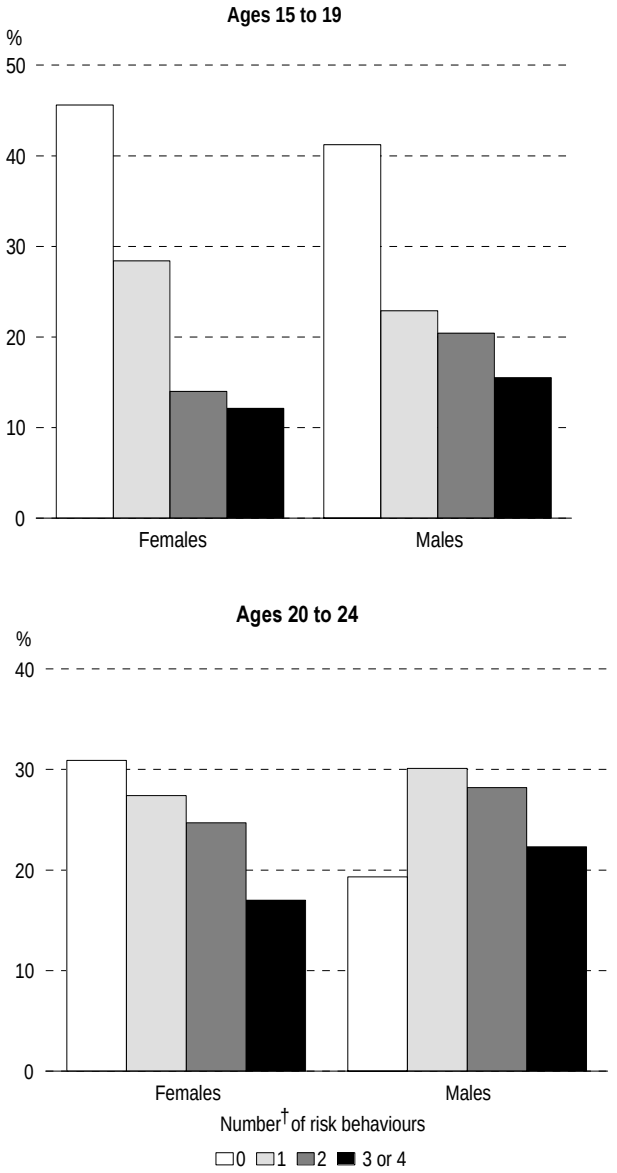
Percentage of sexually active† 15- to 24-year-olds with at least two sex partners plus condom non-use in past year, by age group and sex, Canada excluding territories, 1994/95



Data source: *1994/95 National Population Health Survey, Supplementary file*
Note: *Excluded from calculations are married, common-law, divorced, or widowed individuals with a single sex partner.*
† At least one sex partner in past year

Among teenagers, multiple-risk behaviour was less common. Over 40% had not engaged in any of these activities in the previous year. Even so, 16% of males and 12% of females reported at least three of these behaviours.

Chart 6
Percentage distribution of number of risk behaviours among 15- to 24-year-olds, by age group and sex, Canada, 1994/95



Data source: *1994/95 National Population Health Survey, Supplementary file*
† Sum of four behaviours: daily or occasional smoking; at least one episode of binge drinking in past year; two or more sex partners in past year; never or sometimes using condom

Patterns

The risk behaviour of young people tends to fall into specific patterns. For instance, among all females aged 15 to 24 who engaged in a single risk behaviour, nearly half reported binge drinking, and about a third, smoking. Among single-risk males, binge drinking was, by far, the most typical risk behaviour, reported by 80% (Table 1).

Given this pattern for single risks, it is not surprising that the most common two-risk combination for both sexes was smoking and binge drinking. However, among males, almost as many reported binge drinking and one of the sexual risk behaviours.

Deterrents and facilitators

Not all 15- to 24-year-olds are equally likely to engage in multiple-risk behaviour. A number of demographic, socioeconomic and personal characteristics tend to be associated with such behaviour. Some of these factors are positively associated with it, while others seem to be deterrents.

Table 1
Patterns of risk behaviour among 15- to 24-year-olds, Canada excluding territories, 1994/95

Pattern of risk behaviour	% of total		% within category	
	Females	Males	Females	Males
Total	**100**	**100**		
No risk behaviour	**39**	**32**	**100**	**100**
One risk behaviour	**28**	**26**	**100**	**100**
Smoking			33	--
Binge drinking			48	80
Sexual (multiple partners or condom non-use)			19†	--
Two risk behaviours	**19**	**24**	**100**	**100**
Smoking + binge drinking			45	49
Binge drinking + a sexual risk behaviour			32	46
All other combinations			23†	--
Three risk behaviours	**9**	**14**	**100**	**100**
Smoking + binge drinking + a sexual risk behaviour			80	74
Both sexual risk behaviours + smoking or binge drinking			--	26†
Four risk behaviours	**5†**	**5†**	**100**	**100**

Data source: *1994/95 National Population Health Survey, Supplementary file*
† Estimate subject to high sampling variability
-- Sample too small to permit reliable estimate

When each age group was considered alone, 20- to 24-year-olds engaged in higher levels of multiple-risk behaviour than did 15- to 19-year-olds (Tables 2 and 3). The age difference, however, was no longer statistically significant when all other variables were controlled, primarily because several social role variables (namely, never having been married, being a student and living with parents) were associated with being in the younger age group (see significant correlations between cohort and these three variables in Appendix B) and were stronger predictors of multiple-risk behaviour than was age.

The assumption of adult roles (for example, marriage) has generally been found to diminish involvement in potentially hazardous activities.[2,8] And in fact, young people who had never been married reported higher levels of multiple-risk behaviour than did those who were or had been married (including common-law relationships). Another adult role, being employed, was not associated with multiple-risk behaviour in either sex. Moreover, two "non-adult" roles, being a student and living with parents, actually tended to deter multiple-risk behaviour. Non-students would be predicted to engage in more risk behaviours than those who were attending school, college or university. Previous research, too, has found somewhat higher levels of smoking and sexual risk

Table 2
Regression results predicting multiple-risk behaviour from socio-demographic, social role, and personal variables, females aged 15 to 24, Canada excluding territories, 1994/95

Variable	b	se	beta	R^2 change	Adjusted R^2
Cohort†	.079	.125	.034	.020***	.019***
Income†	-.028	.020	-.063	.014***	.031***
Social roles				.111***	.139***
Never married	.838***	.152	.280***		
Student	-.592***	.123	-.248***		
Employed	.067	.094	.028		
Lives with parent(s)	-.461**	.143	-.195***		
Personal risk factors				.030***	.167***
Distress	.057***	.015	.182***		
Unhappy	-.024	.095	-.012		
Self-esteem	.018	.017	.051		
Personal protective factors				.047***	.212***
Mastery	-.016	.012	-.053		
Social support	.110	.082	.044		
Religious attendance	-.573***	.103	-.209***		
Intercept	.634				
Total R^2	.22***				

Data source: *1994/95 National Population Health Survey, Supplementary file*
Note: *b=unstandardized regression coefficient. beta=standardized regression coefficient. se=standard error (jacknife estimate). The regression coefficients and standard errors are for the full regression model (with all variables controlled). R^2 change is presented for each block of predictors entered hierarchically in steps denoted by bold print. Sample size is 945 after listwise deletion.*
† The regression coefficient for this variable was significant when first entered in the hierarchical regression analysis. In the final model controlling for all other variables, it no longer attained significance.
** p < 0.05*
*** p < 0.01*
**** p < 0.001*
F(12, 932)=22.17, p < 0.001

Table 3
Regression results predicting multiple-risk behaviour from socio-demographic, social role, and personal variables, males aged 15 to 24, Canada excluding territories, 1994/95

Variable	b	se	beta	R^2 change	Adjusted R^2
Cohort†	.145	.124	.061	.040***	.039***
Income‡	.043*	.023	.092*	.001	.039***
Social roles				.073***	.108***
Never married	.488**	.178	.131**		
Student	-.579***	.133	-.239***		
Employed	.063	.116	.026		
Lives with parent(s)	-.405**	.164	-.155**		
Personal risk factors				.027***	.132***
Distress	.031*	.018	.088*		
Unhappy	.155	.103	.077		
Self-esteem	-.013	.022	-.031		
Personal protective factors				.037***	.166***
Mastery	.003	.018	.009		
Social support	-.196	.157	-.080		
Religious attendance	-.528***	.129	-.179***		
Intercept	1.845				
Total R^2	.18***				

Data source: *1994/95 National Population Health Survey, Supplementary file*
Note: *b=unstandardized regression coefficient. beta=standardized regression coefficient. se=standard error (jacknife estimate). The regression coefficients and standard errors are for the full regression model (with all variables controlled). R^2 change is presented for each block of predictors entered hierarchically in steps denoted by bold print. Sample size is 807 after listwise deletion.*
† The regression coefficient for this variable was significant when first entered in the hierarchical regression analysis. In the final model controlling for all other variables, it no longer attained significance.
‡ The regression coefficient for this variable was not significant when first entered in the hierarchical regression analysis. In the final model controlling for all other variables, it attained significance.
** p < 0.05*
*** p < 0.01*
**** p < 0.001*
F(12, 794)=14.38, p < 0.001

Limitations

One of the strengths of this research is the aggregation of several risk behaviours to form a multiple-risk behaviour index. The use of this index, however, is not without shortcomings. The four individual risk behaviours (smoking, binge drinking, sex with multiple partners, and sex without a condom) were each dichotomized prior to forming the aggregate index. Dichotomization of variables necessarily reduces the standard deviation, which limits the amount of variance that can be explained by predictors in the regression equation.

The decision to dichotomize was based on several considerations, including the fact that two of the variables (smoking and sex without a condom) had only three possible response options. In the case of smoking, the natural distribution showed that the vast majority of respondents reported smoking either daily or not at all (very few indicated smoking occasionally), thus making dichotomization of smoking behaviour a reasonable choice. Although binge drinking and sex with multiple partners could have been represented with continuous variables, the distributions were positively skewed, but with some outliers so extreme that the regression results likely would have been biased had continuous measures been used. Taking into account the possible response options for each risk behaviour, the distributions of the separate behaviours, and the need to standardize the risk behaviours for the aggregate index, dichotomization seemed to be the best solution. For selected purposes, the use of dichotomous variables to indicate the absence or presence of risk behaviour is not uncommon in the literature.[9,10]

On a related note, the specific cut-off used to define risk is necessarily somewhat arbitrary.[9] For example, in this analysis, the risk of binge drinking was defined as one occasion within the last year, which might be considered a too liberal definition of risk. Similarly, only two sex partners in the last year would not be considered risky by some definitions. Consensual definitions do not exist, however, and are unlikely to arise until researchers use standardized questions and measures of risk behaviour across studies. Readers should exercise caution in interpreting the results of this analysis by understanding clearly how multiple-risk behaviour was defined and measured.

Finally, the regressions that predict multiple-risk behaviour left large portions of variance unexplained (78% for females and 82% for males). Nevertheless, the amount of variance explained in this analysis is in line with other surveys that examine risk behaviours in large, cross-sectional studies of adolescents and young adults.[2,8,11]

behaviour among non-students than students, although students may be more likely to binge drink.[5,8] As might be expected, young people who lived with at least one parent would be predicted to report fewer risk behaviours. The increased autonomy associated with leaving home may create a context in which risk behaviours would be explored by young adults. Overall, marital status, employment status, student status and living arrangements explained 11.1% and 7.3% of the variance in multiple-risk behaviour for females and males, respectively, after controlling for age and income.

Household income was not strongly associated with multiple-risk behaviour. Among females, lower income was related to higher levels of multiple-risk behaviour when it was entered in the second step of the multiple regression model, but lost significance when all other variables were included. Among males, income was not a significant predictor of multiple-risk behaviour when entered in the second step of the regression, but in the final model that controlled for all other variables, higher income predicted higher scores on the multiple-risk index.

Distress increases risk

For both sexes, higher distress was significantly linked with higher levels of multiple-risk behaviour. However, neither unhappiness nor low self-esteem was a significant predictor, possibly because of the strong relationship of distress to unhappiness and self-esteem (Appendix B). Together, these three personal risk factors accounted for about 3% of the variance in multiple-risk behaviour among females and males, after controlling for socio-demographic and social role variables.

Religious attendance decreases risk

A number of factors are "protective" with regard to multiple-risk behaviour; that is, they might be expected to decrease the chances of participation in such activities. Three were examined in this analysis: sense of mastery, social support, and attendance at religious services. A sense of mastery and social support were not significant predictors of multiple-risk behaviour. But for both sexes, attendance at religious services was linked with lower

A risk-taking age

The National Population Health Survey contains no information about drinking and driving. However, it does show that at ages 15 to 24, binge drinking is relatively prevalent.

Based on impaired driving charges, drunk driving is more common among young adults than among teenagers. In 1996, the 20-to-24 age group represented a somewhat larger share of persons charged with impaired driving than they did of licensed drivers.[12] At ages 16 to 19, however, the numbers charged were proportional to the number of licensed drivers. Males made up the vast majority of people charged with impaired driving.

Motor vehicle accident fatality rates rise sharply after age 15. In 1994, the mortality rate from motor vehicle accidents for males aged 0 to 14 was less than 5 deaths per 100,000. At ages 15 to 19 and 20 to 24, the rate soared above 30. By age 25, the rate dropped back below 20 where it remained until age 75 and older. Females were much less likely than males to die in a motor vehicle accident. Nonetheless, the pattern by age was the same for females, with rates almost tripling between ages 10 to 14 and 15 to 19.

Motor vehicle accident deaths, by sex and age group, Canada, 1994

	Males		Females	
	Number of deaths	Deaths per 100,000	Number of deaths	Deaths per 100,000
All ages	**2,223**	**15.3**	**939**	**6.4**
0-4	40	3.9	36	3.7
5-9	43	4.3	20	2.1
10-14	50	4.9	29	3.0
15-19	308	30.6	110	11.5
20-24	322	30.9	79	7.8
25-29	219	18.8	74	6.5
30-34	219	16.1	78	5.9
35-39	179	14.0	52	4.1
40-44	151	13.4	59	5.2
45-49	125	12.5	52	5.3
50-54	94	12.3	47	6.2
55-59	94	14.9	40	6.3
60-64	80	13.4	41	6.6
65-69	67	12.9	57	9.7
70-74	82	19.7	57	10.7
75-79	68	25.6	49	12.8
80-84	55	33.8	40	14.6
85+	27	27.2	19	8.3

Data source: *Canadian Vital Statistics Data Base*

levels of multiple-risk behaviour. This echoes other research showing that beliefs in traditional norms may lessen involvement in multiple-risk activities.[11] Together, these personal protective factors explained about 5% of the variance in females' and 4% of the variance in males' multiple-risk behaviour, after controlling for all other variables in the analysis.

Concluding remarks

Overall, the factors considered in this analysis explained 22% of the variance in multiple-risk behaviour among females and 18% of the variance among males. Clearly, there are other important predictors of risk behaviour that were not assessed by the NPHS. If family difficulties (for instance, parent-adolescent conflict)[13] and involvement with friends who engage in reckless activities had been considered, the regression models might have explained substantially more of the variance in multiple-risk behaviour. Additional information on the family, peer, neighbourhood and cultural contexts would increase understanding of who is most at risk.[14-16] However, the social role variables that were examined (in particular, whether the young person lived with parents or had a spouse) provide important insight about the circumstances in which risk behaviour is elevated or reduced.

The NPHS does not address other equally important and relatively common risk behaviours such as illicit drug use, delinquency, and driving while drunk[16] (see *A risk-taking age*). A more comprehensive set of risk behaviours might better distinguish young people who are experimenting with a few potentially harmful activities from those who are engaged in a pattern of such conduct.

Finally, given that the data were collected from the participants at only one point in time, it is not possible to disentangle cause-and-effect relations. For instance, multiple-risk behaviour might be as much the cause of distress as it is the result. Follow-up data on NPHS respondents will shed light on the sources, course and consequences of multiple-risk behaviour among teenagers and young adults as they mature.

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Appendix A

Independent variables

Sociodemographic characteristics

Cohort refers to the age group of the respondents. The two cohorts, 15 to 19 and 20 to 24, were distinguished by scores of 0 and 1, respectively.

Household income was scored as 1 (no income), 2 (less than $5,000), 3 ($5,000 to $9,999), 4 ($10,000 to $14,999), 5 ($15,000 to $19,999), 6 ($20,000 to $29,999), 7 ($30,000 to $39,999), 8 ($40,000 to $49,999), 9 ($50,000 to $59,999), 10 ($60,000 to $79,999), or 11 ($80,000 or more). Data were missing for 79 respondents (4%).

Social roles

Marital status was coded as 0 (married, living common-law, divorced, separated or widowed) or 1 (never married). No data were missing.

Student status (0 if not a student; 1 if attending school) was determined by the response to "Are you currently attending a school, college or university?" Data were missing for two respondents.

Employment status was coded as 0 (not currently working) or 1 (currently has a job). Data were missing for 20 respondents (1%).

Lives with parent(s) was coded as 0 (those who reported any arrangement other than living with at least one parent) or 1 (living with at least one parent). Data were missing for eight respondents.

Personal risk factors

Distress was measured with six items based on a subset of questions from the Composite International Diagnostic Interview (CIDI).[17] The CIDI is a structured diagnostic instrument designed to produce diagnoses according to the definitions and criteria of both DSM-III-R and the Diagnostic

Criteria for Research of the ICD-10. Each item was rated on a five-point scale ranging from "none of the time" (0) to "all of the time" (4). Respondents were asked, "During the past month, about how often did you feel:

- … so sad that nothing could cheer you up?
- … nervous?
- … restless or fidgety?
- … hopeless?
- … worthless?
- … that everything was an effort?"

The sum of these items was calculated to form a scale score (ranging from 0 to 24), with higher scores indicating stronger feelings of distress. Data were missing for 37 respondents (1.9%).

Unhappiness was measured by a single item asking, "Would you describe yourself as being *usually*: Happy and interested in life? (1); Somewhat happy? (2); Somewhat unhappy? (3); Unhappy with little interest in life? (4); or So unhappy that life is not worthwhile? (5)." Scores ranged from 1 to 5, with higher scores indicating more unhappiness. One respondent did not provide information for this question.

Self-esteem, or the positive feelings that an individual holds for him/herself, was measured with six items.[18,19] Each item was rated on a five-point scale, ranging from "strongly agree" (0) to "strongly disagree" (4). The items were:

- You feel that you have a number of good qualities.
- You feel that you're a person of worth at least equal to others.
- You are able to do things as well as most other people.
- You take a positive attitude toward yourself.
- On the whole, you are satisfied with yourself.
- All in all, you're inclined to feel you're a failure (reverse scoring).

A scale was constructed from the sum of the items (ranging from 0 to 24), with higher scores indicating higher self-esteem. Data were missing for 38 respondents (1.9%).

Personal protective factors

Mastery, or the extent to which individuals believe that they are in control of their lives, was measured with seven items[18] rated on a five-point scale, ranging from "strongly agree" (0) to "strongly disagree" (4). The seven items were:

- You have little control over the things that happen to you.
- There is really no way you can solve the problems you have.
- There is little you can do to change many of the important things in your life.
- You often feel helpless in dealing with the problems of life.
- Sometimes you feel that you are being pushed around in life.
- What happens to you in the future mostly depends on you (reverse scoring).
- You can do just about anything you really set your mind to (reverse scoring).

The sum of the items was calculated (ranging from 0 to 28), with higher scores indicating a superior sense of mastery. Data were missing for 42 respondents (2.1%).

Perceived social support was measured by "yes/no" responses to four items:

- Do you have someone you can confide in, or talk to about your private feelings or concerns?
- Do you have someone you can really count on to help you out in a crisis situation?
- Do you have someone you can really count on to give you advice when you are making important personal decisions?
- Do you have someone who makes you feel loved and cared for?

The number of "yes" responses was summed to form an index ranging from 0 to 4, with higher scores indicating more social support. Scores were missing for 42 respondents (2.1%).

Religious attendance was measured with a single question: "Other than on special occasions (such as weddings, funerals or baptisms), how often did you attend religious services or religious meetings

in the past 12 months? The response categories were: At least once a week; At least once a month; At least three or four times a year; At least once a year; Not at all. Respondents who replied "At least once a week" or "At least once a month" were assigned a score of 1 (regular attendance). All others were assigned a score of 0. Data were missing for 37 respondents (1.9%).

Appendix B

Pearson correlations among variables, by sex (cohorts combined)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
Cohort (1)	...	-.23*	-.42*	-.44*	.18*	-.48*	-.07*	-.05	.11*	.07*	.02	-.05	.14*
Income (2)	-.01	...	.14*	.13*	.14*	.42*	-.02	-.16*	.15*	.13*	.08*	.03	-.15*
Social roles													
Never married (3)	-.34*	.21*	...	.39*	-.06*	.53*	.09*	.02	-.03	.01	.03	-.00	.07*
Student (4)	-.45*	.10*	.25*	...	-.18*	.38*	.07*	.03	-.04	.03	.05	.02	-.23*
Employed (5)	.20*	.15*	-.14*	-.26*	...	.00	-.10*	-.11*	.13*	.14*	.00	-.05	.05
Lives with parent(s) (6)	-.37*	.35*	.53*	.26*	-.04	...	-.04	-.01	-.03	.00	.03	.10*	-.21*
Personal risk factors													
Distress (7)	.00	-.04	.02	.01	-.11*	-.01	...	.48*	-.35*	-.40*	-.24*	-.02	.19*
Unhappy (8)	.01	-.11*	.04	-.09*	-.03	-.02	.43*	...	-.48*	-.44*	-.31*	-.04	.07*
Self-esteem (9)	.03	.12*	.06*	.10*	.04	.07*	-.29*	-.37*	...	.52*	.21*	-.04	-.01
Personal protective factors													
Mastery (10)	.01	.21*	.04	.08*	.07*	.07*	-.41*	-.35*	.49*	...	.24*	.04	-.10*
Social support (11)	.00	.10*	-.04	.03	.05	.03	-.22*	-.15*	.13*	.18*	...	-.01	-.01
Religious attendance (12)	-.10*	-.06*	.06*	.02	.01	.07*	.00	.01	-.03	.00	-.03	...	-.25*
Multiple-risk index (13)	.20*	.04	-.02	-.29*	.08*	-.16*	.14*	.15*	-.10*	-.09*	-.12*	-.19*	...

Data source: *1994/95 National Population Health Survey, Supplementary file*

Note: *Correlations for females are above the diagonal; correlations for males are below. Sample size for females is 945, and for males, 807 (listwise deletion).*

** $p < 0.05$*

··· Figure not applicable

Current and future hospitalization after heart attack

Helen Johansen, Cyril Nair and Gregory Taylor

Abstract

Objectives

This article provides an overview of patients who were hospitalized in 1993/94 because of acute myocardial infarction (AMI) and projects how many AMI patients there could be in the future.

Data source

The Person-Oriented Information Data Base was used for this analysis.

Analytical techniques

Hospital inpatients who had a primary diagnosis of AMI were analyzed, as well as their subsequent hospitalizations for coronary heart disease in the fiscal year. The age-sex specific hospitalization rates were used with population projections to estimate future hospital use.

Main results

Of the nearly 45,000 Canadians who were discharged from hospital in 1993/94 with a primary diagnosis of AMI, most (72%) had only one hospital stay within the fiscal year, but 18% had two related stays, and 10% had three or more. AMI patients were hospitalized an average of 14.6 days. The projected number of AMI patients and the number of hospital days used will increase by approximately 36% each decade to the year 2026.

Key words

acute myocardial infarction, projection, length of stay, hospital separation records, record linkage

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In 1994/95, nearly one in twenty Canadians aged 20 and older reported having heart disease,[1] a major cause of long-term disability and death.[2] The total cost of cardiovascular disease in Canada was estimated to range from $14.1 billion to $20.4 billion in 1994.[3]

One of the direct costs associated with heart disease is the use of hospital services. In this article, hospital use in 1993/94 is analyzed for patients who had a primary diagnosis of acute myocardial infarction (AMI)—commonly known as a heart attack.

AMI originates with a reduction or blockage of blood flowing through the coronary arteries. This may arise from a blood clot, spasm, or severe disruption in the heart's rhythm. The reduction in blood flow produces an inadequate oxygen supply to the heart, resulting in the death of heart-muscle tissue. An AMI patient usually experiences sudden, severe chest pain that may spread to the arms and throat. For women, mild angina is commonly the initial symptom, and diagnosis is more problematic for them, as the usual diagnostic tests are more difficult to apply.

Methods

Data source

Hospital morbidity files are provided to Statistics Canada annually by the provinces (data on the Nortwest Territories and the Yukon were not included here). Each record contains information abstracted from a patient's hospital chart and pertains to one continuous hospital stay. Before these data are forwarded to Statistics Canada, edit checks are conducted by the Canadian Institute for Health Information or by provincial health ministries. Statistics Canada performs further consistency edits to ensure the integrity of the data.

In the Person-Oriented Information Data Base used in this analysis, hospital records in each province for fiscal year 1993/94 were linked using health insurance identification numbers. (Patient names are not provided to Statistics Canada.) For further privacy protection, some provincial health ministries scrambled health insurance identification numbers to ensure that individuals could not be identified.

Analytical techniques

Hospital patients often receive multiple diagnoses. The condition accounting for the longest length of stay is known as the "tabulation diagnosis." The tabulation diagnosis is almost always the same as the primary diagnosis—the condition responsible for the hospital stay. In this article, for ease of reference, the term " primary diagnosis" is used for tabulation diagnosis. A tabulation diagnosis of AMI (ICD-9 code 410) was used to select hospital patients for analysis.[4] Subsequent hospitalizations among AMI patients with a tabulation diagnosis of coronary heart disease (ICD-9 codes 410 to 429) were analyzed as well. AMI patients who died in hospital were also included.

Researchers have concluded that the use of ICD-9 code 410 to identify hospitalized cases of AMI results in a modest overestimation of the true number, but that this approach is warranted because of the expense of validation procedures.[5] The inclusion of patients admitted to hospital for tests to rule out a diagnosis of AMI can artificially inflate the number of AMI patients.[6,7] Consequently, patients who were in hospital less than five days and who were discharged alive without having a percutaneous transluminal coronary angioplasty (the dilatation of a blood vessel by means of a balloon catheter that is inflated to flatten plaque against the artery wall) were excluded from this analysis.

Statistics Canada has published low-, medium-, and high-growth population projections for Canada.[8] The low-growth projection assumes declining immigration, a decline in fertility to 1.5 births per woman, and life expectancy of 77 years for males and 83 years for females. The medium-growth projection assumes a continuation of current trends: a constant immigration of 250,000 per year, a fertility rate of 1.7 births per woman, and life expectancy of 78.5 years for males and 84 years for females. The high-growth projection assumes an increase in immigration, an upturn in fertility to 1.9 children per woman, and life expectancy of 81 and 86 years for males and females, respectively.

To estimate the future number of AMI patients to 2026, 1993/94 hospitalization rates by sex and five-year age group were applied to Statistics Canada's projected population estimates. The results were then summed for each sex. This projection is based on the premise that 1993/94 hospitalization rates will persist in the future.

To estimate the future hospital needs of AMI patients to 2026, their hospital days in 1993/94 by sex and five-year age group were applied to projected population estimates. The results were then summed for each sex. This projection is based on the assumption that the average length of hospital stay in 1993/94 will persist in the future.

Other projections were calculated based on the premise that the average annual percentage change in the number of patients and the average length of stay between 1989 and 1993 would continue until 2026. Also, the average percentage decline needed to maintain a steady state was calculated.

Patient counts and hospitalization rates for 1992/93 were also calculated but are not shown in this article. The figures for 1992/93 reveal patterns that correspond to those for 1993/94. However in 1993/94, counts and rates were slightly lower.

Limitations

In the Person-Oriented Information Data Base, record linkage was conducted separately for each province. Thus, a patient with AMI-related hospital admissions in two different provinces during the same fiscal year would be counted twice. Though possible, the likelihood of this event was considered negligible.

The linkage covers only one fiscal year, as hospital records for some provinces could not be linked for more than one year. For patients who were hospitalized in 1993/94 because of a heart attack and who also had related hospital stays in 1994/95, the latter stays were not considered in this article. This has the effect of underestimating the total number of stays and hospital days per patient.

It is difficult to diagnose the elderly, because they are more likely to have multiple conditions. Also, disease severity, which affects length of stay, is not known.

The validity and reliability of hospital discharge data need to be considered.[9] Some studies have found AMI hospital-discharge diagnoses to be good.[10-12] Two Canadian studies found false-positive rates of 8% to 21%, but they included patients who were admitted with a possible AMI that was later ruled out.[13,14] Meehan et al.[12] found an accuracy of 96% for the coding of an AMI among Medicare beneficiairies aged 65 and older who were hospitalized in six Connecticut hospitals between 1989 and 1991. Although the data from this research had very similar trends to those obtained from the FINMONICA acute myocardial infarction register, the actual rates were different.[15]

A considerable proportion of hospitalized AMI patients have subsequent hospital stays related to having had a heart attack. Thus, to examine the full extent of hospital use associated with AMI, all relevant hospital stays for individual AMI patients need to be included. In this analysis, hospital separation records for fiscal year 1993/94 for a patient who was admitted to hospital with a primary diagnosis of AMI were linked to that patient's subsequent separation records involving coronary heart disease.

The projected aging of the population suggests that the incidence of heart disease and the associated costs may increase. In this article, the future number of AMI patients and the hospital days that they will require were estimated for different scenarios based on Statistics Canada's population projections (see *Methods*).

More men than women have heart attacks

Nearly 45,000 Canadians were discharged from hospital in 1993/94 with a primary diagnosis of AMI (Table 1). Although men comprised the majority of AMI patients, women accounted for over a third. At younger ages, male patients greatly outnumber female patients (Chart 1). The prevalence peaked at a younger age for men (65 to 69 years) than for women (75 to 79 years). Because women tend to outlive men, it is not surprising that female patients exceed male patients after age 80.

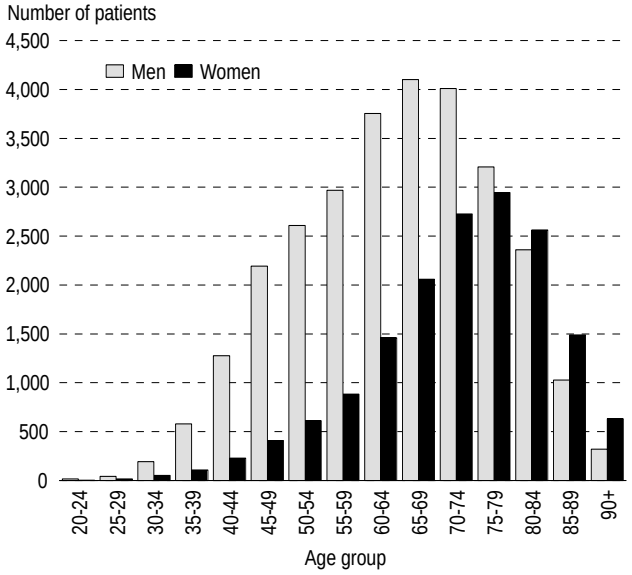
Taking into consideration the number of men and women at different ages, hospitalization rates show a different picture, increasing for both sexes until age 85 (Chart 2). Thereafter, the rates declined, probably because of competing illnesses and increased out-of-hospital AMI deaths. At all ages, AMI hospitalization rates were higher for men.

Table 1
Summary information on AMI patients, Canada excluding territories, 1993/94

	Both sexes	Men	Women
AMI patients	44,832	28,653	16,179
Hospital days†	654,983	394,182	260,801
Hospital discharges†	64,955	41,695	23,260
Average number of hospital days/patient†	14.61	13.76	16.12
Average number of discharges/patient†	1.45	1.46	1.44
In-hospital deaths	17.9%	14.7%	23.6%

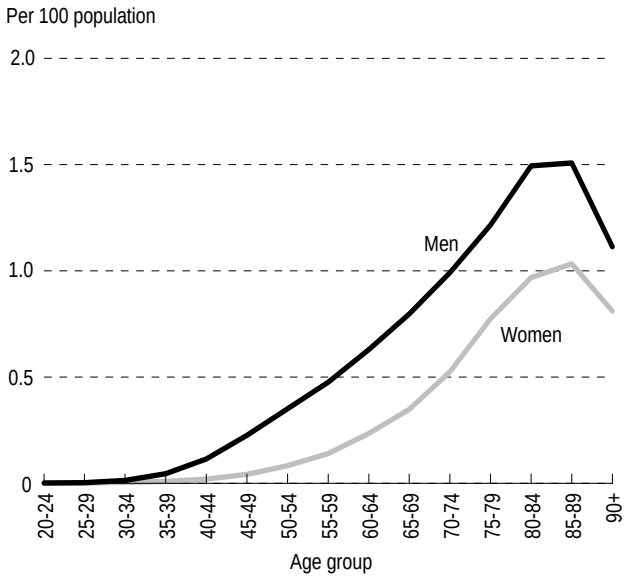
Data source: *Person-Oriented Information Data Base*
† Includes first AMI-related stay and all subsequent stays for coronary heart disease.

Chart 1
Number of hospitalized AMI patients, by age group and sex, Canada excluding territories, 1993/94



Data source: *Person-Oriented Information Data Base*

Chart 2
AMI hospitalization rate, by age group and sex, Canada excluding territories, 1993/94



Data source: *Person-Oriented Information Data Base*

Almost 3 in 10 re-hospitalized within the year

A sizeable proportion of AMI patients were re-hospitalized later in the year. In 1993/94, the majority (72%) of AMI patients had only one hospital stay, but 18% had two AMI-related hospital stays and 10% had three or more. Repeat hospitalization rates were similar for both sexes. Re-admissions occur for several reasons, including programs of planned in-patient care such as revascularization (bypass surgery) or reinfarction (another heart attack) and other cardiac complications.[16]

Younger patients—higher re-admission rates

Older AMI patients might be expected to have more hospital stays than younger patients. However, the average number of re-admissions is higher for younger patients (Chart 3). This may be due to longer stays and a greater chance of death among elderly patients. Also, younger patients are more likely to be re-admitted for cardiac procedures, such as bypass surgery. These procedures are often not done at the time of a heart attack, but deferred because of waiting lists and scheduling considerations.

Rates increase from west to east

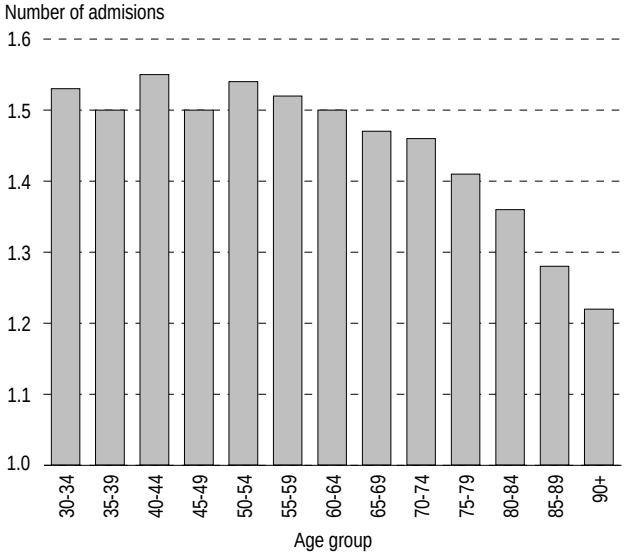
Age-adjusted hospitalization rates by province and sex tend to increase from west to east across Canada (Chart 4). Risk factor levels for heart disease also show a similar pattern, with a higher percentage of people with two or more risk factors increasing from west to east.[1]

Women have longer stays

For a patient's first[a] AMI-related hospitalization in 1993/94, the average length of stay was 10.9 days, a figure consistent with past research.[17] When all subsequent stays with a primary diagnosis of AMI were included (that is, hospitalizations due to another heart attack were considered), the average rose to 11.8 days. And when subsequent stays with a diagnosis of coronary heart disease were included, the average reached 14.6 days. As expected, average stays—both for first hospitalizations only and for

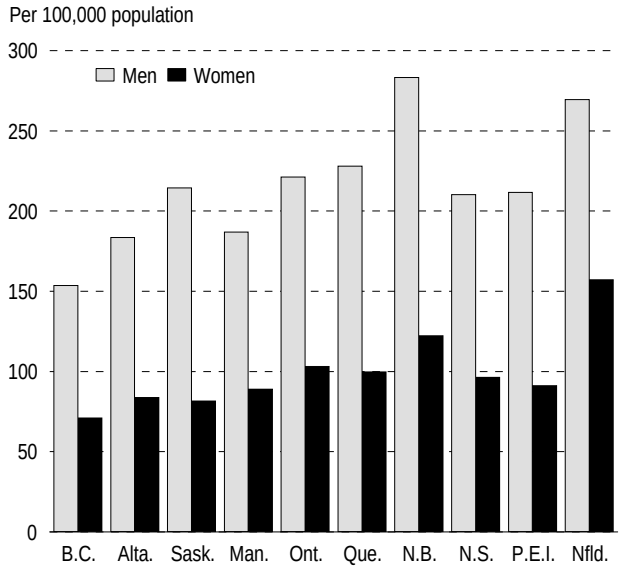
[a] *The first hospitalization in 1993/94 may not be a patient's initial hospitalization, as some patients may have been admitted to hospital in 1992/93 because of a heart attack.*

Chart 3
Average number of hospital admissions per AMI patient,† by age group, Canada excluding territories, 1993/94



Data source: *Person-Oriented Information Data Base*
† Includes first AMI-related stay and all subsequent stays for coronary heart disease.

Chart 4
Age-adjusted AMI hospitalization rate, by sex and province, 1993/94



Data source: *Person-Oriented Information Data Base*
Note: *Data are age-standardized to the 1992 Canadian population to control for differing age structures of provincial populations.*

those that include subsequent hospitalizations—were longer for older patients (Chart 5).

Female AMI patients tend to have longer hospital stays than male patients. The average total length of stay for women in 1993/94 was 16.1 days versus 13.8 days for men (Table 1). This is possibly a reflection of the fact that women tend to have more severe disease and complications.[18]

In-hospital death rates higher for women

Approximately 18% of hospitalized AMI patients died in hospital in 1993/94 (Table 1), a figure consistent with other research.[19] The overall in-hospital death rate was much higher for women than for men: 24% versus 15%. Even though female AMI patients tend to be older than their male counterparts, this did not explain the difference. When calculated by age group, in-hospital death rates remain higher for women at all ages younger than 75. After that age, the rates are approximately equal for both sexes (Chart 6).

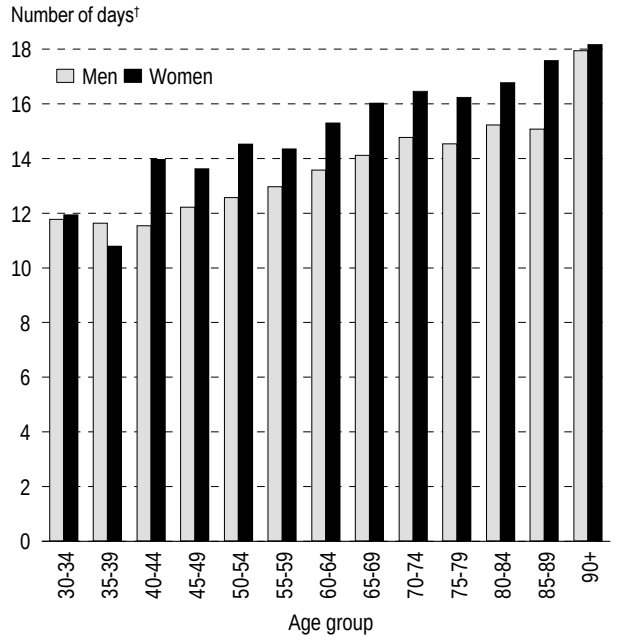
In-hospital deaths account for only a portion of AMI deaths: the majority occurred among patients not admitted to a hospital. (Patients in emergency rooms are not considered admitted.) According to vital statistics data, approximately 69% of male AMI deaths and 60% of female AMI deaths occurred outside hospitals.

Numbers projected to rise

Statistics Canada has published low-, medium-, and high-growth population projections for Canada.[8] Regardless of which projection scenario is considered, the proportion of Canadians aged 65 and older will increase from 12% of the total population to approximately 16% between 1993 and 2016. The most rapidly growing age group will be those aged 85 and older, whose numbers will more than double.

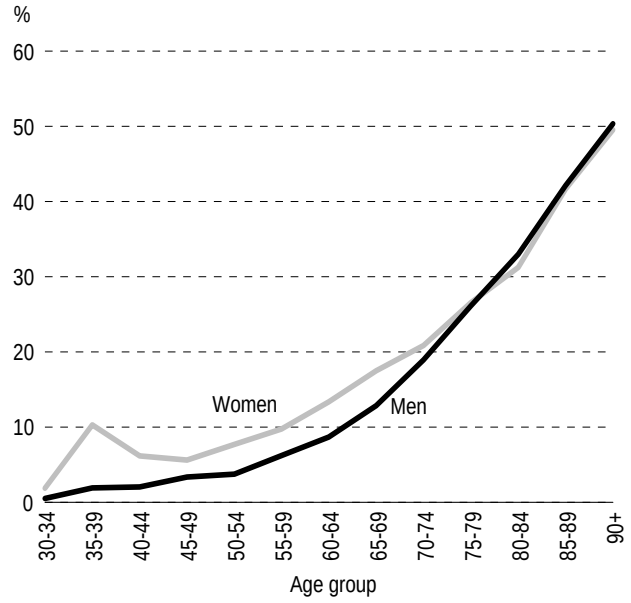
As the proportion of seniors increases, the number of AMI patients will climb (see *Related research*). Assuming that the 1993/94 AMI hospitalization rate by age and sex persists in the future, the number of male AMI patients in 2026

Chart 5
Average number of hospital days per AMI patient, by age group and sex, Canada excluding territories, 1993/94



Data source: *Person-Oriented Information Data Base*
† Includes days from first AMI-related stay and all subsequent stays for coronary heart disease.

Chart 6
Percentage of hospitalized AMI patients who died in hospital, by age group and sex, Canada excluding territories, 1993/94



Data source: *Person-Oriented Information Data Base*

Related research

Researchers using a computer model that projected coronary heart disease in the United States found that without changes in risk factors or the efficacy of therapies after 1980, population aging would increase coronary heart disease prevalence by approximately 40% to 50% by the year 2010.[20] A more recent study predicted a 30% increase (over 1993 figures) in the number of patients requiring cardiac revascularization (surgical procedures that increase blood flow to the heart muscle) by 2010.[21] This picture of a dramatic increase in the use of inpatient services has been shown for hospital patients in general and reflects the increasing proportion of older Canadians in the population.[22]

will be between 57,100 (based on the low-growth population projection) and 68,000 (based on the high-growth population projection). For women, the numbers range from 33,200 to 38,200 (Chart 7). This increase for men and women combined is approximately 36% in each decade.

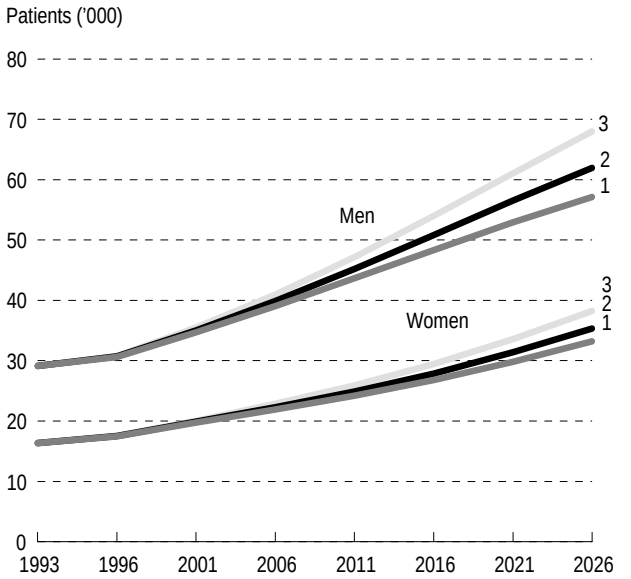
To maintain the number of AMI patients at the 1993/94 level, the percentage of patients in each age group (by sex) would have to decrease 2.3% each year.

More hospital days

Of course, the number of hospital days needed for AMI will also increase. Assuming that the average, total length of stay by age group and sex in 1993/94 persists in the future, the number of hospital days used by male AMI patients is projected to be between 800,000 and 914,000 in 2026 (Chart 8). The number of hospital days used by female AMI patients would range from 540,000 to 564,000. Assuming that 365 hospital days are equivalent to one hospital bed, the total need would rise from 1,794 beds in 1993/94 to between 3,673 and 4,049 beds in 2026.

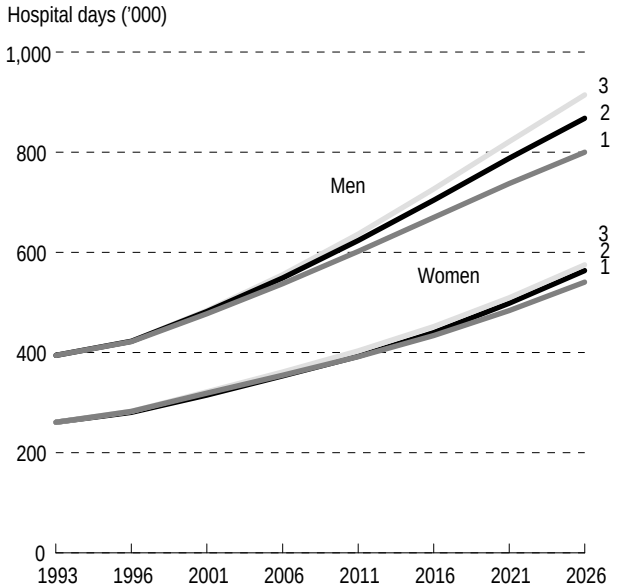
To maintain the number of hospital days at the 1993/94 level, a decrease of 2.3% each year in days per 1,000 population would be needed.

Chart 7
Projected number of AMI patients, Canada excluding territories, 1993 to 2026



Data source: *Population Projections Section, Demography Division, Statistics Canada; Person-Oriented Information Data Base*
Notes: *Projections assume 1993/94 hospitalization rates persist in the future. Low-, medium- and high-growth projections are numbered 1, 2 and 3, respectively.*

Chart 8
Projected number of hospital days needed for AMI patients, Canada excluding territories, 1993 to 2026



Data source: *Population Projections Section, Demography Division, Statistics Canada; Person-Oriented Information Data Base*
Notes: *Projections assume 1993/94 hospitalization rates persist in the future. Low-, medium- and high-growth projections are numbered 1, 2 and 3, respectively.*

Other scenarios

For these projections, current hospitalization rates and the average length of stay were assumed to remain constant in the future. However, it is unlikely that this will happen.

Changes in smoking, exercise, diet, and other lifestyle behaviours will likely affect future rates. A number of additional factors may also influence these rates. For example, health promotion intiatives, improved treatments and screening programs have helped to decrease the number of people going to hospital by reducing the occurrence and severity of disease.

The total number of hospital days used for AMI has also declined in recent years. Quality care management approaches have improved the effectiveness and efficiency of hospital care. Developing and implementing Patient Care Maps—a timetable of tests, procedures and medications needed for an average patient with a given condition—has reduced the waiting time between tests and procedures.[23-25]

Reductions in the average length of hospital stay have also been achieved by replacing hospital care with less expensive alternatives. For example, ambulatory care has been used after selected surgeries.[26]

"Telemedicine," too, is being explored as an option for patients in remote regions. They are linked with specialists who conduct patient interviews and send test results via telephone before a decision is made to move the patient to an urban centre.

Since future changes in hospitalization rates for AMI cannot be predicted, hospital discharge rates between 1989 and 1993 were examined. A decline of 0.16% per year occurred during this period. If it is assumed that this decline persists in future, the number of AMI hospital patients will increase by 16.7% a decade, about half as much as shown in Chart 7.

Similarly, if the average annual decrease in the number of hospital days for AMI that occurred between 1989 and 1993 continues, the projected number of hospital days *declines* in spite of an aging population. However, this decrease in the number of days per discharge was close to 4% a year and it is unlikely that this rate of decline could continue indefinitely.

Concluding remarks

The projections provide an indication of the impact that the aging of the population will have on hospital resources needed for AMI. Continuation of past initiatives and new approaches will be needed to control costs as the population ages. ●

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Changing trends in melanoma incidence and mortality

Leslie A. Gaudette and Ru-Nie Gao

Abstract

Objectives

This article analyzes trends in melanoma incidence and mortality rates. Information on sun exposure supplements these statistics.

Data sources

Melanoma incidence data were obtained from the National Cancer Incidence Reporting System and from the Canadian Cancer Registry. Cancer mortality data were extracted from the Canadian Vital Statistics Data Base. Information on sun exposure is from the 1996 Sun Exposure Survey.

Analytical techniques

Incidence and mortality rates were age-standardized to the 1991 Canadian population to account for changes in the age structure of the population over time. The average annual percentage changes in age-specific rates were calculated for selected time periods.

Main results

After years of steady increases, melanoma incidence and mortality rates have levelled off as a result of declining rates in younger age groups, and for melanoma of the trunk among men and of the leg among women. Incidence rates for men are now higher than those for women; mortality rates for men are twice as high as for women.

Key words

skin neoplasms, cohort effect, sunburn, sunscreen, health surveys, clothing

Authors

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Throughout the 1970s and early 1980s, melanoma incidence and mortality rates were rising among Canadians.[1] This trend was also observed among other White populations around the world.[2] The upsurge has been attributed to increasing exposure to ultraviolet light, and was expected to continue because of the predicted depletion of the ozone layer.[3,4] More frequent, intermittent exposure to intense sunlight, as a result of greater participation in outdoor activities and winter travel, has been implicated as well.[5] (See *What is melanoma?*)

Rising incidence rates have also been ascribed to earlier detection of thinner lesions and the ability to diagnose melanomas that are essentially benign. Earlier detection can lead to improved survival and lower mortality rates. Since the mid-1980s, melanoma incidence and mortality rates in Canada have tended to level off.[6]

This article examines the factors underlying these changes by analyzing trends by sex, age group and site of melanoma from 1969 to the mid-1990s (see *Methods* and *Definitions).* Data from the 1996 Sun Exposure Survey supplement these statistics.

Methods

Data sources

Incidence data for invasive melanoma of the skin were obtained from the National Cancer Incidence Reporting System for 1969 to 1991 and from the Canadian Cancer Registry for 1992 and 1993. Each year, provincial and territorial cancer registries report information on all cases of cancer diagnosed among their residents to the Health Statistics Division at Statistics Canada,[7] which maintains these data bases.

Mortality data for 1969 to 1996 were extracted from the Canadian Vital Statistics Data Base maintained at Statistics Canada, which compiles information provided by the vital statistics registrars in each province and territory.[8]

Data on sun exposure are from the 1996 Sun Exposure Survey,[9] conducted by Statistics Canada in September and October that year. This survey, sponsored by the Institute of Health Promotion Research at the University of British Columbia, was funded by a number of national and provincial organizations and government departments. The target population was all Canadians aged 15 and older, excluding residents of the Northwest Territories and the Yukon, and residents of institutions. Of 5,847 households selected by a modified random-digit dialling procedure, 4,023 respondents comprised the final sample, for an overall response rate of 69%. Data were collected by computer-assisted telephone interviews; proxy responses were not allowed.

Respondents were asked: "During June to August, in your leisure hours, how much time each day (on average) were you in the sun?" Those who averaged at least 30 minutes a day in the sun were asked: "When you were in the sun for 30 minutes or more, how frequently did you: ...Seek shade? …Avoid the sun between 11 a.m. and 4 p.m.? …Cover your head? ….Wear clothing to protect your skin from the sun? (long sleeve shirt, long pants, t-shirt)? …Wear sunglasses? …Use sunscreen on your face? ….Use sunscreen on your body?" The response options were *always, often, sometimes, rarely, never.* This analysis groups together those who answered *always* and *often*.

Respondents were asked several questions about sunburns. Responses to the following were combined into one index for total sunburns: "A sunburn is defined as any reddening of the skin received either from the sun or artificial methods of tanning. During June to August, how many times have you had the following types of sunburns: …A blistering burn that required medical attention? …A blistering burn that did not require medical attention? …Redness or sensitivity with peeling? …Redness or sensitivity, with no peeling?" For this analysis, respondents were grouped as having had 0, 1 to 2, or 3 or more sunburns.

Those who reported at least one sunburn were asked about their most recent sunburn: "Which part of your body was most seriously sunburned?" The response options were *face, scalp or neck, back or shoulders, arms, legs, chest or stomach.* In this analysis, responses for *face, scalp or neck* were combined as "head." Responses for *back or shoulders* and *chest or stomach* were combined into "trunk."

Analytical techniques

Incidence and mortality rates were age-standardized to the 1991 Canadian population to account for changes in the age structure of the population over time. Population estimates were adjusted for net census undercoverage from 1971 onwards. International comparisons were based on the World Standard Population.

Changes in the annual age-standardized cancer incidence and mortality rates for melanoma were examined by calculating the average annual percentage change (AAPC) over various time periods. The AAPC is $(e^{\beta} - 1)100$, where β is the slope from a regression of log rates on year.

Limitations

Cancer incidence data may be under- or over-reported as a result of variations in procedures and data sources used to register cases, and differences in definitions used by registries to determine what is, or is not, an invasive cancer.[10] In general, registration procedures have improved to the point where cancer registration since 1984 is considered to be relatively consistent across Canada, and coverage for Canadian incidence data has been estimated to be 95% or more complete.[7] This overall estimate may vary by province and site.[11] Melanoma is known to be under-registered in Quebec because that registry relies on hospital separation records rather than pathology reports.[12]

Interpretation of data from the Sun Exposure Survey may be affected by the 69% response rate. People with more knowledge of, or interest in, health-promoting behaviour may be over-represented in the sample. Inferences based on these data about the association between sun exposure and melanoma incidence and mortality are limited by the cross-sectional nature of the survey and its focus on recent behaviours.

Incidence and mortality level off

During the 1970s and early 1980s, age-standardized incidence rates of melanoma rose steeply for both sexes, but were slightly higher for women than men (Chart 1). In the mid-1980s, women's incidence rates levelled off, and the rate among men surpassed that for women. Since 1989, men's rates, too, have levelled off. A number of other countries have reported this change in sex ratio.[13]

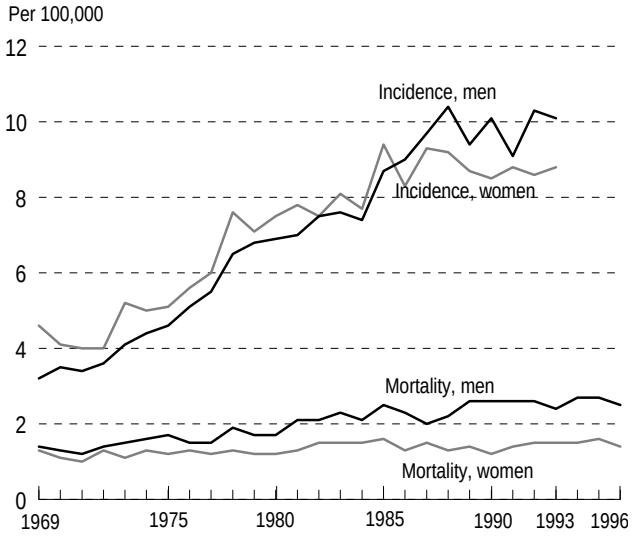
Throughout the past quarter century, age-standardized mortality rates for men exceeded those for women. Moreover, since the early 1980s, mortality rates have risen more rapidly among men, which widened the gap between the sexes.

Incidence declines at younger ages

Between 1969 and 1984, incidence rates increased on average by 2% to 7% per year in each age group among men, and by 3% to 4% among women (Chart 2, Appendix Tables A and B). Mortality increased significantly among men aged 40 and older, and significantly but less rapidly among women aged 60 or more. Significant decreases occurred for 20- to 29-year-olds of both sexes.

A different pattern emerged between 1985 and 1993. For both men and women in most age groups, the large average annual percentage increases in incidence rates were replaced either by declines, or by much smaller increases. Among women,

Chart 1
Age-standardized melanoma incidence (1969 to 1993) and mortality (1969 to 1996) rates, Canada



Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry, Canadian Vital Statistics Data Base*
Note: *Rates are age-standardized to the 1991 Canadian population adjusted for net census undercoverage.*

Definitions

Incidence: The number of new melanoma cases diagnosed during the year.

Mortality: The number of deaths during the year attributed to melanoma based on the underlying cause of death.

Age-specific rate: The number of new melanoma cases or melanoma deaths during the time period in a given group, expressed as a rate per 100,000 population in that age group.

Age-standardized rate: The number of new melanoma cases or melanoma deaths per 100,000 that would have occurred in the standard population (1991 Canadian population) if the actual age-specific rates observed in a given population had prevailed in the standard population. In some tables, annual age-standardized incidence rates (ASIRs) and age-standardized mortality rates (ASMRs) are based on age-specific rates calculated by aggregating counts of new cases or deaths for 1989 to 1993, the most recent five-year period for which incidence data were available.

Melanoma of the skin was identified by code 172 from the International Classification of Diseases, Ninth Revision (ICD-9).[14] The codes used to identify each subsite are:

Head: 172.0, lip; 172.1, eyelid; 172.2, ear; 172.3, other and unspecified parts of the face; and 172.4, scalp and neck
Trunk: 172.5, trunk except scrotum
Arm: 172.6, upper limb including shoulder
Leg: 172.7, lower limb
Other: 172.8, other; 172.9, site unspecified.

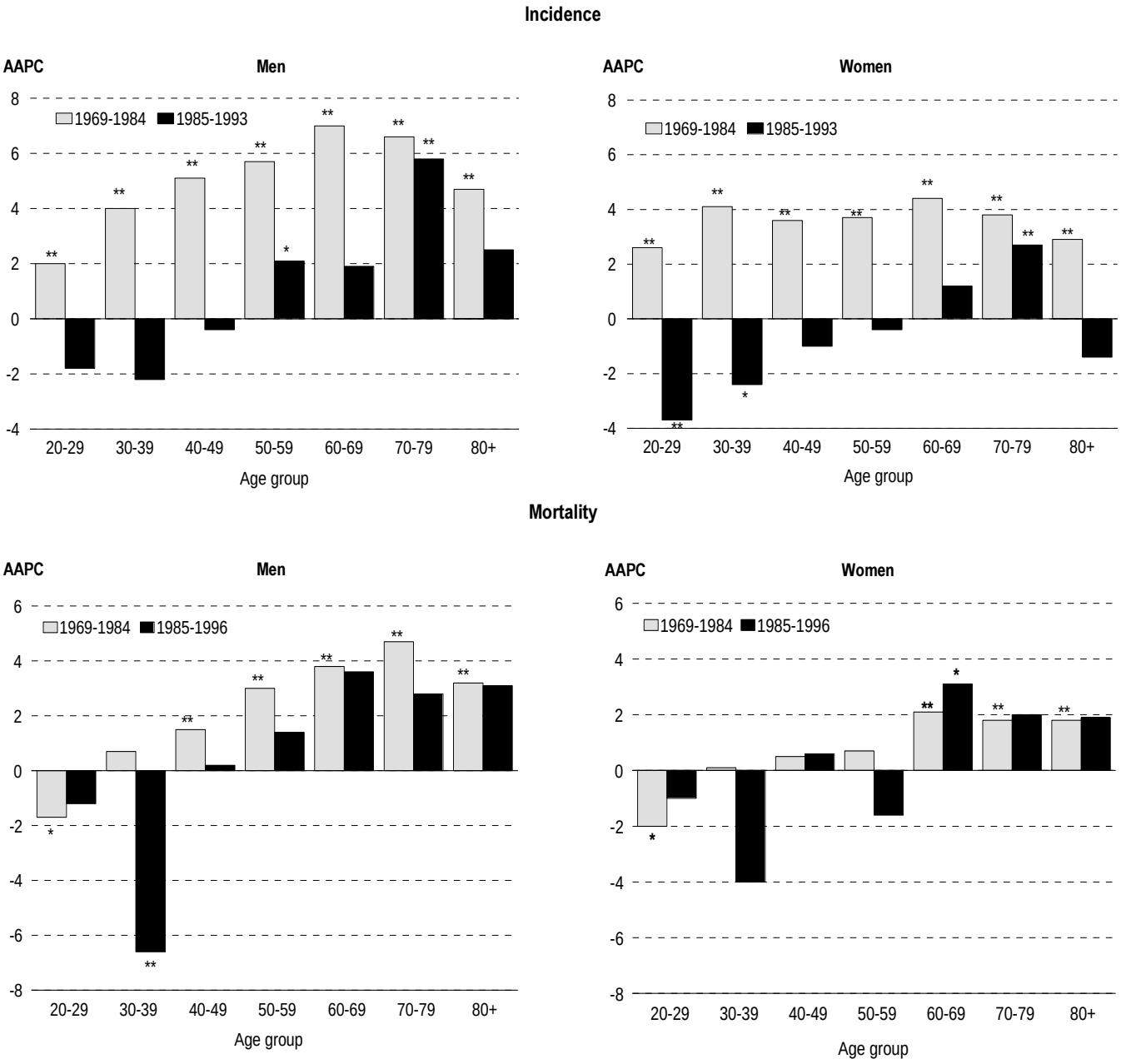
Codes from the International Classification of Diseases for Oncology, Second Edition[15] were used to identify melanomas by histology: 8720-8790. The major histological forms are:

Superficial spreading melanoma: 8740, 8741, 8743
Lentigo maligna melanoma: 8742
Nodular melanoma: 8721
Acral lentiginous melanoma: 8744.

incidence rates declined for all age groups under 60, with significant decreases for those in their twenties and thirties. Only among women aged 70 to 79 did rates rise significantly, and at a pace comparable with the earlier period. These trends were less pronounced among men, with non-significant declines among those younger than 50, increases of about 2% at ages 50 to 69 and 80 and older, and a larger, statistically significant increase for 70- to 79-year-olds.

Trends in age-specific mortality rates also changed in the more recent period. For those aged 60 and older, mortality rates rose among both sexes in both time periods. Among women, non-statistically

Chart 2
Average annual percentage change (AAPC) in age-specific melanoma rates, Canada, 1969 to 1984 and 1985 to 1993



Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry, Canadian Vital Statistics Data Base*
** Significantly different from zero (p < 0.05)*
*** Significantly different from zero (p < 0.01)*

significant declines occurred in most age groups under 60. Among men, there was a statistically significant decrease for those aged 30 to 39; at ages 40 to 59, rates did not increase significantly.

Changes in trends related to birth cohort

These changes in trends for age-specific rates are influenced by birth cohort effects, which were analyzed by plotting trends in the age-specific incidence rates by the median year of birth (data not shown). The largest increases in melanoma incidence rates among men occurred for those born between 1905 and 1909 and 1925 and 1929. Among women, the largest increases occurred in those born between 1915 to 1919 and 1925 to 1929. These results are similar to those reported in Norway for incidence data,[16] and in Australia[17] and England and Wales[18] for mortality data (see *International trends*). A slight decline in incidence was also noted for Canadian women born in 1950 or later, while men's rates tended to level off. These results are similar to those found in the mortality analyses.[17,18]

In addition to birth cohort effects, a period effect is evident since rates have levelled off or declined in most age groups for men under 45, and women

What is melanoma?

In 1998, melanoma accounted for an estimated 3,150 new cases, ranking ninth among the major forms of cancer for both Canadian men and women.[19] This was only about 5% of the estimated 64,000 new cases of other forms of skin cancer, primarily basal and squamous cell carcinomas. Melanoma, however, is by far the most serious form of skin cancer, accounting for about three times as many deaths (an estimated 740 in 1998) each year as all other forms of skin cancer combined. Although melanoma was once considered a near-lethal disease, survival rates five years after diagnosis are now relatively high: 88% for women and 74% for men.[20]

Malignant melanoma is a cancer morphology (or cell type) that can occur at primary sites other than the skin. Melanomas develop from cells that produce the pigment melanin. They can arise from nevi, or pigmented moles, which normally pose no health threat. Superficial spreading melanoma (SSM), the most common form in both men and women, generally arises from a pre-existing nevus. In Canada, it accounts for about 40% to 50% of melanomas of the trunk, arms and legs. Initially, its growth pattern is flat, however, the surface may become elevated and irregular as it reaches into the dermis (the thick layer of tissue just below the skin's surface).[21] Intermittent, rather than chronic, exposure to the sun[22] and development of atypical nevi during childhood[21] are associated with its development.

Nodular melanoma also tends to form from a pre-existing lesion, but the growth is more vertical than the horizontal growth pattern of SSM.[21] It accounts for about 10% of all melanomas at any site, including the head. Lentigo maligna melanomas (LMM) are flat, tan-coloured lesions, associated with occupational exposure. They occur in skin chronically exposed to the sun.[21] In Canada they are found primarily on the head and face, accounting for about 25% of melanomas at that site. A fourth form, acral lentiginous melanoma, occurs primarily on the palms of the hands or soles of the feet and is most commonly found in dark-skinned populations.[21]

The relationship of sun exposure and risk of melanoma is more complex than for other forms of skin cancer, which are directly related to chronic exposure to ultraviolet light from the sun.[23] Intense but intermittent exposure to sunlight during childhood and/or vacations are the main risk factors for melanoma, with chronic exposure playing a lesser role. Ultraviolet light is now thought to act both as an initiator of the carcinogenic process during childhood, and then as a promoter of subsequent pre-malignant and malignant change from early adulthood.[24] Other reported risk factors include a history of sunburns, fair skin, increased number of nevi, dysplastic nevi, previous melanoma and family history.[23]

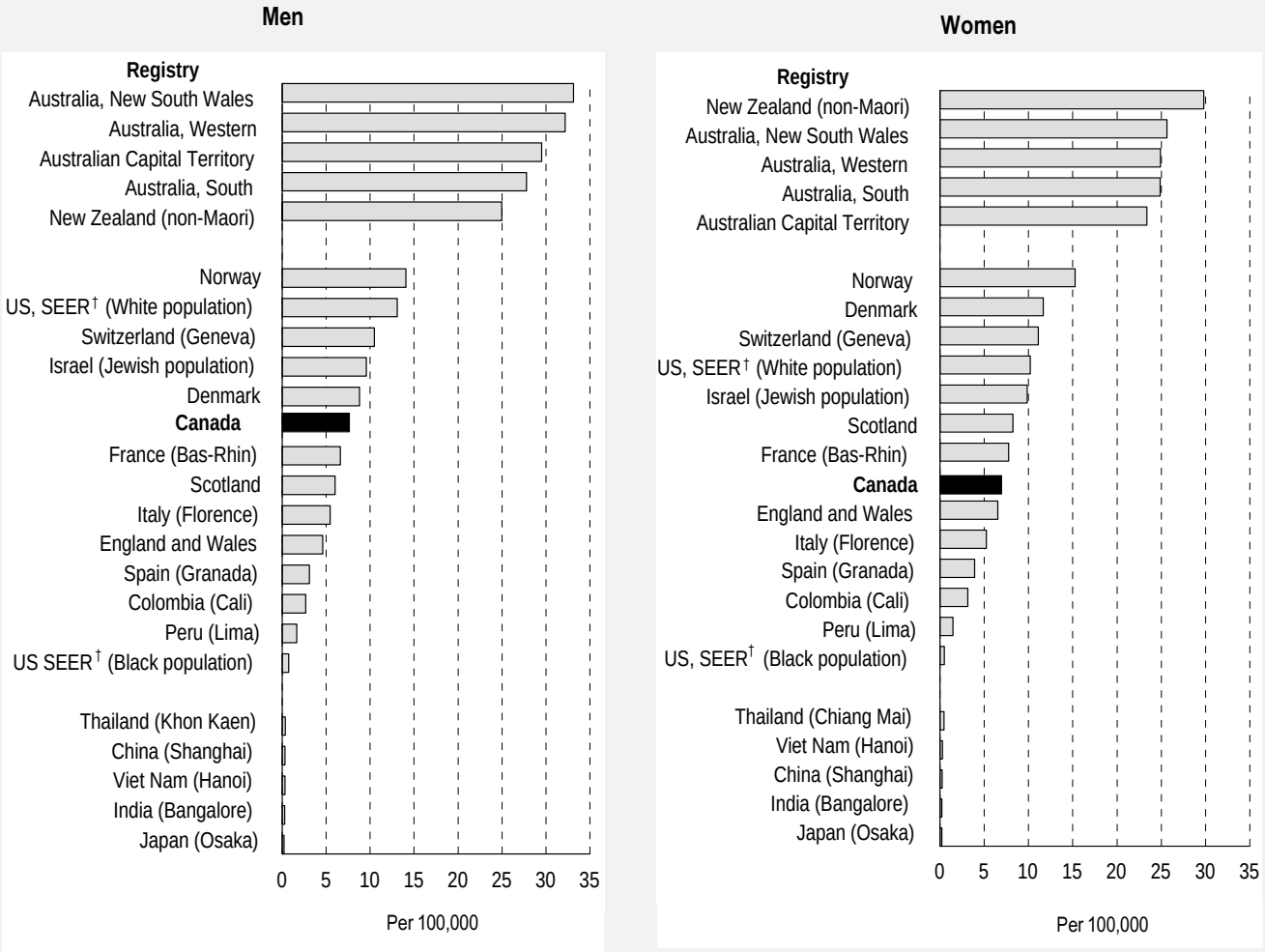
With proper treatment at an early stage, melanoma is potentially curable. Early detection of lesions before they metastasize is generally thought to explain improved survival rates.[23] However, some researchers have reported that increased detection may be identifying invasive melanomas that have no potential to metastasize, without necessarily reducing the number of cases of advanced disease diagnosed.[13,25] Surgery, the main form of treatment, involves excising the tumour (and a wide margin of normal skin around it). Radiation therapy can be used to prevent it from spreading. Chemotherapy and immunotherapy have produced long-term responses only in a minority of cases.[21]

International trends

Melanoma incidence rates are highest among White populations in Australia and New Zealand that live closest to the equator, and lowest in Asian and Black populations in India, China, Japan, Thailand and the United States. Canadian rates are about one-quarter of the highest rates in Australia, but are 25 times higher than the lowest rates.[2]

In recent years, increased melanoma incidence—but flat mortality rates—has been reported in the United States, Denmark and the United Kingdom, with some tendency to decline in younger age groups.[2,18] Greater awareness of melanoma signs and symptoms could be leading to earlier diagnosis of thinner lesions, for which survival is more favourable.[13] A pattern of increasing incidence rates with no decline in mortality rates could also be explained by over-diagnosis of lesions that are essentially benign.[13,25,26] However, this explanation is not supported by recent reports of slight declines in mortality from melanoma among women in Australia and Scotland.[17,27] These declines have been ascribed to lifestyle changes that reduced sun exposure as a result of public education programs.[17]

International age-standardized melanoma incidence rates, 1988-1992



Data source: *Reference 28*
Notes: *Rates are age-standardized to the World Standard Population. Chart includes registries with five highest and lowest rates, plus selected populations with intermediate rates.*
† The Surveillance, Epidemiology and End Results program

under 55. These cohort effects have been related to differences in exposure to sunlight,[17,18] and more specifically, to changing styles of clothing for outdoor recreation.[16]

Rates vary across country

Melanoma incidence and mortality rates vary across Canada (Table 1). Based on five-year averages for 1989 to 1993, the highest incidence rates for both sexes were in British Columbia, Nova Scotia and Prince Edward Island. Rates were also high in Ontario, New Brunswick, Alberta and Saskatchewan. By contrast, Quebec's rates were about half the Canadian average. As well, rates were low for men in Newfoundland.

Melanoma mortality rates among men tended to be high in Ontario and the Maritimes. For women, rates were high in Ontario and British Columbia. For both sexes, mortality rates were relatively low in Quebec and Manitoba, and lowest in Newfoundland.

Not only were melanoma mortality rates lower among women than men, but women's mortality rates were also relatively lower compared with incidence. The ratio of mortality to incidence rates was about 25% for men, but just 16% for women, reflecting women's higher survival. Ratios of mortality to incidence were high in Quebec for both sexes, attributable in part to incomplete registration of new cases.[7,12] However, since Quebec's mortality rates are also just 70% to 85% of the Canadian average, some protective factor may also be playing a role. The unusually low ratio among men and women in Newfoundland may be due in part to small numbers.

More common among women up to age 50

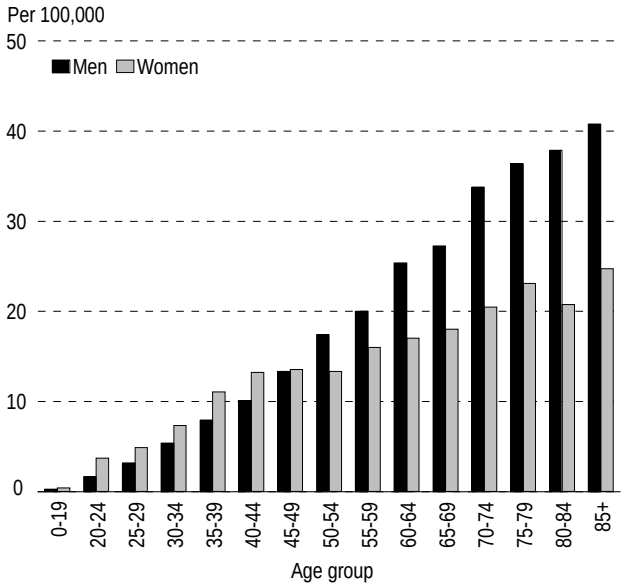
Melanoma is the third most commonly diagnosed cancer in men and women aged 30 to 39. Incidence rates rise steadily with age among men, but among women tend to level off and increase less rapidly after age 45 (Chart 3). Nevertheless, incidence rates are higher among women than men up to age 50.

Table 1
Age-standardized melanoma incidence and mortality rates, by sex, Canada, provinces and territories, 1989-1993

Province	Incidence rate		Mortality rate	
	Men	Women	Men	Women
	Per 100,000			
Canada	**9.8**	**8.7**	**2.5**	**1.4**
Newfoundland	4.9	7.0	1.0	0.4
Prince Edward Island	12.3	11.5	3.6	1.1
Nova Scotia	12.7	11.5	3.1	1.1
New Brunswick	10.9	10.4	3.0	1.0
Quebec	4.8	4.4	1.8	1.2
Ontario	12.1	9.8	3.0	1.6
Manitoba	9.2	9.1	1.9	1.3
Saskatchewan	10.5	9.3	2.2	1.3
Alberta	10.1	9.9	2.5	1.4
British Columbia	12.4	12.2	2.8	1.7
Yukon	8.1	2.8	5.7	–
Northwest Territories	3.0	6.5	3.0	–

Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry, Canadian Vital Statistics Data Base*
Note: *Rates are standardized to the 1991 Canadian population adjusted for net census undercoverage.*
– Nil

Chart 3
Age-specific melanoma incidence rates, by sex, Canada, 1989-1993



Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry*

Men affected on trunk, women on leg

The overall increase in melanoma incidence during the 1970s and early 1980s resulted primarily from the dramatic rise in rates for the trunk among men, and for the leg among women (Chart 4). Subsequently, the flattening of men's overall rates has occurred because of the levelling of incidence rates for the trunk, leg and possibly head. Nonetheless, men's rates for melanoma of the arm have continued to increase and are now similar to women's. Among women, slightly declining rates for the leg and trunk underlie the flattening of the overall melanoma rate.

Thus, by 1993, melanoma occurred nearly twice as often on men's trunks as on their head or arms. Among women, the leg was most frequently affected, followed by the arm and trunk. These differences in rates by body site are influenced by different levels of exposure to ultraviolet light, which may be related to clothing styles.[16,29]

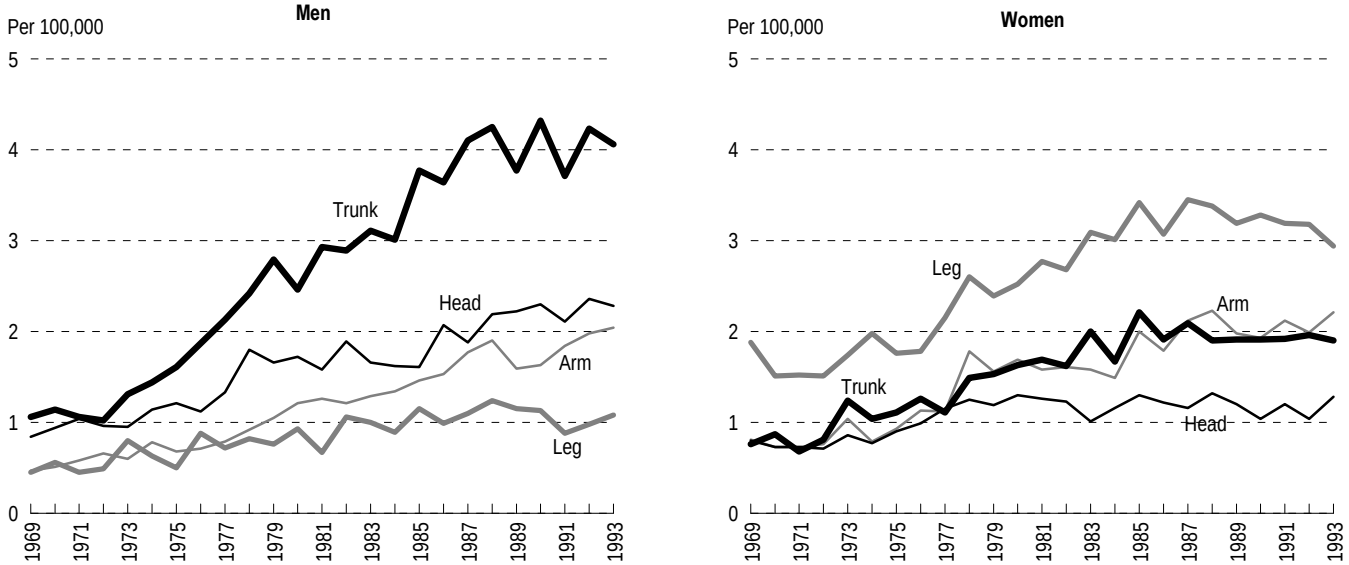
Incidence varies by site

The pattern of age-specific melanoma incidence rates varies considerably by the body part affected (data not shown). This may reflect different sun exposure patterns with respect to lifetime duration, intensity and intermittency,[30] as well as changing clothing styles.[16,31] Melanomas of the head show the most distinctive pattern. Rates for both sexes are similar and low up to age 50. Thereafter, rates rise continuously and exponentially, but those for men are typically at least twice those for women. The higher rates among men, largely due to higher incidence on the ears, scalp and neck,[22] have been attributed to balding among men and women's longer hair styles.[29]

Age-specific incidence rates for melanoma of the trunk rise from age 20 to 24 and are similar for both sexes up to age 35. Women's rates then level off and decline slightly starting around age 50. Men's rates continue to rise until age 60, when they are at least three times those for women. Men's rates then level off and decline from age 80.

Similar age-specific incidence rates for melanoma of the trunk among men and women until age 30 likely reflect similar levels of exposure before puberty. The continued rise in age-specific rates among men is likely a consequence of additional

Chart 4
Age-standardized melanoma incidence rates, by subsite and sex, Canada, 1969 to 1993



Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry*
Note: *Rates are age-standardized to the 1991 Canadian population adjusted for net census undercoverage.*

intermittent sun exposure in young adulthood during both recreational and work activities,[31] whereas women's trunks would be exposed to the sun primarily during recreational activities, particularly sunbathing (see *Sun exposure*).

Men's and women's rates for melanoma of the arm are relatively comparable, rising steadily to peak at ages 70 to 79. Rates for women slightly exceed those for men up to age 50, but are somewhat lower for ages 60 and older. This pattern may be influenced by similar levels of sun exposure of the arm for men and women, perhaps related to similar propensities to wear short-sleeved or sleeveless garments.

Incidence rates for melanoma of the leg among women rise steadily to peak at ages 65 to 74, with

Sun exposure

During the summer of 1996, 34% of Canadians aged 15 and older reported having one or two sunburns and 19% had three or more. Men were more likely than women to have had three or more sunburns: 23% compared with 16%. The proportion experiencing three or more sunburns declined steadily with age, from 30% at ages 15 to 24 to just 7% at age 65 and older.

Among Canadians experiencing at least one sunburn, the trunk, including the back, shoulders and chest, was the most common site (47%) of the most serious sunburn. However, the site most commonly burned varied by age and sex. The head, including the face, was the most common site burned at ages 45 to 64, particularly for men. By contrast, the trunk was the main body part burned among those under 35.

Canadians used a variety of strategies to protect themselves from the sun. About 4 in 10 reported wearing protective clothing, covering their head, seeking shade, or using sunscreen on their face. More often than men, women sought shade and used sunscreen. Men were more likely to cover their head or to wear protective clothing.

Measures taken to limit sun exposure differed by age. Older people were much more likely to report that they sought shade, wore protective clothing or covered their heads. Those aged 35 to 44 were the most likely to use sunscreen.

Sunburns and body parts affected, by sex and age group, population aged 15 and older, Canada excluding territories, 1996

	% of population sunburned		Main body part burned (most serious sunburn)				
	1 or 2 times	3+ times	Total	Trunk	Head	Arms	Legs
					%		
Both sexes	**34**	**19**	**100**	**47**	**30**	**17**	**6**
Men	34	23	100	47	31	17	5
Women	34	16	100	47	29	16	8
Age group							
15-24	38	30	100	54	28	14	4
25-34	42	26	100	54	28	14	6
35-44	42	21	100	47	28	17	7
45-54	33	15	100	35	36	21	9
55-64	26	11	100	36	38	17	8
65+	14	7	100	23	33	37	2

Data source: *1996 Sun Exposure Survey*

Protective behaviours during leisure hours, by sex and age group, population aged 15 and older, Canada excluding territories, 1996

	Seek shade	Cover head	Wear protective clothing	Use sunscreen on face
			% often or always	
Both sexes	**38**	**43**	**43**	**38**
Men	33	54	47	23
Women	44	31	38	55
Age group				
15-24	26	38	31	35
25-34	35	37	42	40
35-44	39	38	38	43
45-54	41	46	49	35
55-64	50	58	48	38
65+	48	58	56	30

Data source: *1996 Sun Exposure Survey*

slightly lower rates at age 80 and older. Rates among men are lower and rise more slowly, but quite steadily with age up to 80 and older. Women's rates are typically two to three times those of men, except at age 80 and older, where men's rates are just slightly less. The lower rates among men have been attributed to men's legs being less exposed to the sun.[29]

Men and women older than 80 have similar rates of melanoma of the leg, possibly because the women (who were born in 1910 or earlier) wore long skirts in childhood and young adulthood and did not expose their legs to the sun. Among women, the incidence of leg melanomas appears to have levelled off in the mid-1980s and may now be declining after years of rapid increases. The tendency of women to wear longer skirts and pants since the mid-1970s may have provided sufficient protection from the sun to reduce their risk.

Concluding remarks

It is well established that sunburns during childhood may initiate melanoma development. But sun exposure can also play a role in promoting development of melanoma among adults. In Canada, changing incidence and mortality trends appear to be related to changes in sun exposure or protective behaviours in early childhood and among adults. At least part of the increase during the 1970s may be explained by increasing sun exposure among children and adults as patterns of recreational activity and outdoor dress changed over the past century. Declining rates are now observed in younger Canadians, while rates at older ages continue to increase, suggesting that sun exposure patterns may have changed among those born since 1950.

Melanoma incidence rates for some parts of the body have levelled off, or have started to decline over the past decade. This, too, suggests that changes in sun exposure and protective behaviours such as wearing clothing or sunscreen, which may have become more widespread as sun safety messages were developed beginning in the early 1980s, are having an impact on health outcomes.

Melanoma is now more common among men than women. And although survival rates are generally high, men are more likely than women to die from melanoma. Further, men reported more multiple sunburns and used different protective strategies than did women.

These differences in behaviour between the sexes might be considered in the preparation of sun safety messages. As well, health promotion designed to reduce sun exposure may need to consider a variety of strategies. In Australia,[4,32] for instance, efforts have ranged from publishing articles in fashion magazines to providing more shade at public events. Canadian organizations have recently developed consensus recommendations on a wide range of strategies to reduce health risks from ultraviolet radiation.[33]

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Appendix

Table A

Number of new cases and age-standardized, crude and age-specific melanoma incidence rates, by sex and year of diagnosis, Canada, 1969 to 1993

Year	Number of cases	Age-standardized incidence rate	Crude rate	Age group							
				0-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
				Per 100,000 population							
Men											
1969	257	3.2	2.4	0.1	1.9	3.2	3.2	5.2	5.5	9.4	15.8
1970	291	3.5	2.7	0.3	1.2	3.3	4.7	5.8	7.3	9.0	13.9
1971	303	3.4	2.7	0.2	1.6	2.7	4.8	6.3	7.3	9.4	14.8
1972	321	3.6	2.9	0.3	2.1	2.9	4.2	6.0	7.8	10.6	10.4
1973	376	4.1	3.3	0.3	2.0	3.6	4.6	7.9	8.7	9.3	22.8
1974	409	4.4	3.6	0.3	2.0	3.2	5.9	8.6	8.3	11.7	24.7
1975	432	4.6	3.7	0.1	2.5	4.9	4.9	8.1	8.1	16.3	16.4
1976	493	5.1	4.2	0.3	2.2	4.9	7.6	8.3	11.2	12.8	18.3
1977	547	5.5	4.6	0.2	2.5	3.5	9.7	10.4	11.8	13.7	18.8
1978	636	6.5	5.3	0.3	2.7	5.5	8.7	10.1	14.6	16.5	31.3
1979	690	6.8	5.7	0.2	2.6	6.1	8.9	13.2	13.3	19.5	28.1
1980	720	6.9	5.9	0.1	2.3	6.5	8.9	12.7	17.3	20.0	22.4
1981	754	7.0	6.1	0.2	2.9	6.8	8.6	12.7	18.4	17.0	22.5
1982	812	7.5	6.5	0.2	2.5	6.1	8.1	15.0	18.6	22.3	35.1
1983	829	7.6	6.5	0.3	2.3	6.2	9.0	14.6	17.0	22.4	37.0
1984	845	7.4	6.6	0.2	2.9	6.4	10.3	14.0	18.0	19.5	26.6
1985	1,007	8.7	7.8	0.3	2.5	7.3	11.1	16.9	24.7	21.4	30.7
1986	1,043	9.0	8.0	0.3	3.0	6.7	11.6	15.6	22.6	26.1	41.6
1987	1,162	9.7	8.8	0.2	3.1	8.1	13.3	17.1	23.5	31.4	30.7
1988	1,285	10.4	9.6	0.4	3.5	7.7	13.0	18.9	28.8	33.7	32.0
1989	1,178	9.4	8.7	0.2	2.5	7.1	11.3	18.0	23.7	31.7	37.4
1990	1,294	10.1	9.4	0.3	1.9	7.2	12.0	18.7	27.7	35.2	43.1
1991	1,199	9.1	8.6	0.3	3.0	5.7	11.0	17.3	23.6	32.6	35.7
1992	1,390	10.3	9.8	0.4	2.6	6.5	12.1	20.7	28.1	37.2	35.9
1993	1,392	10.1	9.7	0.3	2.5	6.5	11.4	18.5	28.0	37.1	42.7
Women											
1969	402	4.6	3.8	0.3	2.1	4.4	7.5	7.3	9.7	10.3	14.8
1970	374	4.1	3.5	0.3	3.1	4.0	6.1	7.5	6.0	10.5	9.4
1971	368	4.0	3.4	0.2	2.5	3.4	6.3	6.5	6.6	10.4	14.7
1972	385	4.0	3.5	0.4	2.4	4.2	6.6	6.5	6.5	10.6	9.5
1973	502	5.2	4.5	0.3	4.0	5.7	8.6	7.1	8.0	11.6	15.1
1974	501	5.0	4.4	0.3	3.1	4.6	7.8	8.7	9.7	10.4	16.8
1975	526	5.1	4.5	0.3	3.1	5.4	7.2	9.4	9.6	11.6	15.0
1976	589	5.6	5.0	0.3	3.0	6.6	7.6	10.6	10.8	10.2	19.4
1977	644	6.0	5.4	0.2	3.4	6.7	9.8	10.1	9.8	13.1	21.8
1978	834	7.6	6.9	0.5	4.7	9.2	11.3	13.6	12.5	14.5	20.7
1979	790	7.1	6.5	0.3	4.2	7.9	10.9	11.6	14.0	14.7	20.2
1980	861	7.5	7.0	0.4	5.1	8.1	11.8	11.4	15.5	15.2	18.0
1981	914	7.8	7.3	0.2	4.9	9.5	12.0	13.8	13.8	15.4	18.3
1982	905	7.5	7.1	0.3	4.6	9.2	11.1	12.4	13.2	16.6	20.3
1983	989	8.1	7.7	0.5	4.4	10.1	11.7	16.0	13.8	14.2	19.8
1984	966	7.7	7.5	0.5	4.4	9.7	9.8	12.6	15.0	16.9	21.7
1985	1,207	9.4	9.2	0.5	4.9	11.5	14.3	15.7	18.4	18.6	27.2
1986	1,092	8.3	8.3	0.4	5.2	8.9	12.8	13.7	14.9	20.1	22.2
1987	1,241	9.3	9.3	0.4	5.7	10.4	15.0	14.4	18.2	20.3	21.8
1988	1,249	9.2	9.2	0.5	4.9	10.5	14.8	15.9	16.1	19.7	24.9
1989	1,214	8.7	8.8	0.3	4.9	9.9	13.3	15.4	15.2	18.9	25.1
1990	1,222	8.5	8.7	0.5	4.1	8.8	14.1	14.9	17.0	19.1	21.8
1991	1,285	8.8	9.1	0.3	4.9	8.9	13.6	14.5	18.1	22.6	20.9
1992	1,297	8.6	9.0	0.5	4.0	9.5	12.5	13.3	18.9	22.8	21.3
1993	1,356	8.8	9.3	0.4	3.8	8.6	13.4	15.2	18.3	24.2	23.8

Data sources: *National Cancer Incidence Reporting System, Canadian Cancer Registry*

Table B
Number of melanoma deaths and age-standardized, crude and age-specific mortality rates, by sex, Canada, 1969 to 1996

Year	Number of deaths	Age-standardized mortality rate	Crude rate	Age group							
				0-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
				Per 100,000 population							
Men											
1969	111	1.4	1.1	-	0.6	0.9	1.3	2.0	4.4	3.8	8.3
1970	107	1.3	1.0	-	0.3	0.9	1.1	2.7	3.7	4.1	8.1
1971	100	1.2	0.9	-	0.4	0.4	2.3	1.7	2.8	2.6	8.4
1972	122	1.4	1.1	-	0.5	0.7	1.9	2.2	2.7	5.3	10.4
1973	129	1.4	1.1	-	0.3	1.2	2.3	2.4	3.7	4.1	5.5
1974	149	1.6	1.3	-	0.5	1.0	2.2	2.9	4.3	5.1	8.2
1975	157	1.7	1.4	-	0.7	1.3	1.7	3.0	3.9	6.0	9.6
1976	139	1.5	1.2	-	0.5	1.2	2.0	3.0	2.2	6.0	6.8
1977	145	1.5	1.2	-	0.4	1.2	1.8	3.3	3.8	4.4	6.0
1978	186	1.9	1.5	0.1	0.4	1.1	2.8	3.7	5.0	5.9	7.3
1979	171	1.7	1.4	-	0.3	1.2	1.8	4.0	4.2	4.6	9.8
1980	176	1.7	1.4	-	0.5	1.6	2.2	3.1	3.7	5.5	7.7
1981	220	2.1	1.8	-	0.4	1.4	2.7	4.1	5.6	7.1	10.6
1982	222	2.1	1.8	-	0.4	1.2	1.9	5.0	6.1	6.0	11.5
1983	244	2.3	1.9	-	0.6	1.3	2.4	4.1	6.4	7.5	13.5
1984	229	2.1	1.8	0.1	0.6	1.1	2.2	3.8	5.2	7.0	16.4
1985	279	2.5	2.2	0.1	0.4	1.3	2.5	4.5	7.0	9.5	16.5
1986	255	2.3	2.0	-	0.4	1.7	2.6	3.1	5.7	9.4	12.8
1987	234	2.0	1.8	0.1	0.4	1.3	2.1	4.0	5.7	7.0	8.2
1988	260	2.1	1.9	-	0.5	1.3	2.0	4.6	5.5	9.6	8.4
1989	317	2.6	2.3	-	0.3	1.4	3.2	4.7	6.8	10.6	13.2
1990	318	2.6	2.3	-	0.1	1.7	2.1	4.6	6.4	10.9	19.1
1991	330	2.6	2.4	-	0.2	1.2	2.4	5.1	8.1	10.0	13.5
1992	337	2.6	2.4	-	0.3	1.0	2.1	4.5	8.5	10.9	17.1
1993	323	2.4	2.3	-	0.4	1.1	2.4	4.0	6.7	11.0	13.6
1994	373	2.7	2.6	-	0.4	1.1	2.3	4.9	8.4	12.7	14.1
1995	380	2.7	2.6	-	0.4	0.9	2.3	4.2	9.4	11.4	18.2
1996	367	2.5	2.5	-	0.3	0.5	2.8	5.1	7.6	10.6	15.1
Women											
1969	113	1.3	1.1	-	0.4	0.6	2.3	2.9	2.7	3.6	4.9
1970	95	1.1	0.9	-	0.4	1.1	1.1	1.3	2.2	4.9	5.8
1971	90	1.0	0.8	-	0.2	0.4	1.6	2.1	2.1	3.4	4.9
1972	127	1.3	1.1	0.1	0.7	0.7	1.8	1.9	2.9	4.4	7.6
1973	104	1.1	0.9	-	0.3	1.0	1.5	1.8	1.5	4.5	5.5
1974	129	1.3	1.1	-	0.4	0.8	1.6	2.7	3.1	3.6	7.5
1975	115	1.1	1.0	-	0.4	0.8	1.9	1.5	2.2	3.6	6.9
1976	132	1.3	1.1	-	0.2	1.4	1.5	2.3	2.8	4.1	6.2
1977	131	1.2	1.1	-	0.5	1.0	1.7	1.7	3.0	4.2	6.4
1978	145	1.3	1.2	0.1	0.4	1.0	1.1	2.0	4.4	3.7	6.9
1979	135	1.2	1.1	-	0.3	0.9	1.3	3.0	2.4	4.1	5.2
1980	145	1.2	1.2	-	0.3	0.7	1.7	3.3	1.9	3.6	7.8
1981	151	1.3	1.2	-	0.4	1.1	1.8	2.3	3.2	3.8	5.1
1982	179	1.5	1.4	-	0.3	1.5	1.9	2.9	2.8	4.6	8.2
1983	187	1.5	1.5	-	0.4	1.1	1.9	3.0	3.5	4.9	7.2
1984	184	1.5	1.4	-	0.4	1.2	1.9	2.2	3.5	4.0	8.7
1985	208	1.6	1.6	-	0.3	1.3	2.1	2.5	4.0	5.1	9.3
1986	173	1.3	1.3	-	0.1	1.0	1.3	2.4	3.1	5.6	6.4
1987	201	1.5	1.5	-	0.4	0.9	2.0	3.3	2.8	5.2	7.2
1988	189	1.3	1.4	-	0.3	0.8	1.7	3.0	2.9	4.3	7.7
1989	200	1.4	1.4	-	0.5	0.9	1.7	1.6	3.4	5.5	8.1
1990	179	1.2	1.3	-	0.2	0.9	1.2	2.7	2.4	4.9	7.3
1991	213	1.4	1.5	-	0.3	0.7	1.9	2.2	3.3	5.7	8.9
1992	237	1.5	1.6	0.1	0.2	0.9	2.3	2.4	3.6	5.4	9.4
1993	239	1.5	1.6	0.1	0.2	1.4	1.7	1.8	3.9	5.9	8.1
1994	237	1.5	1.6	-	0.2	0.5	2.1	2.7	4.3	5.0	7.4
1995	271	1.6	1.8	-	0.2	0.7	1.4	2.5	4.6	7.8	9.9
1996	260	1.5	1.7	0.1	0.3	0.7	2.0	2.1	4.1	5.7	9.6

Data source: *Canadian Vital Statistics Data Base*
- Nil

Maternal education and risk factors for small-for-gestational-age births

Wayne J. Millar and Jiajian Chen

Abstract

Objectives

This article examines the association between maternal education, smoking and other risk factors and small-for-gestational-age (SGA) births.

Data source

The data are from the 1994/95 National Longitudinal Survey of Children and Youth. The analysis was restricted to a subsample of 4,181 children younger than age 2 and was based on information provided by their biological mothers.

Analytical techniques

Logistic regression was used to estimate the odds ratios for SGA by maternal education, controlling for maternal smoking during pregnancy, household income, family status, maternal age at birth of child, and use of prenatal care.

Main results

Maternal education and smoking during pregnancy appear to have independent effects on SGA, after controlling for other risk factors. The effects of maternal education, smoking and other risk factors are likely underestimated, as the analysis pertains only to children who had survived at the time of the interview.

Key words

pregnancy outcome, low birthweight, maternal behaviour, maternal exposure, smoking during pregnancy

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The prevention of small-for-gestational-age (SGA) births is an important public health objective in the overall strategy to improve child health.[1-3] SGA refers to birthweight less than the 10th percentile of the most recent Canadian birthweight norms by infant sex, gestational age and singleton or multiple birth status.[4] SGA babies may be at higher risk of fetal and infant mortality than non-SGA births.[5,6] While SGA births and preterm births (gestational age less than 37 weeks regardless of birthweight) are two types of low birthweight, the former appear to be more liable to be delayed in subsequent development and to remain small.[7,8]

Several Canadian studies based on vital statistics have indicated an inverse association between adverse birth outcomes and socioeconomic status.[6,9,10] One of the primary indicators of socioeconomic status, educational attainment, is also closely related to a number of other risk factors.[7,11-14] Among the risk factors associated with poor birth outcomes that tend to be more prevalent among

Methods

Data sources

The data are from the first cycle of the National Longitudinal Survey of Children and Youth (NLSCY), conducted in 1994/95. The target population was children from newborn to age 11. In each NLSCY household, up to four children were selected at random, and a question was asked to determine who in the household was the person most knowledgeable about them. For 91.3% of the selected children, that person was the mother (89.9%, biological; 1.4%, step, adoptive or foster).

The first NLSYC cycle resulted in a responding sample of 13,439 households. In these households, 22,831 children were selected to participate in the survey. Data will be collected every two years as these children grow to adulthood.[1] The overall response rate at the household level was 86%. Response rates for the health outcomes of children and the characteristics of persons most knowledgeable (the adult who provided the information) for the sampled children were over 91%.

This analysis is restricted to a subsample of 4,181 children younger than age 2 whose biological mothers were interviewed (Appendix Table A).[15] All responses relating to the birth outcome are based on the mother's recall. The focus of the analysis is small-for-gestational-age (SGA) births; namely, birthweight less than the 10th percentile of Canadian birthweight norms, by infant sex, gestational age, and singleton or multiple birth status.

Analytical techniques

Several behavioural, demographic and socioeconomic risk factors for SGA were examined (see *Definitions)*. Multiple logistic regression was used to estimate the adjusted odds ratios of SGA for maternal education, household income level, maternal age at birth of child, family status, use of prenatal care, and maternal smoking.

The multivariate analysis is based on 4,060 children younger than age 2 in 1994/95 whose mothers reported information on all the variables included in the model. Missing data were excluded. The sample was weighted using sample weights re-scaled to average 1.

In this article, percentages refer to unadjusted prevalence figures (Table 1, Chart 1), while adjusted odds ratios (Table 2) refer to estimates derived from the multiple logistic regression model, which controls for other variables entered in the analysis. Unadjusted odds ratios are also provided (Appendix Tables B and C).

To illustrate the effects of smoking and education on SGA, the estimated probability of SGA under different scenarios was determined by substituting the values of the independent variables in a multiple logistic regression. These estimates are model-based and limited to the current sample.

Limitations

The estimates in this analysis are conservative. The association between risk factors and SGA is subject to selection bias. Infants born too small or too early tend to have higher mortality. Information is not available from the NLSCY about children who died within the first two years of life. Consequently, the number of SGA births will tend to be underestimated, and the effects of risk factors may be attenuated.

To some extent, the NLSCY underestimation of the prevalence of SGA births (compared with vital statistics) may be because the survey results are based on the mothers' recollection of the infants' due date and birthweight. This information could vary with the physicians' clinical assessment and the mothers' recall of what they were told.

The mothers' inability to accurately recall or reluctance to admit the amount smoked during their pregnancy may have reduced the association between smoking frequency and SGA.[16,17] The lack of a more pronounced dose-response association may also be attributable to the lack of specificity in the data about the timing of exposure for the fetus.[18] The use of biochemical markers would likely yield better estimates of tobacco use than reliance on self-report.[19] In an assessment of the dose-dependence of birthweight on smoking, there was a closer dose-effect relationship between birthweight deficits and urinary nicotine metabolites/creatine ratios than with self-reported daily cigarette smoking.[20] A recent Canadian study reported that the mean birthweight of infants was inversely associated with maternal serum cotinine levels and that the relative risk of SGA was significantly higher in smokers.[21]

Information on the mothers' education was collected at the time of the survey, not at the time of the child's birth. It is possible that some mothers may have upgraded their education between these two dates; thus, the association between maternal education and SGA births may be slightly underestimated.

The NLSCY contained questions on alcohol consumption and drug use during pregnancy, both of which have been identified as SGA risk factors.[22] However, the number of women reporting that they had consumed substantial quantities of alcohol was too small for meaningful analysis, and the question on drug use did not probe the nature of the drugs. Consequently, neither of these risk factors was included in the model.

women with low educational attainment are teenage pregnancy, lone motherhood, low income, lack of prenatal care, and smoking during pregnancy.[3,11,16,18,23-35]

This article is based on data from the 1994/95 National Longitudinal Survey of Children and Youth (NLSCY). It asseses the relative importance of selected SGA risk factors and examines the association between maternal education and these risk factors for children younger than age 2 (see *Methods* and *Definitions*). Although the relationship of risk factors to unfavourable birth outcomes has been shown in past research, most of those studies lacked the scope of the population-wide NLSCY.[7]

Maternal education and SGA

Education affects an individual's income-generating ability, and hence, access to adequate diet, shelter, health care services, and other material conditions that can promote a healthy pregnancy. Education also may enhance the ability to access and use information.[12] As well, education is associated with a number of health behaviours that may influence birth outcomes.

According to the NLSCY, 6% of children younger than age 2, an estimated 42,100, had been SGA births (Table 1). The percentage varied substantially by maternal education, dropping from 12% of children whose mothers had less than high school graduation to 5% of those whose mothers had a postsecondary diploma or degree. These results are similar to those of a recent birth cohort study.[6]

Definitions

Definitions

SGA was not directly collected by the NLSCY. It was derived from information about the child's gestational age and birthweight. Mothers were asked, "Was … born before or after the due date?" Those who answered that the baby was not born on the due date were asked the number of days before or after the due date. Mothers were also asked, "What was his/her birthweight in kilograms and grams or pounds and ounces?" This information about gestation and birthweight was used in conjunction with Canadian norms for birthweight to classify births as SGA; specifically, birthweight less than the 10th percentile for infant sex, gestational age, and singleton or multiple birth status.[4] SGA births include full-term births that are too small for their gestational age.[7,36,37]

Smoking during pregnancy was determined by asking "Did you smoke during your pregnancy with …?" Mothers who answered "yes" were asked, "How many cigarettes per day did you smoke during your pregnancy with ….?" These responses were grouped into three categories: no smoking, 1 to 10 cigarettes per day, and 11 or more cigarettes per day. Mothers were also asked, "At what stage in your pregnancy did you smoke this amount?" The same question was repeated for "during the first three months," "during the second three months," and "during the third three months." The response options for each trimester were "yes" or "no." A limitation of these questions is that a "no" response could mean that the mother was smoking more or less. Consequently, the amount smoked during each trimester is not known and could not be used in the analysis. In fact, some mothers may actually have quit smoking at a particular stage in their pregnancy, but this would not be revealed by the NLSCY questions.

Maternal education was defined as less than high school graduation, high school graduation or some postsecondary education, and postsecondary graduation.

Based on household size, *household income* quintiles were derived and further grouped as low (quintiles 1 and 2), middle (quintiles 3 and 4), and high (quintile 5).

Maternal age at birth of child was defined as younger than 20, 20 to 24, 25 to 34, and 35 and older.

Family status was defined as either lone-mother or two-parent family (including stepfather).

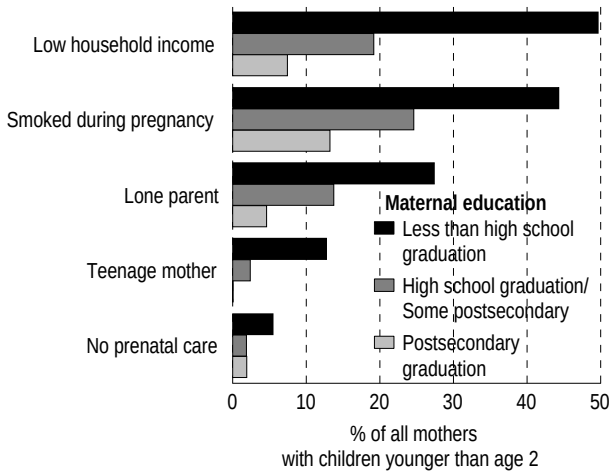
Prenatal care refers to whether the mother received prenatal care from a doctor, nurse or midwife.

Table 1
Children younger than age 2 who were SGA at birth, by mothers' characteristics, Canada excluding territories, 1994/95

Mothers' characteristics	Small for gestational age (SGA)	
	Number	% of all children younger than age 2
Total SGA children younger than age 2	**42,100**	**6**
Educational attainment†		
Less than high school	12,900	12
High school graduation/Some postsecondary	17,100	6
Postsecondary graduation	12,000	5
Smoking status during pregnancy†		
11+ cigarettes per day	6,900	13
1-10 cigarettes per day	12,400	12
Did not smoke	21,700	4
Household income		
Low	11,900	9
Middle	27,400	6
High	2,800	4
Family status		
Lone mother	7,900	10
Father present	34,200	6
Age at birth of child		
Less than 20 years	1,500	7
20-24 years	7,300	7
25-34 years	27,700	6
35+ years	5,600	7
Received prenatal care†		
No	1,800	11
Yes	39,200	6

Data source: *1994/95 National Longitudinal Survey of Children and Youth*
† Excludes missing.

Chart 1
Prevalence of SGA risk factors among mothers of children younger than age 2, by educational attainment, Canada excluding territories, 1994/95



Data source: *1994/95 National Longitudinal Survey of Children and Youth*
- Nil

Risk factors for SGA

Perhaps the most well-known risk factor for SGA is maternal smoking during pregnancy. Smoking causes fetal oxygen deprivation, which can retard fetal growth and result in low birthweight.[38-40] About 12% of children younger than age 2 whose mothers had smoked while pregnant had been SGA births, compared with only 4% whose mothers had not smoked (Table 1, Appendix Table C).

Household income, too, was related to SGA births. In low-income households, 9% of children had been SGA births, compared with 4% of children in high-income households. Similarly, family status was associated with SGA births: 10% of children in lone-mother families had been SGA births versus 6% in two-parent families.

Very few mothers had not received prenatal care (Appendix Table A), but among the children of this minority, 11% had been SGA births. The prevalence of SGA births, however, did not vary by the mother's age when she had the baby.

Maternal education and SGA risk factors

Low maternal education was strongly associated with smoking (Chart 1 and Appendix Table B). This is not surprising, as smoking tends to be more prevalent among people with relatively little education.[41] Forty-four percent of mothers who had not graduated from high school had smoked when they were pregnant, compared with 13% of those who had completed a postsecondary program. In addition, smoking intensity declined with increasing education. About 16% of mothers with less than high school graduation smoked more than 10 cigarettes a day, whereas just 4% who were postsecondary graduates had done so (data not shown). These results are consistent with previous studies.[33,35]

As might be expected, low maternal education was related to low household income, lone parenthood and teenage pregnancy. As well, the percentage of mothers who had received no prenatal care was higher among those who had not completed high school than among postsecondary graduates.

Clearly, maternal education is strongly associated with various risk factors for SGA births. It is equally apparent that many of these risk factors are interrelated. For instance, lone parenthood, teenage motherhood and low income frequently co-exist (data not shown).

Smoking and education crucial factors

After accounting for the effects of maternal education, household income, maternal age at birth of child, family status and the receipt of prenatal care, the odds of having been an SGA birth were significantly higher for children whose mothers had smoked during pregnancy (Table 2). Compared with the children of women who did not smoke, the odds ratios were elevated among children of both heavy smokers (2.7) and light smokers (2.6).

In addition, even after adjusting for smoking during pregnancy, household income, maternal age, family status and prenatal care, the association between low education and SGA persisted. Among children whose mothers had not graduated from high school, the odds of having been an SGA birth were twice as high (2.1) as among those whose mothers were postsecondary graduates.

On the other hand, when other risk factors were taken into account, household income, lone parenthood, prenatal care and maternal age did not have statistically significant effects on SGA. This may be partially related to a health-selection effect. That is, very low birthweight infants might have died by the time of the NLSCY, so the risk factors associated with their births (and subsequent deaths) would not be part of the analysis.

Profiles

The pronounced influence of smoking and education is evident in how the presence or absence of these factors alters the probability of an SGA birth. For instance, consider children of lone mothers aged 25 to 34 living in low-income households, who had not graduated from high school, who received no prenatal care, and who smoked heavily during pregnancy. The estimated probability of having been an SGA birth for such children is 26%. But for children born to mothers with the same characteristics except that they did not smoke during pregnancy, the estimated probability of SGA falls to 11%.

The importance of education can be seen by the differences in probabilities of SGA birth for children whose mothers have the same characteristics except for education. Among children born to lone mothers aged 25 to 34 living in low-income households who received no prenatal care, did not smoke during pregnancy and were postsecondary graduates, the estimated probability of SGA decreases almost by half, from 11% to 6%.

Table 2
Adjusted odds ratios for SGA at birth among children younger than age 2, by mothers' characteristics, Canada excluding territories, 1994/95

Mothers' characteristics	Adjusted odds ratio	95% confidence interval
Educational attainment		
Less than high school	2.1**	1.4, 3.1
High school graduation/Some postsecondary	1.3	0.9, 1.8
Postsecondary graduation†	1.0	...
Smoking status during pregnancy		
11+ cigarettes per day	2.7**	1.9, 4.0
1-10 cigarettes per day	2.6**	1.9, 3.5
Did not smoke†	1.0	...
Household income		
Low	1.7	0.9, 3.1
Middle	1.6	0.9, 2.7
High†	1.0	...
Family status		
Lone mother	1.2	0.8, 1.8
Father present†	1.0	...
Age at birth of child		
Less than 20 years	0.5	0.3, 1.1
20-24 years	0.8	0.5, 1.1
25-34 years†	1.0	...
35+ years	1.1	0.8, 1.7
Received prenatal care		
No	1.2	0.6, 2.4
Yes†	1.0	...

Data source: *1994/95 National Longitudinal Survey of Children and Youth*
Note: *The multivariate analysis is based on 4,060 children younger than age 2 whose mothers reported information on all variables in the model.*
† Reference category, for which odds ratio is always 1.0
··· Not applicable
** $p < 0.05$*
*** $p < 0.01$*

The final example concerns children born in more favourable circumstances. In this case, their mothers were married postsecondary graduates, who had high household income, who had received prenatal care, and who did not smoke during pregnancy. The estimated probability of SGA among these children is 2%.

Implications

According to the 1994/95 National Longitudinal Survey of Children and Youth, maternal education was associated with smoking during pregnancy, household income, teenage parenthood, lone parenthood, and the mother's age when the child was born, all of which were risk factors for SGA among children younger than age 2. These results echo a Canadian study on the prevalence of risk behaviours during pregnancy[42] and a recent analysis of the association between maternal education and SGA.[6] Even when these risk factors were controlled, low levels of maternal educational were associated with increased odds of an SGA birth.

The other variable that remained significantly associated with the odds of an SGA birth, after adjusting for potential confounding factors, was smoking during pregnancy. This is consistent with previous studies,[22,43-46] except there was only a small difference in SGA births among children whose mothers were heavy or light smokers. As noted, the absence of a marked gradient in SGA by smoking intensity may be related to the questions used to measure smoking frequency in the NLSCY, along with the mother's inability to accurately recall the amount she smoked.[17] Selection bias may also be a factor, since maternal smoking, especially heavy smoking, had a weak (not statistically significant) association with low birthweight and pre-term birth (data not shown).

The two risk factors for SGA births shown to be significant in this analysis, low educational attainment and smoking, potentially affect a substantial share of children. In 1994/95, 17% of children younger than age 2 had been born to mothers who had not completed high school, and 23% had been born to mothers who had smoked when they were pregnant.

In Canada, previous national health surveys did not attempt to monitor the smoking behaviour of pregnant women. Nonetheless, there has been a report of a decline in the prevalence of smoking among pregnant women in a local regional study.[35] Further progress may require attention to the social and environmental context that gives rise to high-risk behaviors.[23,24,37,42] The development of health education programs tailored to pregnant women may lead to higher smoking cessation rates than would be attained using conventional clinic information.[47] Education in the broadest sense (including formal education and prenatal care programs) appears to be an important factor in SGA births. Efforts to enable women to improve their educational attainment or to reach pregnant women may affect the prevalence of SGA.[7,47]

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Appendix

Table A
Distribution of children younger than age 2, by mothers' characteristics, Canada excluding territories, 1994/95

Mothers' characteristics	Sample size	Estimated population	% of total
All children younger than age 2	**4,181**	**661,849**	**100**
Educational attainment			
Less than high school	710	112,641	17
High school graduation/Some postsecondary	1,883	283,018	43
Postsecondary graduation	1,577	265,155	40
Missing	11	1,035	--
Smoking status during pregnancy			
11+ cigarettes per day	397	52,942	8
1-10 cigarettes per day	693	99,885	15
Did not smoke	3,043	500,565	76
Missing	48	8,457	1
Household income			
Low	918	130,621	20
Middle	2,841	452,265	68
High	422	78,963	12
Family status			
Lone mother	522	82,250	12
Father present	3,659	579,599	88
Age at birth of child			
Less than 20 years	170	21,462	3
20-24 years	795	108,582	17
25-34 years	2,761	450,136	68
35+ years	455	81,669	12
Received prenatal care			
No	107	16,700	3
Yes	4,030	637,552	96
Missing	44	7,597	1

Data source: *1994/95 National Longitudinal Survey of Children and Youth*
-- Amount too small to be expressed

Table B
Unadjusted odds ratios for risk factors for SGA births, by educational attainment of mothers of children younger than age 2, Canada excluding territories, 1994/95

Risk factor/Mothers' education	Odds ratio	95% confidence interval
Smoked during pregnancy		
Less than high school	5.2**	4.2, 6.4
High school graduation/Some postsecondary	2.1**	1.8, 2.6
Postsecondary graduation†	1.0	...
Smoked heavily during pregnancy		
Less than high school	4.0**	2.9, 5.5
High school graduation/Some postsecondary	2.0**	1.5, 2.7
Postsecondary graduation†	1.0	...
Low household income		
Less than high school	12.2**	9.6, 15.4
High school graduation/Some postsecondary	2.9**	2.4, 3.6
Postsecondary graduation†	1.0	...
Lone mother		
Less than high school	7.7**	5.8, 10.2
High school graduation/Some postsecondary	3.3**	2.5, 4.3
Postsecondary graduation†	1.0	...
Teenage mother‡		
Less than high school	11.2**	7.8, 16.2
High school graduation or more†	1.0	...
No prenatal care		
Less than high school	2.9**	1.8, 4.7
High school graduation/Some postsecondary	1.0	0.6, 1.6
Postsecondary graduation†	1.0	...

Data source: *1994/95 National Longitudinal Survey of Children and Youth*
† Reference category, for which odds ratio is always 1.0
‡ Because very few teenage mothers were postsecondary graduates, the reference category was those who had high school graduation or more.
··· Not applicable
** $p < 0.05$*
*** $p < 0.01$*

Table C
Unadjusted odds ratios for SGA at birth among children younger than age 2, by mothers' characteristics, Canada excluding territories, 1994/95

Mothers' characteristics	Odds ratio	95% confidence interval
Educational attainment		
Less than high school	2.7**	2.0 , 3.8
High school graduation/Some postsecondary	1.4	1.0 , 1.8
Postsecondary graduation†	1.0	...
Smoking status during pregnancy		
11+ cigarettes per day	3.3**	2.3 , 4.8
1-10 cigarettes per day	3.1**	2.3 , 4.1
Did not smoke†	1.0	...
Household income		
Low	2.8**	1.6 , 4.8
Middle	1.8*	1.1 , 2.9
High†	1.0	...
Family status		
Lone mother	1.7**	1.2 , 2.4
Father present†	1.0	...
Age at birth of child		
Less than 20 years	1.1	0.6 , 2.2
20-24 years	1.1	0.8 , 1.6
25-34 years†	1.0	...
35+ years	1.1	0.8 , 1.6
Received prenatal care		
No	1.8	1.0 , 3.5
Yes†	1.0	...

Data source: *1994/95 National Longitudinal Survey of Children and Youth*
† Reference category, for which odds ratio is always 1.0
··· Not applicable
** $p < 0.05$*
*** $p < 0.01$*

Maternal education and fetal and infant mortality in Quebec

*Jiajian Chen, Martha Fair, Russell Wilkins, Margaret Cyr and the Fetal and Infant Mortality Study Group of the Canadian Perinatal Surveillance System**

Abstract

Objectives

This article examines differences in fetal and infant mortality by maternal education in the province of Quebec, where the rates are among the lowest in Canada.

Data source

The data are from linked birth and infant death records (including stillbirths) for the 1990-1991 birth cohorts in Quebec.

Main results

Fetal and infant mortality rates were greater for the offspring of mothers with less than 12 years of education, compared with mothers with at least 14 years, even after adjusting for maternal age, parity, marital status and infant's sex. When intermediate factors such as birthweight or both gestational age and fetal growth were taken into account, the differentials in mortality by education diminished. If all education groups had experienced the low rates attained by the higher education group, the number of fetal and infant deaths would have been reduced by approximately 20%.

Key words

causes of death, low birthweight, small for gestational age, fetal growth, excess deaths, record linkage

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Fetal and infant mortality rates have declined rapidly in industrialized nations in the past decades. In Canada, these rates are among the lowest in the world.[1-3] Nevertheless, there are still marked disparities in infant mortality by socioeconomic status.[4]

Assessing the nature and extent of social inequalities in fetal and infant mortality is necessary in attempts to further reduce them.[5,6] However, since most Canadian vital statistics records do not contain the necessary socioeconomic data, little research has been done linking fetal and infant deaths to socioeconomic status at the individual level. An exception is the province of Quebec, where, since 1976, birth registrations have included the mother's educational attainment.

Maternal education, a modifiable aspect of socioeconomic status,[7] has consistently been found to be inversely related to infant mortality. This association is stronger in countries that do not have universal health

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Methods

Data source

This study was based on singleton live births of any birthweight or gestational age, stillbirths of 500 g or more, and infant death records from the 1990-1991 cohorts of births to mothers whose usual place of residence was Quebec. Among the 192,150 total singleton births, there were 859 stillbirths and 1,004 infant deaths. Live births were followed for one year for mortality, using a probabilistic record linkage technique to match records from the Canadian Birth Data Base to corresponding records in the Canadian Mortality Data Base. The linkage of infant death records to corresponding live birth records was successful for 94% of the infant deaths. By linking the two records, infant deaths could be cross-classified by the marital status and parity of the mother, and by the birthweight and gestational age of the infant.

The birth-death linkage was carried out using the mainframe version of the generalized record linkage system GRLS V1, based on the Fellegi–Sunter model.[8-11] Surnames on the birth and death records were assigned a phonetic code (NYSIIS) to allow for misspellings. Three passes of the files were completed; on each pass only records within the same "pocket" were compared. The pockets were defined as follows: 1) phonetic NYSIIS surname and sex code; 2) date of birth and sex code; and 3) date of birth alone. Rules were set to compare items common to the two files. Fields common to the two files included surname, given names, geographic variables, particulars of the father and mother, birthweight, etc. To determine if paired records from the two data bases refered to the same individual, a weight was calculated based on how closely the records matched. Threshold values were set above which the linkages were accepted or flagged as possible links. Manual resolution was carried out to decide which possible links should be accepted. Where necessary, copies of the source documents (birth and death registrations) were consulted for additional information.

Analytical techniques

Crude relative risks, as well as crude and adjusted odds ratios (using logistic regression) and hazard ratios (using survival analysis) were calculated to investigate the relationship between maternal education and fetal and infant mortality. Potential confounding factors that were examined included maternal age, parity, marital status and infant's sex.[7,12-14] Birthweight or gestational age and fetal growth (see *Definitions)* were added to the models to determine if the influence of maternal education was modified by these intermediate factors. When gestational age and fetal growth were included in the model, low birthweight was excluded because it is known to be the result of preterm birth, fetal growth restriction, or a combination of the two.[7,13,15-18] In the cause-specific survival analysis, deaths due to causes other than the one of interest were considered censored upon such death. The product limit (Kaplan-Meier) method was used to estimate cumulative total mortality.

Using rates in the highest educational group (14 years or more) as an achievable standard, the number of *excess events* was calculated by subtracting expected events from observed events. The expected events were obtained by applying the achievable standard rates to all births with known maternal education. The percentage of all events that were considered avoidable was calculated by dividing excess events by observed events, then multiplying by 100.[4] The result is more commonly known as the population attributable risk percentage (PAR%) (also known as the etiologic fraction, population attributable proportion or risk percentage).

The PAR% is commonly used to denote how much of the disease burden in a population could be attributable to the effects of certain causal factors, assuming that no confounding of the association between the exposure and the disease exists. It can be calculated as $100*(R_t-R_u)/R_t$, where R_t is the risk in the total population and R_u is the risk in the unexposed population; or as $100*(P_{exp}*(RR-1))/(1+P_{exp}*(RR-1))$, where P_{exp} is the prevalence of exposure, and RR is the risk ratio comparing exposed to unexposed.[7,19-22]

Finally, because the two groups with the least maternal education (10 years or less and 11 years) were of particular concern, the attributable fraction was also calculated for these two combined exposed groups, as well as the excess events in the combined groups as a percentage of the excess events in the total cohort with known maternal education. The *attributable fraction* for the exposed is simply the excess events associated with the risk factor, expressed as a percentage of the total events for those exposed to the risk factor.

Limitations

The results are not necessarily generalizable to all of Canada, since only Quebec data are studied here. In Newfoundland, physician notices of birth have recently started collecting information on maternal education, but these data were not available for the years studied here.

Calculations of excess events using only births with known maternal education could result in conservative estimates of excess events and of the PAR % if births and adverse outcomes of unknown maternal education come disproportionately from the lower maternal education groups, which is thought likely.

insurance (such as the United States) and weaker in those with universal health care and a high overall standard of living (such as the Scandinavian countries).[12,23-27]

Although Quebec's fetal and infant mortality rates are among the lowest in Canada,[1,2,28,29] an average of 1,020 stillbirths and infant deaths were recorded yearly from 1990 to 1992, yielding an annual rate of 10 per 1,000 total births (livebirths plus stillbirths).[1]

This article examines the effects of maternal education on fetal and infant mortality in Quebec in the early 1990s. It is based on live birth, stillbirth and infant death records for the 1990-1991 birth cohorts and is limited to singleton births to mothers who were Quebec residents at the time of the birth. Live births in these cohorts were followed for one year for mortality (see *Methods* and *Definitions*).

The analysis demonstrates that marked differences in fetal and infant mortality by education persist in Quebec, despite many years of universal access to free, high-quality health care. The results imply that if all education groups had been able to attain the low rates of the higher education group, the number of fetal and infant deaths would have been reduced by approximately 20%.

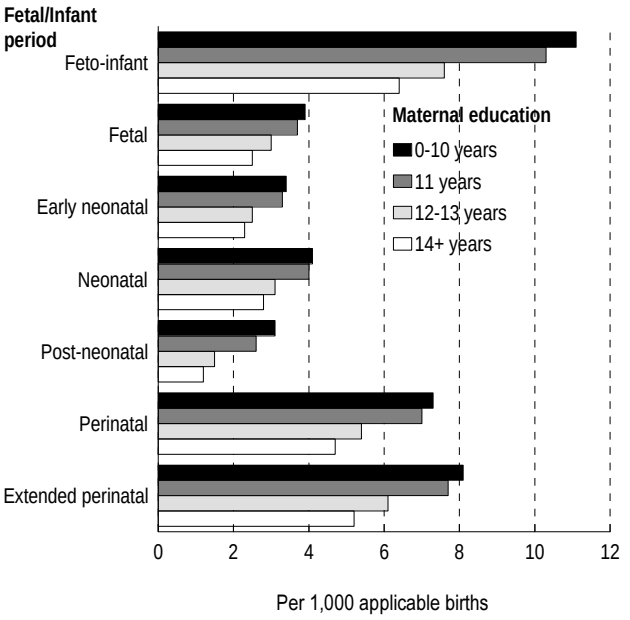
Age-specific deaths

Despite low rates of fetal and infant mortality, a total of 1,863 stillbirths and infant deaths occurred among the 192,150 members of Quebec's 1990 and 1991 cohorts of singleton births. Almost half (859) of these were stillbirths;[9] another 664 infants died within the first 27 days, and an additional 340 children died before their first birthday.

The mother's education was strongly related to the likelihood of a stillbirth or infant death. As maternal education increased, fetal and infant mortality rates declined (Chart 1). The overall feto-infant rate fell from 11.1 fetal and infant deaths per 1,000 births for mothers with 10 or fewer years of education to 6.4 for mothers with 14 or more years of schooling (Table 1).

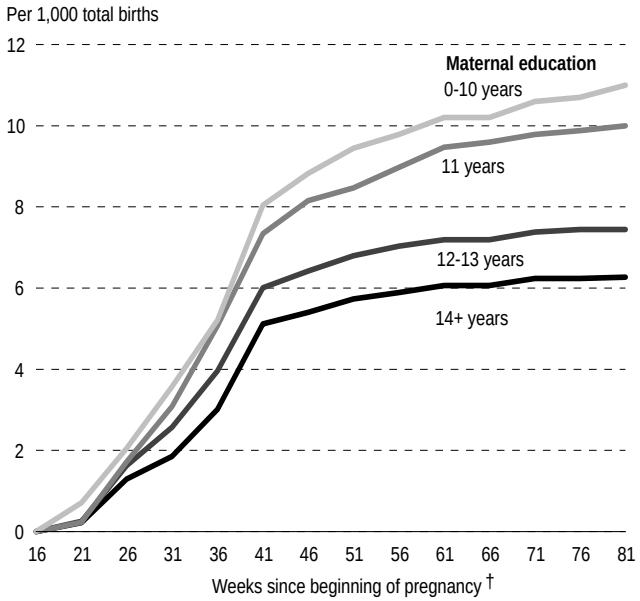
The relationship between lower maternal education and higher mortality was evident regardless of the period of fetal or infant death. The absolute difference in rates was greatest in the

Chart 1
Age-specific fetal and infant mortality rates, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*

Chart 2
Cumulative mortality, by weeks since beginning of pregnancy† and maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Completed weeks of gestation for stillbirths; completed weeks of gestation at birth plus weeks of life after birth for live births

Definitions

Maternal age in years was grouped into four categories: 19 or younger, 20 to 24, 25 to 34, and 35 or older.

Legal *marital status* was divided into two categories: married and not married. The results by marital status must be interpreted with caution because of the high prevalence of common-law unions in Quebec.

Maternal education in years was grouped into four categories: 10 years or less, 11 years, 12 or 13 years, and 14 years or more. These parallel the major divisions in Quebec's education system. It takes 11 years to complete high school, 14 years to complete a vocationally oriented CEGEP (community college) program, and 16 years for a first university degree. Differences in feto-infant mortality rates for breakdowns of educational attainment beyond 14 years were small and did not achieve statistical significance.

Parity refers to the sequential placement of the birth or stillbirth to the particular mother. Four categories were used: first, second, third and fourth or later.

Birthweight in grams was grouped into four categories: 500 to 1,499; 1,500 to 2,499; 2,500 to 4,499; and 4,500 or more. *Low birthweight* (LBW) was 500 to 2,499 g.

Gestational age in completed weeks as reported by the attending physician was grouped into four categories: 33 or less, 34 to 36, 37 to 41, and 42 or more. A *preterm* birth (PT) was less than 37 completed weeks' gestation.

Fetal growth, in terms of percentile of weight for gestational age, infant's sex and plurality (always singleton births in this analysis), was grouped into three categories, based on the most recent Canadian birthweight norms:[30] *small for gestational age* (SGA) (below the 10th percentile), *appropriate for gestational age* (AGA) (10th to 90th percentiles), and *large for gestational age* (LGA) (greater than the 90th percentile).

Infant (0 to 364 days), *neonatal (0 to 27 days)*, and *early neonatal (0 to 6 days) mortality rates* were defined as the number of live births resulting in death within the specified period per 1,000 live births. Except for birthweight-specific and gestational age-specific analyses, all live births were included in the denominators, regardless of birthweight or gestational age.

Late neonatal (7 to 27 days) and *post-neonatal (28 to 364 days) mortality rates* were defined as the number of infant deaths occurring within the specified period per 1,000 infants that survived past the end of the preceding period.

Overall *feto-infant (stillbirths + 0 to 364 days)*, *fetal (stillbirths)*, *perinatal (stillbirths + 0 to 6 days)*, and *extended perinatal (stillbirths + 0 to 27 days) mortality rates* were defined as the number of stillbirths plus infant deaths occurring within the specified period per 1,000 stillbirths and live births. In all cases, stillbirths were limited to fetuses weighing at least 500 g at birth, regardless of gestational age.

Rates are not additive when denominators differ. For example, the sum of the neonatal and postneonatal mortality rate does not equal the infant mortality rate.

Underlying cause of death was coded to the International Classification of Diseases, Ninth Revision (ICD-9).[31] Using the categories proposed by the International Collaborative Effort on Perinatal and Infant Mortality, all underlying causes of deaths were grouped as follows: congenital conditions, sudden infant death syndrome (SIDS), asphyxia-related conditions, immaturity-related conditions, infections, external causes, other specific conditions, and remaining causes.[32] ICD-9 codes defining these groupings are presented in Appendix Table A.

Fetal and infant periods

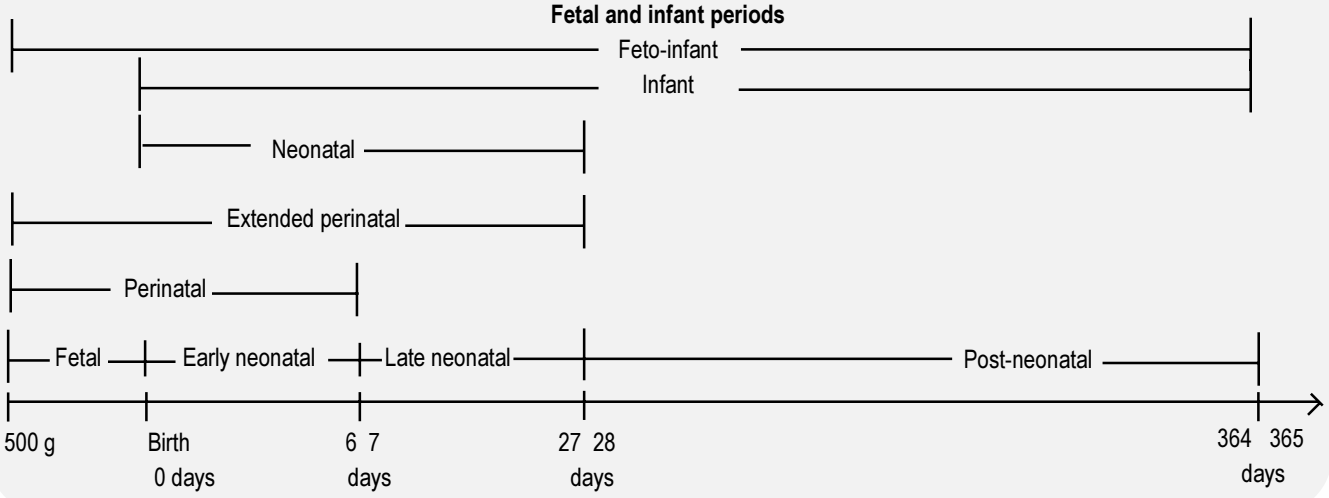


Table 1
Unadjusted feto-infant mortality rates, by selected maternal and birth characteristics, singleton live births and stillbirths, Quebec, 1990-1991

			Feto-infant mortality			
	Number of births	% of total	Rate (per 1,000)	Rate ratio	95% confidence interval	
Total	192,150	100	9.70			
Education						
0-10 years	27,624	14	11.1	1.73*	1.50,	2.01
11 years	22,719	12	10.3	1.61*	1.37,	1.89
12-13 years	62,449	33	7.6	1.19*	1.04,	1.35
14+ years†	69,292	36	6.4	1.00	...	
Missing	10,066	5	40.1	6.27*	5.48,	7.17
Maternal age						
<20	8,036	4	15.4	1.77*	1.47,	2.13
20-24	39,863	21	10.7	1.23*	1.10,	1.37
25-34†	129,099	67	8.7	1.00	...	
35+	15,018	8	12.4	1.43*	1.22,	1.66
Missing	134	--	74.6	8.57*	2.25,	15.98
Marital status						
Married†	116,316	61	8.6	1.00	...	
Not married	75,825	39	11.4	1.33*	1.21,	1.45
Missing	9	--	111.1	12.92*	1.82,	91.81
Parity						
1	88,828	46	11.5	1.60*	1.43,	1.78
2†	66,493	35	7.2	1.00	...	
3	25,980	14	8.8	1.22*	1.04,	1.43
4+	10,837	6	11.4	1.58*	1.45,	1.93
Missing	12	--	1000.0	138.89*	78.32,	246.29
Infant sex						
Male	98,833	51	10.2	1.12*	1.02,	1.23
Female†	93,317	49	9.1	1.00	...	
Birthweight in grams						
500-1,499	1,648	--	432.6	116.92*	105.16,	129.99
1,500-2,499	8,268	4	42.2	11.41*	10.02,	12.99
2,500-4,499†	177,515	92	3.7	1.00	...	
4,500+	2,579	1	4.7	1.27	0.72,	2.24
Missing	2,140	1	58.9	15.92*	13.16,	19.26
Gestational age						
<34 weeks	2,872	1	277.5	66.07*	59.72,	73.10
34-36 weeks	8,386	4	30.3	7.21*	6.25,	8.33
37-41 weeks†	169,145	88	4.2	1.00	...	
42+ weeks	5,744	3	4.2	1.00	0.67,	1.50
Missing	6,003	3	11.7	2.79*	2.18,	3.56
Fetal growth‡						
SGA	18,433	10	25.1	3.64*	3.26,	4.06
AGA†	149,476	78	6.9	1.00	...	
LGA	15,462	8	7.4	1.07	0.88,	1.30
Missing	8,779	5	29.7	4.30*	3.76,	4.93

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Reference category, for which rate ratio is always 1.00
‡ See Definitions.
··· Not applicable
-- Amount too small to be expressed
** p < 0.05*

perinatal period (Chart 1), while the relative difference was most pronounced in the post-neonatal period (odds ratios in Table 2). For all levels of maternal education, the cumulative incidence of deaths and stillbirths rose steeply between 16 and 41 weeks from the beginning of pregnancy (Chart 2). After 41 weeks, mortality rates among the children of mothers in the two lower educational groups continued to rise, while rates for those of mothers in the two higher groups nearly levelled off. This widening gap in cumulative

Table 2
Unadjusted odds ratios for fetal and infant deaths, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio	95% confidence interval	
Fetal death			
0-10 years	1.60*	1.26,	2.04
11 years	1.52*	1.17,	1.97
12-13 years	1.21	0.98,	1.49
14+ years†	1.00	...	
Early neonatal death			
0-10 years	1.50*	1.16,	1.94
11 years	1.47*	1.12,	1.94
12-13 years	1.09	0.87,	1.36
14+ years†	1.00	...	
Perinatal death			
0-10 years	1.55*	1.30,	1.85
11 years	1.50*	1.24,	1.81
12-13 years	1.15	0.99,	1.34
14+ years†	1.00	...	
Neonatal death			
0-10 years	1.50*	1.19,	1.89
11 years	1.44*	1.12,	1.85
12-13 years	1.13	0.93,	1.38
14+ years†	1.00	...	
Extended perinatal death			
0-10 years	1.55*	1.31,	1.83
11 years	1.48*	1.23,	1.77
12-13 years	1.17*	1.01,	1.35
14+ years†	1.00	...	
Post-neonatal death			
0-10 years	2.55*	1.89,	3.45
11 years	2.11*	1.51,	2.96
12-13 years	1.20	0.89,	1.62
14+ years†	1.00	...	

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Reference category, for which odds ratio is always 1.00
··· Not applicable
** p < 0.05*

mortality over the remainder of the first year occurred mostly in the late neonatal and post-neonatal periods, when the vast majority of newborns had already been discharged from hospital. However, the pattern of marked socioeconomic inequality in mortality was already evident by the 28th week, indicating that the process was well under way early in the period of fetal development.

Table 3
Adjusted odds ratios for fetal and infant deaths, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio†	95% confidence interval
Fetal death		
0-10 years	1.72*	1.33, 2.23
11 years	1.60*	1.22, 2.08
12-13 years	1.26*	1.02, 1.55
14+ years‡	1.00	...
Early neonatal death		
0-10 years	1.47*	1.11, 1.93
11 years	1.47*	1.11, 1.96
12-13 years	1.11	0.89, 1.39
14+ years‡	1.00	...
Perinatal death		
0-10 years	1.60*	1.33, 1.93
11 years	1.54*	1.27, 1.87
12-13 years	1.19*	1.02, 1.38
14+ years‡	1.00	...
Neonatal death		
0-10 years	1.42*	1.10, 1.82
11 years	1.42*	1.10, 1.83
12-13 years	1.14	0.93, 1.40
14+ years‡	1.00	...
Extended-perinatal death		
0-10 years	1.56*	1.30, 1.87
11 years	1.50*	1.25, 1.81
12-13 years	1.20*	1.03, 1.39
14+ years‡	1.00	...
Post-neonatal death		
0-10 years	1.67*	1.20, 2.33
11 years	1.61*	1.14, 2.28
12-13 years	1.06	0.78, 1.43
14+ years‡	1.00	...

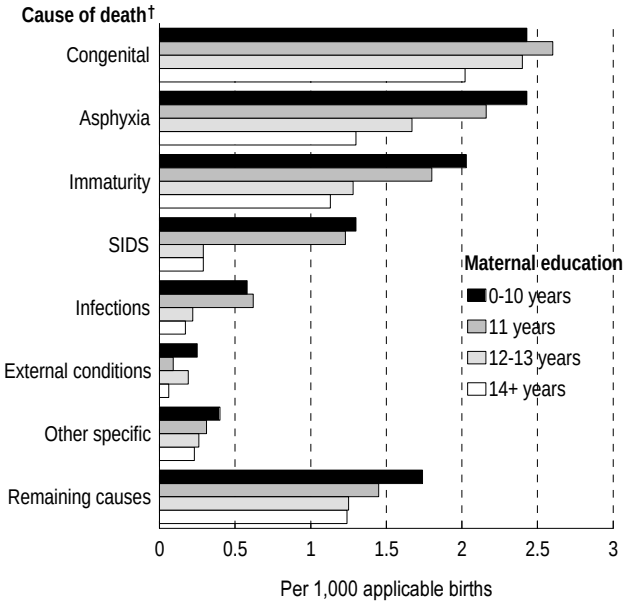
Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Adjusted for maternal age, marital status, parity and infant's sex
‡ Reference category, for which odds ratio is always 1.00
··· Not applicable
** $p < 0.05$*

Adjusted effects

Many factors besides maternal education are linked to stillbirth and infant mortality rates (Table 1). For instance, rates were higher among mothers younger than 20 or older than 34, and among mothers who were not legally married. Rates were also high for first births and for fourth or later births. Boys had higher stillbirth and infant mortality rates than girls.

Yet even after adjusting for maternal age, marital status, parity and infant's sex, the effects of maternal education on fetal and infant mortality remained significant. Regardless of when the death occurred (from fetal to post-neonatal periods), the odds of death were considerably higher for mothers in the two lower educational groups, compared with those with at least 14 years of schooling (Table 3).

Chart 3
Cause-specific fetal and infant mortality rates, by maternal education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† See Appendix Table A.

Cause-specific deaths

Overall, the major underlying causes of feto-infant mortality were congenital-related conditions (2.6 per 1,000), asphyxia (2.3 per 1,000), and immaturity (1.6 per 1,000).

Comparing the most to the least educated groups, the absolute differences in rates were greatest for asphyxia, followed by sudden infant death syndrome (SIDS) and immaturity (Chart 3). Relative differences in rates (rate ratios–not shown) were most pronounced for SIDS, followed by external conditions and infections.

Maternal education was strongly linked with fetal and infant mortality from several specific causes. Babies born to mothers with less than 12 years of schooling had an especially high risk of SIDS, compared with children of the most educated mothers (Table 4, unadjusted). On the other hand, there was no relationship between maternal education and deaths due to congenital conditions, the leading cause of feto-infant mortality. Differences in mortality risk by maternal education were evident for external conditions, although these results must be interpreted with caution, as there were only 25 cases.

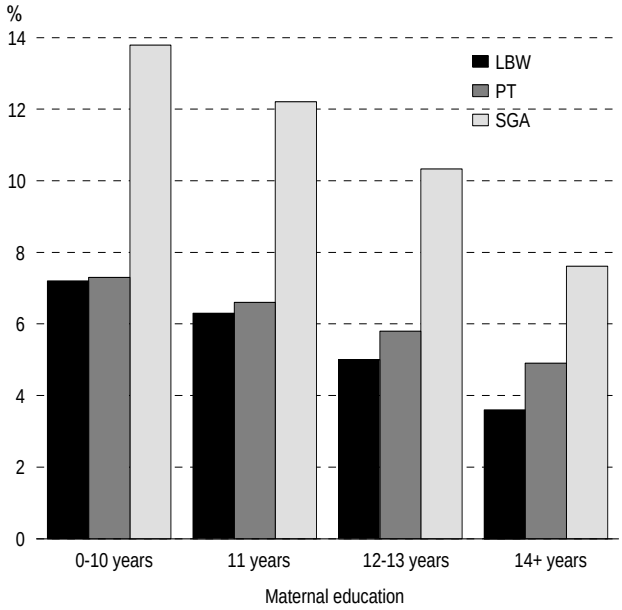
Once the effects of maternal age, parity, marital status and infant's sex were taken into account, the relative risk (hazard ratio) for deaths due to asphyxia, immaturity and infections remained approximately twice as high for infants of mothers with less than 12 years of education, compared with those with 14 or more years of schooling (Table 4, adjusted). The strength of the relationship between maternal education and SIDS diminished, however, after adjusting for these confounding factors. For example, the risk ratio for children of mothers with 11 years of education fell from 4.3 before adjustment to 2.3 after adjustment. To some extent, this reduction in relative risk may have occurred because less educated mothers were more likely to be teenagers and unmarried, both groups with high relative risks of SIDS.[33]

Table 4
Cox regression estimates of mortality hazard ratio, by cause of death and maternal education, singleton births, Quebec, 1990-1991

	Unadjusted		Adjusted†	
Cause of death	Hazard ratio	95% confidence interval	Hazard ratio	95% confidence interval
All causes of feto-infant deaths				
0-10 years	1.76*	1.52, 2.04	1.62*	1.38, 1.90
11 years	1.59*	1.35, 1.87	1.52*	1.29, 1.79
12-13 years	1.19*	1.04, 1.36	1.18*	1.03, 1.35
14+ years‡	1.00	...	1.00	...
All causes of infant deaths§				
0-10 years	1.83*	1.53, 2.20	1.52*	1.24, 1.85
11 years	1.65*	1.35, 2.01	1.48*	1.20, 1.82
12-13 years	1.16	0.98, 1.36	1.11	0.94, 1.31
14+ years‡	1.00	...	1.00	...
Congenital conditions				
0-10 years	1.21	0.90, 1.63	1.17	0.85, 1.60
11 years	1.25	0.91, 1.71	1.22	0.89, 1.68
12-13 years	1.19	0.94, 1.51	1.19	0.94, 1.51
14+ years‡	1.00	...	1.00	...
Asphyxia-related conditions				
0-10 years	1.86*	1.35, 2.57	2.04*	1.45, 2.88
11 years	1.60*	1.12, 2.29	1.72*	1.19, 2.48
12-13 years	1.31	0.98, 1.74	1.37*	1.03, 1.83
14+ years‡	1.00	...	1.00	...
Immaturity-related conditions				
0-10 years	1.87*	1.31, 2.66	1.86*	1.27, 2.72
11 years	1.60*	1.08, 2.37	1.65*	1.10, 2.47
12-13 years	1.21	0.88, 1.67	1.27	0.92, 1.75
14+ years‡	1.00	...	1.00	...
SIDS§				
0-10 years	4.53*	2.62, 7.83	1.74	0.95, 3.18
11 years	4.28*	2.41, 7.60	2.33*	1.28, 4.24
12-13 years	1.00	0.53, 1.89	0.72	0.38, 1.37
14+ years‡	1.00	...	1.00	...
Infections				
0-10 years	3.33*	1.58, 7.04	2.43*	1.08, 5.47
11 years	3.55*	1.64, 7.67	2.92*	1.31, 6.48
12-13 years	1.29	0.60, 2.79	1.17	0.54, 2.55
14+ years‡	1.00	...	1.00	...
External conditions				
0-10 years	4.41*	1.29, 15.05	3.69	0.98, 13.85
11 years	1.53	0.28, 8.35	1.36	0.24, 7.64
12-13 years	3.33*	1.07, 10.33	3.14*	1.00, 9.85
14+ years‡	1.00	...	1.00	...
Other specific/Remaining causes				
0-10 years	1.50*	1.08, 2.08	1.44*	1.02, 2.05
11 years	1.25	0.86, 1.81	1.18	0.81, 1.74
12-13 years	1.02	0.77, 1.37	1.02	0.76, 1.37
14+ years‡	1.00	...	1.00	...

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Adjusted for maternal age, marital status, parity and infant sex.
‡ Reference category, for which hazard ratio is always 1.00
§ Based on live births only.
··· Not applicable
** $p < 0.05$*

Chart 4
Low birthweight, pre-term and small-for-gestational-age births, by maternal education, singleton live births, Quebec, 1990-1991



Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*

Table 5
Odds ratios for low birthweight, pre-term and small-for-gestational-age births, by maternal education, singleton births, Quebec, 1990-1991

	Unadjusted		Adjusted†	
Birth outcome/ Maternal education	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
LBW				
0-10 years	2.06*	1.94, 2.19	2.07*	1.94, 2.21
11 years	1.78*	1.66, 1.90	1.79*	1.67, 1.92
12-13 years	1.39*	1.32, 1.47	1.42*	1.34, 1.50
14+ years‡	1.00	...	1.00	...
PT				
0-10 years	1.53*	1.44, 1.62	1.48*	1.39, 1.58
11 years	1.36*	1.28, 1.45	1.35*	1.26, 1.44
12-13 years	1.20*	1.15, 1.26	1.21*	1.15, 1.27
14+ years‡	1.00	...	1.00	...
SGA				
0-10 years	1.94*	1.86, 2.03	2.04*	1.95, 2.15
11 years	1.69*	1.61, 1.78	1.73*	1.65, 1.82
12-13 years	1.40*	1.35, 1.46	1.43*	1.38, 1.49
14+ years‡	1.00	...	1.00	...

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Adjusted for maternal age, marital status, parity and infant sex
‡ Reference category, for which odds ratio is always 1.00
··· Not applicable
** $p < 0.05$*

Intermediate factors

Maternal education was also inversely related to low birthweight, preterm and small-for-gestational-age births. For example, the low birthweight proportion dropped steadily as maternal education increased, from 7.2% for mothers with 10 or fewer years of schooling to 3.6% for those with at least 14 years (Chart 4). The odds of a low birthweight, pre-term or small-for-gestational-age birth were significantly

Table 6
Odds ratios for fetal and infant deaths, by maternal education adjusted for selected adverse birth outcomes, singleton live births and stillbirths, Quebec, 1990-1991

Fetal and infant period/ Maternal education	Odds ratio†	95% confidence interval	Odds ratio‡	95% confidence interval
Fetal death				
0-10 years	1.07	0.79, 1.45	1.12	0.84, 1.49
11 years	1.22	0.90, 1.67	1.18	0.88, 1.59
12-13 years	1.09	0.85, 1.39	1.06	0.84, 1.33
14+ years§	1.00	...	1.00	...
Early neonatal death				
0-10 years	0.99	0.73, 1.34	0.92	0.68, 1.25
11 years	1.11	0.81, 1.52	1.07	0.78, 1.47
12-13 years	0.92	0.71, 1.18	0.88	0.69, 1.13
14+ years§	1.00	...	1.00	...
Perinatal death				
0-10 years	1.03	0.83, 1.29	1.02	0.82, 1.27
11 years	1.17	0.93, 1.47	1.13	0.90, 1.41
12-13 years	1.00	0.83, 1.20	0.97	0.81, 1.15
14+ years§	1.00	...	1.00	...
Neonatal death				
0-10 years	0.95	0.72, 1.26	0.93	0.70, 1.22
11 years	1.07	0.80, 1.43	1.06	0.80, 1.41
12-13 years	0.96	0.77, 1.20	0.93	0.74, 1.16
14+ years§	1.00	...	1.00	...
Extended perinatal death				
0-10 years	1.01	0.81, 1.24	1.01	0.82, 1.24
11 years	1.14	0.91, 1.41	1.12	0.90, 1.38
12-13 years	1.01	0.85, 1.20	0.98	0.83, 1.16
14+ years§	1.00	...	1.00	...
Post-neonatal death				
0-10 years	1.39	0.98, 1.96	1.40	1.00, 1.96
11 years	1.35	0.94, 1.94	1.38	0.97, 1.97
12-13 years	0.93	0.68, 1.27	0.95	0.70, 1.29
14+ years§	1.00	...	1.00	...

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*
† Adjusted for maternal age, marital status, parity, infant sex, gestational age and fetal growth
‡ Adjusted for maternal age, marital status, parity, infant sex and birthweight
§ Reference category, for which odds ratio is always 1.00
··· Not applicable

higher for all educational levels less than 14 years, whether or not these were adjusted for maternal age, marital status, parity and infant's sex (Table 5).

Low birthweight, pre-term and small-for-gestational-age births were at high risk of fetal and infant mortality. For example, just 5% of singleton births with known birthweight weighed less than 2,500 g, but they accounted for 60% of fetal and neonatal deaths (data not shown).

When either birthweight or both gestational age and fetal growth were adjusted for, educational differences in fetal and infant mortality at different ages of death disappeared for the two lowest educational groups (odds ratios close to 1.0) except for the post-neonatal period (odds ratio of 1.4) (Table 6). These factors are key intervening variables that strongly mediate the association between the mothers' education and fetal and infant mortality.

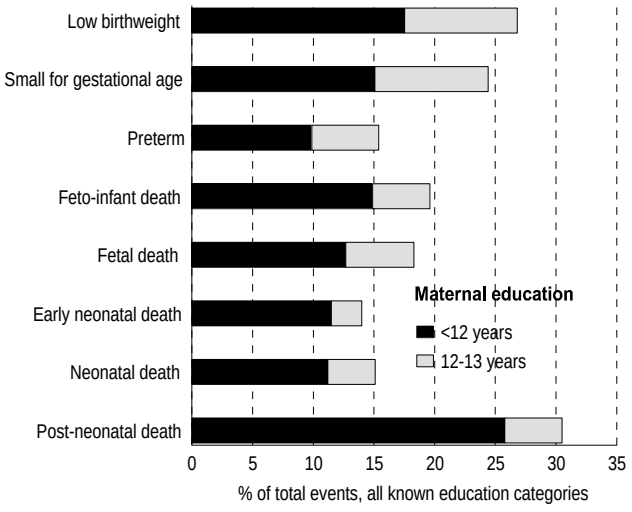
Room for improvement

Assuming that the low levels of fetal and infant mortality and other adverse birth outcomes (low birthweight, pre-term and small-for-gestational-age births) among mothers with 14 or more years of education could be achieved by all, a considerable proportion of the observed events could be considered "excess," or potentially avoidable (Chart 5 and Appendix Table B). Births to mothers with 14 or more years of education accounted for 38% of all births with known maternal education.

If the rates for mothers with the highest level of education had prevailed among all mothers, 27% of all low birthweight births could have been avoided. As well, 15% of pre-term births and 24% of small-for-gestational-age births were potentially avoidable. Twenty percent of fetal and infant deaths were excess, with post-neonatal deaths having the most potential for reduction among age-specific deaths (31%). For specific causes, the highest excess was for deaths due to SIDS and to infections/external causes (both 48%).

Since mothers with less than 12 years of education had the highest rates of fetal and infant mortality and other adverse outcomes, the corresponding excesses were also higher. Although this group represented slightly more than one-quarter (28%) of all births with known maternal education, they accounted for about two-thirds of excess low birthweight, pre-term and small-for-gestational-age births. In addition, 69% of excess fetal deaths and 80% of excess infant deaths, including 85% of post-neonatal and 100% of excess SIDS deaths occurred among the offspring of these mothers.

Chart 5
Excess adverse birth outcomes based on rates for births to mothers with 14 or more years of education, singleton live births and stillbirths, Quebec, 1990-1991



Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*

Smoking and teenage childbearing

Cigarette smoking during pregnancy has been identified as an important modifiable risk factor for perinatal mortality, low birthweight, pre-term and small-for-gestational-age births.[7,16,34,35] Women with low educational attainment are more likely to smoke before and during pregnancy, and to smoke more heavily, than those with more education.[36-39]

A recent study of perinatal care in Nova Scotia reported that smoking during pregnancy doubled the risk of low birthweight and that teenage mothers and unmarried mothers were more likely to smoke when they were pregnant.[40] The present analysis of Quebec data shows that teenage mothers and unmarried mothers tended to be in the low educational group. Nonetheless, even after

controlling for maternal age, marital status, parity and infant's sex, the effects of education on low birthweight remained important and significant. It is likely that maternal educational differences in low birthweight, and ultimately, in fetal and infant mortality, are at least partially accounted for by differences in smoking behaviour.

In Sweden, excess infant mortality among mothers with less education has been partially attributed to teenage childbearing and "delay in seeking medical care or non-compliance with medical care," even though access to medical care is universal.[25,41] A recent Canadian study documents a persistent income inequality in the utilization of prenatal care in Winnipeg and suggests that "universal health insurance does not remove all barriers to access."[42] However, in Quebec, few births were to teenage mothers, and those births appear to have accounted for only a small part of the total maternal educational differences in fetal and infant mortality.

Education is important, not only because of its direct effects, but also because it is intertwined with many other factors directly and indirectly relevant to health, such as adequate income, better pre-conception health of the mother, good nutrition during pregnancy and after birth, effective access to pre- and post-natal care, knowledge of risk factors, and avoidance of risk behaviours.

Concluding remarks

Quebec has among the lowest fetal and infant mortality rates in Canada. However, marked differences in fetal and infant mortality by maternal education persist despite many years of universal access to publicly funded, high-quality health care. If all mothers had been able to attain the low rate of fetal and infant mortality already achieved by Quebec mothers with the highest educational attainment, one-fifth of all fetal and infant deaths and nearly one-third of post-neonatal deaths could have been avoided.

Maternal education affects fetal and infant mortality largely through the key intervening factors of low birthweight, or pre-term and small-for-gestational-age births. Consequently, reductions in fetal and infant mortality will require addressing the causes of these intervening factors. Breaking the link between maternal education and the associated risk factors, such as smoking, would further reduce Quebec's already low level of fetal and infant mortality. The highest potential for improvement exists among mothers with less than 12 years of education, who accounted for a disproportionately large share of excess deaths, especially in the post-neonatal period and for non-congenital-related conditions. ●

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Appendix

Table A

ICD-9† codes for cause of fetal and infant mortality

Congenital conditions	270-275, 277-279, 282, 284, 286-288, 330, 335, 343, 359, 394-411, 414-417, 424-426, 550-553, 560, 571, 572, 740-759, 777.1
Asphyxia-related conditions	761.6, 761.7, 762.0-762.2, 762.4-762.6, 763, 766-768, 770.1, 772.2, 779.0, 779.2
Immaturity-related conditions	761.3-761.5, 761.8, 761.9, 762.7, 764, 765, 769, 770.2-770.9, 772.1, 774, 777.5, 777.6, 778.2, 779.6, 779.8
Infections	001-139, 254.1, 320-326, 382, 420-422, 460-466, 475-477, 480-491, 510, 511, 513, 540, 541, 566, 567, 570, 572.0, 590, 591, 770.0, 771, 790
Other specific conditions	140-250, 251-253, 283, 331, 423, 430-432, 441, 442, 493, 494, 514-516, 556-559, 762.3, 762.8, 762.9, 772.0, 772.3-772.9, 773, 775, 776, 778.0, 779.4, 779.5
Sudden infant death syndrome (SIDS)	798, 799, E913
External conditions‡	260-263, 507, E800-E912, E914-E999
Remaining causes	All remaining codes

Data source: *Reference 32*

† International Classification of Diseases, Ninth Revision (Reference 31)

‡ External conditions refer to all deaths from injury and poisoning (ICD-9 Chapter 17), except accidental mechanical suffocation (E913), classified according to the "events, circumstances and conditions" that caused them, plus protein-calorie malnutrition (ICD 260-263) and pneumonitis due to inhalation of solids and liquids (ICD 507).

Table B

Excess adverse birth outcomes for all births with known maternal education, and for births to mothers with less than 12 years of education, singleton live births and stillbirths, Quebec, 1990-1991

		All births with known maternal education					Births to mothers with less than 12 years of education					
			Adverse outcomes					Adverse outcomes				
Birth outcome	Rate in births to mothers with 14+ years of education (1)	Births (2)	Observed (3)	Expected (4)	Excess (5)	PAR% (6)	Births (7)	Observed (8)	Expected (9)	Excess (10)	Attributable fraction (11)	< 12 years as % of all (12)
Low birthweight	0.03636	180,107	8,948	6,549	2,399	26.8	49,737	3,376	1,808	1,568	46.4	65.4
Preterm	0.04906	176,419	10,233	8,655	1,578	15.4	48,944	3,412	2,401	1,011	29.6	64.1
Small for gestational age	0.07606	173,914	17,491	13,228	4,263	24.4	48,137	6,294	3,661	2,633	41.8	61.8
Fetal deaths	0.00247	182,084	551	450	101	18.3	50,343	194	124	70	36.1	69.3
Early neonatal deaths	0.00226	181,533	477	410	67	14.0	50,149	168	113	55	32.7	82.1
Neonatal deaths	0.00276	181,533	590	501	89	15.1	50,149	204	138	66	32.4	74.2
Post-neonatal deaths	0.00122	180,943	318	221	97	30.5	49,945	143	61	82	57.3	84.5
Perinatal deaths	0.00472	182,084	1,028	859	169	16.4	50,343	362	238	124	34.3	73.4
Extended perinatal deaths	0.00522	182,084	1,141	950	191	16.7	50,343	398	263	135	33.9	70.7
Feto-infant deaths	0.00644	182,084	1,459	1,173	286	19.6	50,343	541	324	217	40.1	75.9
Infant deaths	0.00398	181,533	908	723	185	20.4	50,149	347	200	147	42.4	79.5
Sudden infant death syndrome (SIDS)	0.00029	182,084	102	53	49	48.0	50,343	64	15	49	76.6	100.0
Asphyxia	0.00130	182,084	310	237	73	23.5	50,343	116	65	51	44.0	69.9
Immaturity	0.00113	182,084	255	206	49	19.2	50,343	97	57	40	41.2	81.6
Infection/External causes	0.00023	182,084	81	42	39	48.1	50,343	39	12	27	69.2	69.2
Congenital	0.00202	182,084	416	368	48	11.5	50,343	126	102	24	19.0	50.0
Other specific/Remaining	0.00147	182,084	295	268	27	9.2	50,343	99	74	25	25.3	92.6

Data source: *Linked birth and infant death records plus stillbirths from Canadian Birth Data Base and Canadian Mortality Data Base*

Note: *PAR%=Population attributable risk percentage*

(4)=(1)(2); (5)=(3)-(4); (6)=100*(5)/(3); (9)=(1)*(7); (10)=(8)-(9); (11)=100*(10)/(8); (12)=100*(10)/(5).*

Errata

Health Reports, Summer, 1998, Volume 10, Number 1

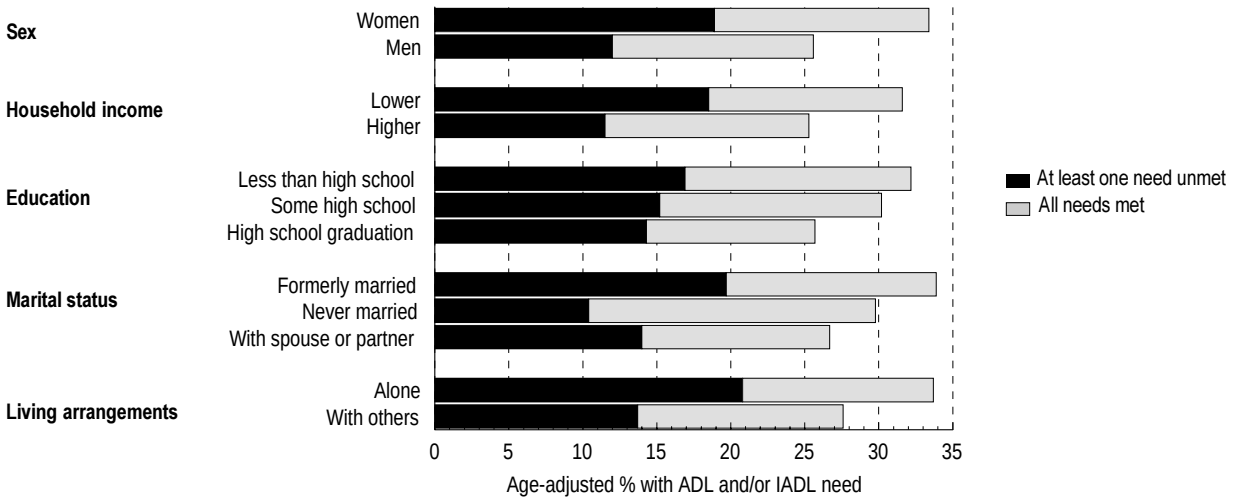
Seniors' needs for health-related personal assistance

Jiajian Chen and Russell Wilkins

Chart 1, page 45

The percentage of seniors living alone and who had at least one unmet need should be 20.8%.

Chart 1
Prevalence of need and unmet need for health-related personal assistance among seniors, by selected characteristics, household population, Canada, 1991



Data source: *1991 Health and Activity Limitation Survey*

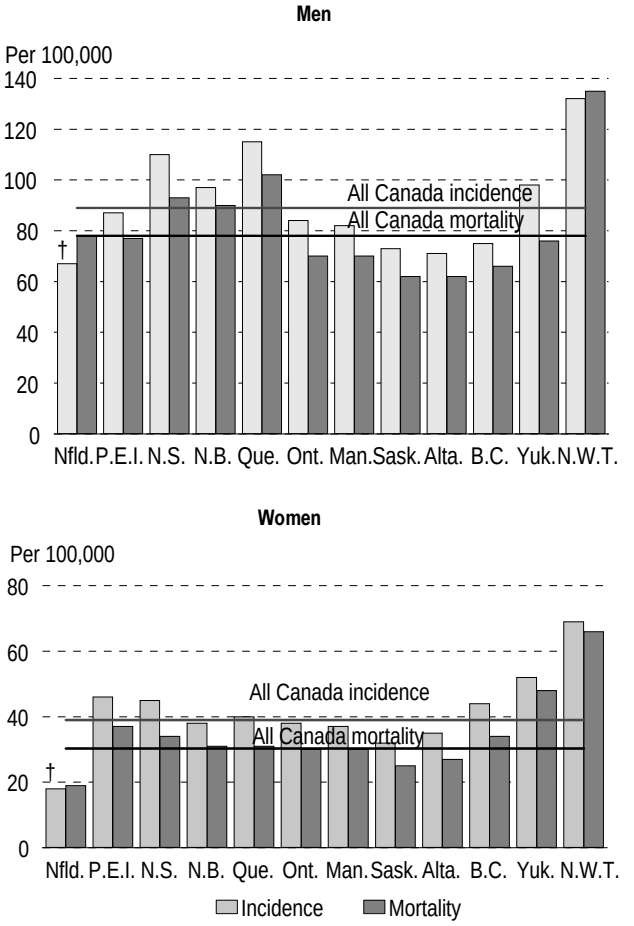
A reprint of the article containing the correction may be obtained by calling (613) 951-5059.

Cancer incidence and mortality across Canada
Leslie A. Gaudette, Christopher A. Altmayer, Marek Wysocki and Ru-Nie Gao

Chart 2, page 59

The "All Canada mortality" rate for women should be 30.3 per 100,000.

Chart 2
Annual age-standardized lung cancer incidence and mortality rates, by sex, Canada, provinces and territories, 1991-1993



Source: *Canadian Cancer Registry, National Cancer Incidence Reporting System, Canadian Vital Statistics Data Base*
Note: *Rates are age-standardized to the 1991 Canadian population adjusted for net census undercoverage.*
† Incidence rates may be lower than mortality rates because of incomplete reporting of new cases.

A reprint of the article containing the correction may be obtained by calling (613) 951-1736.

Data Releases

Synopses of recent health information produced by Statistics Canada

Births, 1996

Just under 366,200 babies were born in 1996, down 3.1% from 1995. This was the largest annual rate of decline since 1972. However, babies born in 1996 were healthier than ever, as the proportion of low birthweight babies and the rate of infant mortality declined.

Fertility, which has been virtually stable for several years, fell significantly in 1996 to an almost historic low. The average number of live births per woman declined from 1.64 in 1995 to 1.59, which is only slightly above the 1987 record low of 1.58.

In 1987, Quebec's extremely low rate of 1.37 live births per woman pulled down the Canadian average. By 1996, however, the average number of live births per woman fell to historical lows in all provinces and territories except Quebec, Manitoba and the Northwest Territories.

The fertility rate fell below 1.6 births per woman in Quebec, Ontario and British Columbia, below 1.5 in Nova Scotia and New Brunswick, and below 1.3 in Newfoundland. The Prairie provinces and both the territories had higher rates than the rest of Canada.

In 1996, the average number of live births per woman was lower in Canada than in France, Australia, the United Kingdom and the United States, but higher than in Germany, Spain and Japan.

The average age of mothers rose from 28.8 in 1995 to 29.0 in 1996. In Quebec, 53% of births occurred outside marriage in 1996, compared with 50% the year before. The proportion in the rest of Canada remained stable at about 24%.

The proportion of low birthweight babies (those weighing less than 2,500 grams) declined after increasing for three consecutive years. In 1996, 5.8% of babies were below this weight threshold, down from 5.9% the year before.

More importantly, Canada's infant mortality rate dropped below the level of 6 infant deaths per 1,000 live births for the first time. In 1996, the infant mortality rate was 5.6 infant deaths per 1,000 live births, down from 6.1 in 1995.

Canada's infant mortality rate was below that of the United States, the United Kingdom, Australia and Italy, but above that of France, Germany, Sweden and Japan.

Quebec led with a remarkably low rate of 4.6 infant deaths per 1,000 live births (close to Japan's rate of 4.5). New Brunswick and Prince Edward Island also had infant mortality rates below 5 per 1,000, while British Columbia's rate was 5.1. The highest provincial rate was in Saskatchewan (8.4).

For further information on this release, contact Russell Wilkins (613-951-5305) or Heather Gilmour (613-951-8388), Health Statistics Division. To order custom tabulations, contact Client Custom Services (613-951-1746).

Postcensal Population Estimates

Each issue of *Health Reports* includes current quarterly population estimates. July 1, 1997 estimates are shown on the following page.

Preliminary postcensal population estimates, by sex and age group, Canada, provinces and territories, July 1, 1997

	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
							'000						
Both sexes	**30,286.6**	**563.6**	**137.2**	**947.9**	**762.0**	**7,419.9**	**11,407.7**	**1,145.2**	**1,023.5**	**2,847.0**	**3,933.3**	**31.6**	**67.5**
<1	363.2	5.6	1.7	10.3	8.1	82.9	139.2	15.5	13.0	38.1	46.9	0.5	1.5
1-4	1,552.6	24.3	7.1	44.1	35.4	362.2	594.4	65.2	56.3	159.3	196.5	1.9	5.9
5-9	2,049.4	35.4	9.9	63.0	48.8	474.0	777.5	83.5	79.3	214.6	253.1	2.4	8.0
10-14	2,027.1	41.2	10.1	64.1	51.5	456.8	758.5	81.5	81.8	215.7	257.2	2.4	6.4
15-19	2,024.1	43.2	10.0	63.4	52.3	502.0	731.8	78.7	77.3	203.3	254.5	2.3	5.3
20-24	2,034.5	43.7	9.7	65.1	55.3	485.5	750.8	79.7	70.5	202.6	264.0	2.2	5.4
25-29	2,203.0	44.3	9.7	68.3	57.0	503.9	851.3	81.0	64.0	218.5	296.2	2.4	6.3
30-34	2,564.4	45.7	10.7	77.9	62.5	619.3	1,003.7	90.0	73.8	243.8	327.4	3.1	6.5
35-39	2,706.0	47.5	11.0	82.9	64.6	674.3	1,024.0	95.2	82.7	267.1	347.3	3.3	5.9
40-44	2,465.9	47.0	10.2	76.3	62.2	626.5	905.8	86.9	78.0	242.2	323.2	2.9	4.8
45-49	2,183.8	43.1	9.6	69.4	57.2	560.0	809.3	76.3	63.8	195.1	293.3	2.8	3.8
50-54	1,794.1	34.8	8.0	57.7	45.6	478.7	666.0	62.7	51.0	151.4	233.7	2.0	2.5
55-59	1,382.6	25.2	6.1	44.3	34.6	365.6	520.5	48.9	42.3	113.9	178.6	1.0	1.8
60-64	1,210.0	21.0	5.6	38.6	29.5	310.9	463.2	43.8	40.0	98.6	156.5	0.8	1.4
65-69	1,141.3	18.7	5.0	35.0	28.5	294.0	438.0	42.5	39.5	89.1	149.3	0.8	1.0
70-74	986.1	15.9	4.4	30.4	25.0	246.2	381.9	39.5	36.6	73.4	131.9	0.5	0.6
75-79	743.0	13.0	3.7	26.0	20.3	177.8	278.6	32.6	31.2	55.9	103.4	0.2	0.2
80-84	476.6	8.1	2.6	17.3	13.1	111.1	174.3	22.8	22.8	35.9	68.4	0.1	0.2
85-89	251.6	4.1	1.4	9.2	7.1	58.7	92.1	12.2	12.9	18.5	35.3	0.0	0.1
90+	127.1	1.8	0.8	4.7	3.5	29.6	46.8	6.6	6.7	10.0	16.7	0.0	0.1
Males	**14,999.7**	**281.3**	**67.8**	**466.7**	**376.9**	**3,657.2**	**5,636.3**	**567.8**	**508.3**	**1,432.5**	**1,953.6**	**16.3**	**35.0**
<1	186.0	2.8	0.9	5.2	4.2	42.5	71.4	7.9	6.5	19.5	24.2	0.2	0.7
1-4	795.8	12.5	3.7	22.8	18.1	185.2	304.5	33.4	28.6	81.8	101.3	0.9	3.0
5-9	1,049.5	18.2	5.1	32.4	24.9	242.7	398.3	42.9	40.4	109.9	129.2	1.3	4.2
10-14	1,035.4	21.0	5.2	32.6	26.2	232.8	388.2	42.0	41.4	110.4	131.0	1.2	3.3
15-19	1,037.3	21.7	4.9	31.9	26.9	257.2	375.9	39.9	40.1	104.1	130.8	1.2	2.7
20-24	1,032.1	22.3	5.0	33.1	28.1	247.2	380.2	40.8	36.0	103.4	132.2	1.1	2.7
25-29	1,110.4	22.7	5.0	34.9	29.0	256.6	425.8	41.2	32.0	110.8	148.0	1.2	3.3
30-34	1,298.2	22.7	5.2	39.5	31.6	316.0	507.0	45.7	36.7	124.4	164.5	1.6	3.4
35-39	1,364.7	23.7	5.4	40.9	32.3	341.0	516.6	48.6	41.8	136.1	173.6	1.6	3.0
40-44	1,231.0	23.3	5.1	37.5	30.8	313.7	449.1	43.6	40.1	123.4	160.5	1.4	2.5
45-49	1,096.0	21.7	4.9	34.6	28.9	280.4	402.7	38.5	32.8	99.5	148.4	1.4	2.1
50-54	899.1	17.7	4.1	29.2	23.2	237.5	332.0	31.6	25.7	77.1	118.4	1.1	1.4
55-59	687.3	12.9	3.1	22.1	17.4	180.0	257.5	24.1	20.8	58.2	89.6	0.7	1.0
60-64	593.7	10.6	2.7	19.0	14.5	149.3	226.5	21.7	19.9	49.3	79.1	0.4	0.7
65-69	544.9	9.2	2.5	16.4	13.3	135.8	209.6	20.1	19.2	43.7	74.2	0.5	0.5
70-74	439.0	7.5	2.0	13.4	11.0	106.2	169.5	17.6	16.9	33.9	60.5	0.3	0.3
75-79	305.6	5.7	1.5	10.6	8.5	69.7	114.9	13.4	13.3	23.8	44.1	0.1	0.1
80-84	177.9	3.2	0.9	6.5	5.0	38.7	65.2	8.7	9.1	13.8	26.8	0.0	0.1
85-89	81.9	1.4	0.5	3.0	2.3	17.5	29.6	4.2	4.7	6.4	12.3	0.0	0.1
90+	33.7	0.5	0.2	1.1	0.9	7.2	11.8	1.8	2.1	3.1	5.0	0.0	0.0
Females	**15,286.9**	**282.3**	**69.4**	**481.2**	**385.1**	**3,762.7**	**5,771.4**	**577.4**	**515.2**	**1,414.5**	**1,979.7**	**15.3**	**32.5**
<1	177.2	2.8	0.8	5.1	3.9	40.5	67.8	7.6	6.5	18.6	22.6	0.2	0.7
1-4	756.8	11.8	3.4	21.3	17.3	177.0	289.9	31.9	27.7	77.5	95.2	1.0	2.8
5-9	999.9	17.2	4.8	30.5	23.9	231.2	379.2	40.6	38.8	104.7	123.9	1.1	3.9
10-14	991.8	20.3	4.9	31.5	25.3	223.9	370.3	39.5	40.4	105.3	126.1	1.2	3.1
15-19	986.8	21.5	5.0	31.5	25.4	244.9	355.9	38.8	37.2	99.3	123.8	1.1	2.6
20-24	1,002.4	21.4	4.7	32.1	27.2	238.2	370.6	38.9	34.5	99.2	131.8	1.1	2.7
25-29	1,092.6	21.6	4.8	33.5	28.0	247.3	425.5	39.8	32.0	107.7	148.2	1.2	3.1
30-34	1,266.2	23.0	5.5	38.5	30.9	303.2	496.7	44.3	37.1	119.4	162.9	1.5	3.1
35-39	1,341.3	23.8	5.6	42.0	32.3	333.4	507.4	46.6	40.9	131.0	173.7	1.7	2.9
40-44	1,234.9	23.6	5.0	38.8	31.4	312.7	456.6	43.4	38.0	118.8	162.7	1.5	2.3
45-49	1,087.8	21.5	4.7	34.7	28.3	279.7	406.6	37.8	31.0	95.6	144.9	1.4	1.6
50-54	895.0	17.1	3.9	28.6	22.4	241.2	333.9	31.1	25.2	74.3	115.3	0.9	1.1
55-59	695.3	12.3	3.0	22.2	17.2	185.6	263.0	24.8	21.5	55.7	89.0	0.4	0.8
60-64	616.2	10.4	2.9	19.6	15.0	161.6	236.7	22.1	20.1	49.3	77.4	0.4	0.7
65-69	596.4	9.5	2.5	18.5	15.2	158.2	228.4	22.3	20.3	45.5	75.2	0.3	0.5
70-74	547.1	8.4	2.3	17.0	14.0	140.0	212.3	21.9	19.7	39.5	71.4	0.2	0.3
75-79	437.4	7.3	2.2	15.3	11.8	108.1	163.7	19.2	17.9	32.1	59.4	0.1	0.2
80-84	298.7	4.9	1.7	10.9	8.1	72.4	109.2	14.1	13.8	22.0	41.5	0.1	0.1
85-89	169.7	2.6	1.0	6.2	4.8	41.2	62.5	8.0	8.2	12.1	23.0	0.0	0.0
90+	93.4	1.3	0.6	3.6	2.6	22.3	35.0	4.8	4.6	6.9	11.7	0.0	0.0

Source: *Population Estimates Section, Demography Division*
Note: *The population estimates are adjusted for net census undercoverage and include non-permanent residents.*

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	First version + Dummy Master Files Bootstrap variance estimation Files and program	Second version			
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