Asthma mortality in Canada, 1946 to 1990

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OBJECTIVE: To assess the impact of asthma on Canadian mortality rates over a 45-year period.
DESIGN: A descriptive, population-based study.
SETTING: Canada.
SUBJECTS: All persons who died from asthma in Canada from 1946 to 1990 as reported to Statistics Canada in Ottawa.
MAIN OUTCOME MEASURES: Standardized mortality ratios, age-specific patterns of death, potential years of life lost (PYLL) and life expectancy lost.
RESULTS: A total of 12,010 male and 8486 female asthma deaths were recorded in Canada from 1946 to 1990. Mortality rates for both sexes declined from a high of between three to six deaths in 1951 to 1955 to approximately two deaths per 100,000 in 1986 to 1990, with the decline in rates being greater for males than females. Age-specific mortality rates were highest at all ages in 1951 to 1955, except for 15 to 24 years when deaths rates for the 1981 to 1985 period were greater. PYLL exhibit the same pattern as mortality, peaking in 1951 to 1955 and subsequently declining with each period. Loss in life expectancy due to asthma was about one month (not significant) in all time periods.
CONCLUSIONS: Asthma mortality rates have declined significantly over the study period. This decline appears to be linked with the convergence of sex-specific rates and with changes in the patterning of age-specific mortality. The impact of asthma on the life expectancy of Canadians is small.

Key Words: *Asthma, Mortality*

La mortalité asthmatique au Canada de 1946 à 1990

OBJECTIF : Évaluer l'impact de l'asthme sur les taux de mortalité au Canada sur une période de plus de 45 ans.
MODÈLE : Étude descriptive de la population concernée.
CONTEXTE : Canada
SUJETS : Toutes les personnes décédées des suites de l'asthme au Canada entre 1946 et 1990 tel que rapporté par Statistique Canada à Ottawa.
PRINCIPAUX INDICATEURS DES RÉSULTATS : Rapport standardisé de mortalité, taux de décès spécifiques pour l'âge, années potentielles de vie perdues et diminution de l'espérance de vie.
RÉSULTATS : Un total de 12 010 hommes et de 8 486 femmes décédés des suites de l'asthme a été enregistré au Canada de 1946 à 1990. Les taux de mortalité, pour les deux sexes, avec un record de mortalité compris entre 3 et 6 décès pour 100 000, de 1951 à 1955, ont chuté à environ deux décès pour 100 000, de 1986 à 1990 et, diminués plus rapidement chez les hommes que chez les femmes. Les taux de mortalité spécifiques pour l'âge étaient les plus élevés pour tous les âges de 1951 à 1955, excepté pour les 15 à 24 ans dont les taux de mortalité pour la période de 1981 à 1985 étaient plus élevés. Les années potentielles de vie perdues révèlent un schéma identique du record des taux de mortalité de 1951 à 1955, puis d'une diminution de ces taux pour chaque période. La diminution de l'espérance de vie causée par l'asthme était d'environ 1 mois (non significatif) pour toutes les périodes.
CONCLUSIONS : Les taux de mortalité attribuables à l'asthme ont chuté de manière significative pendant la période couverte par l'étude. Cette diminution semble être liée à la convergence des taux de décès spécifiques pour le sexe et aux changements dans le taux de décès spécifiques à l'âge. L'impact de l'asthme sur l'espérance de vie des Canadiens est faible.

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ASTHMA IS A COMMON CHRONIC RESPIRATORY DISEASE that affects millions of people worldwide and inflicts a considerable financial burden on society. Although there are no definitive estimates of the prevalence of asthma based on a single uniform definition, this chronic illness is estimated to affect between 9 and 12 million people in Canada and the United States alone (1,2). Furthermore, population-based studies in Australia, the Netherlands and New Zealand have shown the prevalence of bronchial hyperreponsiveness, a condition which may predispose an individual to asthma, to be between 11 and 24% in asymptomatic children and adults (3-5). In the United States, the direct and indirect societal costs of asthma were estimated to exceed US$6 billion in 1990, with the largest direct medical cost being in-patient hospital services (US$1.6 billion) and the largest indirect cost being reduced productivity due to loss of school days (US$1 billion) (6).

Most often when asthma is well controlled on an outpatient basis, it rarely leads to hospitalization or death. However, recent increases in asthma death rates in most developed countries (7-11) suggest that the etiologic factors associated with this chronic illness are still not well understood. Changes in asthma mortality rates have been shown to be highest in young adolescents and adults, where rates of death increased by as much as threefold (7,8,12), and in New Zealand and the United Kingdom where the asthma mortality reached epidemic proportions (7). Several hypotheses have been put forward to explain this worldwide phenomenon, the most notable being that beta-agonist use increases the risk of death, particularly in those with severe asthma (13). Increases in mortality were also hypothesized to be associated with shifting patterns of physician diagnosis, especially from bronchitis to asthma in children and chronic obstructive pulmonary disease to asthma in older smokers (14-15); availability of better diagnostic tests (16); changes in the classification of deaths over time; and secular changes in the prevalence and severity of asthma worldwide (17,18). Overall, in contrast to the declining rates of death for other chronic diseases, asthma death rates have been shown to be on the rise throughout the developed world.

The present study was designed to examine whether these recent historical increases in asthma mortality rates have had a detrimental impact on adult health. Relying on mortality data for Canada, we undertook a longitudinal analysis to determine the impact of asthma on Canadian mortality rates over a recent 45-year period starting in 1945. The aim of this study was to assess how asthma mortality rates have changed over time and to measure the impact of these changes on overall mortality and life expectancy in men and women.

PATIENTS AND METHODS

Information on asthma mortality and the population at risk of death was obtained from the Canadian Centre for Health Statistics in Ottawa. Asthma deaths by sex, age-group and year were compiled from Statistics Canada tabulations that mention asthma as the underlying cause of death. Age and

TABLE 1
Conditions included in the coding of asthma deaths in the International Classification of Diseases (ICD) Revision, 1948-1977

	ICD revision*				
	5th	6th	7th	8th	9th
ICD code	112	241	241	493	493
Date introduced in Canada	1941	1950	1958	1969	1979
Asthma					
Atopic					x
Allergic, any cause		x	x	x	
Allergic, unspecified					x
Allergic, stated cause					x
Bronchial	x	x	x	x	x
Catarrh	x				
Childhood					x
Dropsy	x				
Hay	x	x	x	x	x
Immunological process					x
Infantile	x				
Platinum					x
Spasmodic	x	x	x	x	
Bronchitis, acute	x				
Bronchitis, allergic		x	x	x	x
Bronchitis, asthmatic		x			x
Bronchitis, chronic	x				
Hay fever with asthma		x	x	x	x
Late-onset asthma					x

*Data taken from reference 19

sex-specific population figures for Canada were obtained from censal and post-censal annual estimates. Calculated cause and age-specific rates were expressed as rates per 100,000 population.

Five revisions of the International Classification of Diseases (ICD) were used by Statistics Canada to classify asthma deaths from 1945 to 1990 (19). Changes in the diagnostic categories included under rubrics of asthma over this time period are shown in Table 1. Out of the 19 conditions listed, only two – bronchial asthma and hay fever – were included in all five revisions; 12 of the 19 conditions listed were included in only one out of the five revisions of ICD.

Asthma mortality rates were assessed by comparing changes in age-specific and crude and standardized rates of death over nine five-year periods. Standardized rates were calculated by directly adjusting to the Canadian age-structure in 1971 to 1975 period age-specific death rates. Once rates were standardized, period standardized mortality ratios (SMR) were constructed by comparing asthma mortality rates in the period 1971 to 1975 with rates for the other eight periods. Statistical significance was assessed by determining whether the expected number of deaths, if 1971 to 1975 rates applied, exceeded the observed number of deaths at a 5% and 1% level of significance (20).

The impact of asthma on overall mortality was assessed using two measures. The first, potential years of life lost (PYLL), was used to determine the impact of asthma on infant, child and young and middle-aged adult mortality by

TABLE 2
Asthma mortality rates and standardized mortality ratios (SMR) for Canada, 1946-1990

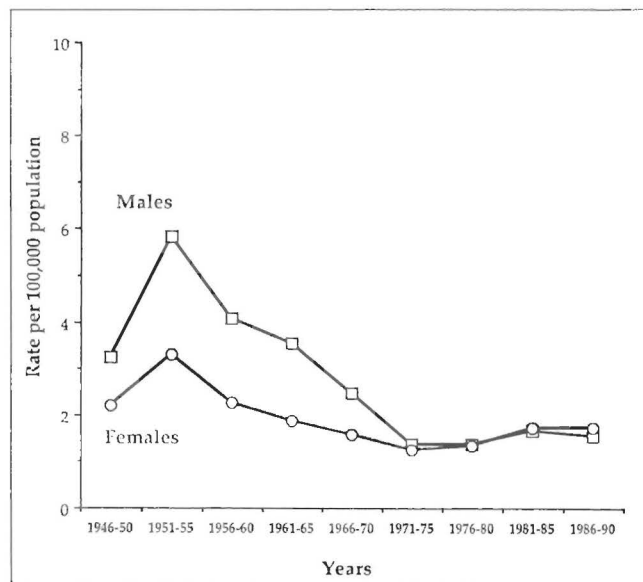| Time period	Observed deaths	Expected deaths*	Observed death rate[†]	SMR[‡]
All ages				
1946-1950	1717	863	2.65	1.99[§]
1951-1955	3310	992	4.46	3.34[§]
1956-1960	2595	1122	3.05	2.31[§]
1961-1965	2462	1263	2.60	1.95[§]
1966-1970	2031	1416	1.96	1.43[§]
1971-1975	1590	1590	1.44	1.00
1976-1980	1719	1792	1.46	0.96
1981-1985	2434	2025	1.96	1.20[§]
1986-1990	2638	2252	2.04	1.17[§]
5-34 years				
1946-1950	92	82	0.28	1.12
1951-1955	152	90	0.42	1.68[§]
1956-1960	118	104	0.28	1.14
1961-1965	113	116	0.24	0.98
1966-1970	122	131	0.23	0.93
1971-1975	148	148	0.25	1.00
1976-1980	212	160	0.34	1.32[§]
1981-1985	283	164	0.45	1.73[§]
1986-1990	275	162	0.45	1.70[§]

*The number of deaths expected if 1971 to 1975 rates for Canada applied; [†]Rates are deaths per 100,000 population; [‡]Ratio of the number of deaths observed to the number expected; [§]Significantly different from 1 at P<0.01

Figure 1) *Asthma standardized mortality rates in Canada, by sex, 1946 to 1990. Rates are deaths per 100,000 population per year*
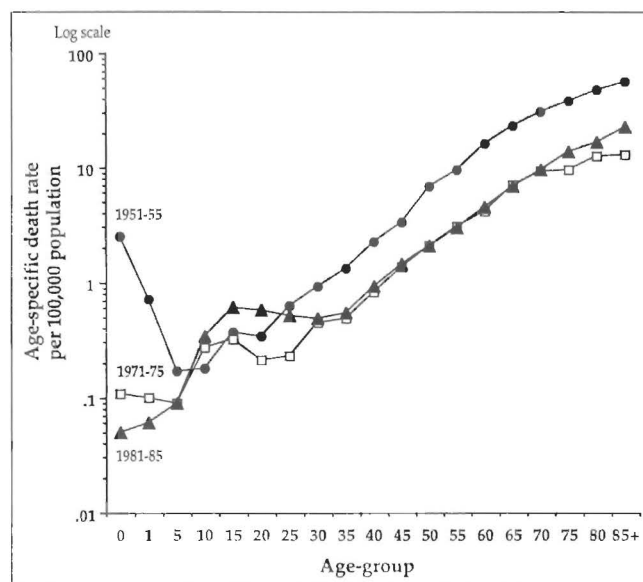
Figure 2) *Age-specific asthma mortality rates in Canada, by specific period. Rates are deaths per 100,000 population per year. Note the Y axis is logarithmic*

calculating the potential number of years of life lost before age 75 years. PYLL were calculated by multiplying the total number of age-group deaths by the average number of years remaining to age 75 years. Time trends were examined using the PYLL index, which is a ratio of the observed to expected PYLL if 1971 to 1975 asthma mortality rates applied. For PYLL index, significant differences in the observed and expected number of deaths at a 0.05 and 0.01 level were determined using a χ^2 test. The second measure, life expectancy lost due to asthma, was evaluated at birth by constructing cause deleted life tables using standard demographic techniques (21-23). These tables were designed to measure the impact of removing deaths attributable to asthma on life expectancy at birth. A significant loss in life expectancy was determined from the ratio of the expected loss to the corresponding standard error around this estimate. If this critical ratio exceeded a threshold value of 2.33, then the loss in life expectancy was deemed significant at a 0.01 level (21).

A more detailed description of how the SMR, PYLL and PYLL index, and life expectancy lost were calculated appears in Appendix 1.

RESULTS

A total of 12,010 male and 8486 female asthma deaths were recorded in Canada from 1946 to 1990. The majority of these deaths occurred in men and women above the age of 64 years. In men, 56.5% of all asthma deaths occurred among

those 65 years of age and over; while in women 53.1% of all deaths occurred in this age group. In contrast, 6.2% of male and 9.1% of female deaths over this period occurred among those aged five to 34 years.

A comparison of SMR with crude mortality rates over nine periods from 1946 to 1990 (Table 2) shows that SMR was highest for the period 1951 to 1955, with the asthma mortality rate of 4.46 deaths per 100,000 population being 3.34 times (95% confidence interval [CI] 3.22 to 3.45) higher than the rate in 1971 to 1975. Over the interval 1956 to 1980, SMR declined from 2.31 (95% CI 2.22 to 2.40) to 0.96 (95% CI 0.91 to 1.01) of the death rate in 1971 to 1975. During the
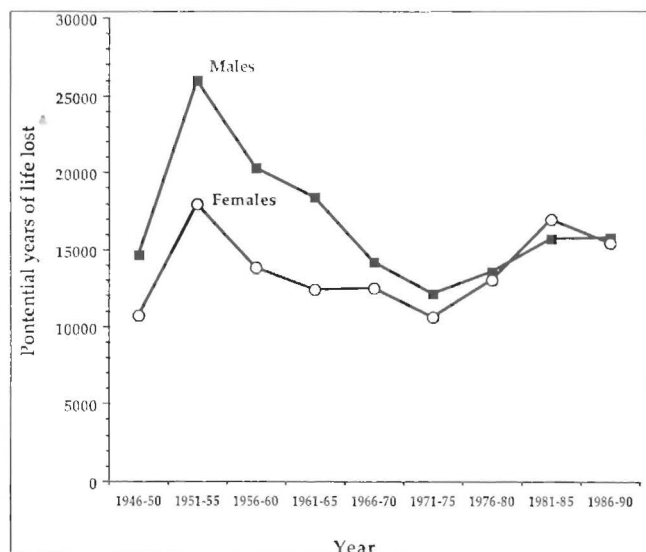
Figure 3) *Potential years of life lost before age 75 from asthma in Canada, by sex, 1946-1990*

Period	Males e_x^0 (years)	Males Loss due to asthma (years)	Females e_x^0 (years)	Females Loss due to asthma (years)
1946-1950	65.69	0.05	69.64	0.04
1951-1955	67.10	0.08	72.07	0.06
1956-1960	67.84	0.06	73.47	0.04
1961-1965	68.47	0.05	74.77	0.04
1966-1970	68.97	0.04	76.07	0.04
1971-1975	69.49	0.03	77.23	0.03
1976-1980	70.78	0.02	79.00	0.04
1981-1985	72.54	0.03	80.59	0.05
1986-1990	73.46	0.03	81.37	0.06

1980s, SMR rose again, peaking in 1981 to 1985 at 1.20 (95% CI 1.15 to 1.25) of the 1971 to 1975 rate of death. When this comparison was restricted to deaths occurring during ages five to 34 years, SMR were highest for the periods 1951 to 1955, 1981 to 1985, and 1986 to 1990. For all three periods, the rate of death was approximately 1.7 times higher than in 1971 to 1975.

Male death rates declined from 5.82 deaths per 100,000 population in 1951 to 1955 to 1.54 deaths per 100,000 population in 1986 to 1990; female death rate declined from 3.30 to 1.74 deaths per 100,000 population over the same time interval (Figure 1). The gap between sex-specific rates was largest in 1951 to 1955 at 2.52 deaths per 100,000 population, and smallest in 1976 to 1980 at 0.02 deaths per 100,000 population.

Patterns of age-specific mortality for men and women from ages 0 to 85 years and over were examined for three periods: 1951 to 1955, 1971 to 1975, and 1981 to 1985 (Figure 2). Age-specific mortality rates in 1951 to 1955 were highest at all ages, except for ages 15 to 24 years when death rates for the 1981 to 1985 period were of greater magnitude. The largest reduction in age-specific rates over time occurred for those aged less than one year, where rates declined from 2.50 deaths per 100,000 population in 1951 to 1955 to 0.05 deaths per 100,000 population in 1981 to 1985.

Figure 3 illustrates PYLL before age 75 years by sex from 1946 to 1990. PYLL attributable to asthma declined from 25,940 and 17,976 in 1951 to 1955 to 12,134 and 10,633 in 1971 to 1975 for men and women, respectively. In 1951 to 1955, PYLL was 3.23 times higher for men and 2.65 times higher for women than expected if 1971 to 1975 sex-specific asthma rates applied. In the most current period, 1986 to 1990, PYLL figures for men and women are of the same magnitude at 15,840 and 15,416, respectively.

For all periods and either sex, the loss in life expectancy at birth attributed to asthma was around one month and was not significant at a 0.01 level (Table 3). In comparison, male life expectancy at birth rose by nearly eight years from 65.7 to 73.5 years, and female life expectancy increased by almost 12 years from 69.6 to 81.4 years over this 45-year period.

DISCUSSION

Our study demonstrates that there has been a nearly three-fold decline in asthma death rates since the early 1950s. This decline is apparent for both men and women and at most ages, except between 15 and 24 years. Moreover, the loss of life expectancy at birth attributable to asthma for men and women is negligible over the course of the study. Overall the decline in asthma mortality appears to be linked to the convergence of male and female rates in the 1970s and 1980s and with changes in the pattern of age-specific mortality over time.

Contrary to our expectation the analysis shows that even though asthma death rates increased slightly in the late 1970s, rates of deaths have sharply declined over this 45-year period. Based on current available research (8) we would have expected that increases in asthma deaths in the 1970s were part of a longer historical trend. This historical pattern of mortality has been especially evident in New Zealand and Australia, where rates of death for those aged five to 34 years have been shown to have increased notably since 1940 (10,11). However, our data do not support such a trend and suggest that recent moderate increases in asthma mortality are actually part of an overall decline in mortality.

The effect of asthma on life expectancy is likely to be even smaller than we have estimated, for two reasons. The first is a difficulty in validating that a death attributed to asthma on a death certificate is actually due to asthma. Although the coding of asthma on death certificates in New Zealand, the United Kingdom and Australia has been shown to have a sensitivity of between 87 and 97%, the specificity of these coding practices has been demonstrated to be only between 59 and 69% (24-26). Based on the prevalence of the disease these specificities and sensitivities lead to a positive predictive value of a certified asthma death actually being caused

by asthma to average 50% overall, and to range from 40 to 84% depending on age (26). Asthma appears to be erroneously over-represented as the underlying cause of death mainly because of other comorbid conditions, particularly chronic obstructive lung disease and cardiovascular disease, being present at the time of death (26,27).

The second reason for the low impact of asthma on life expectancy is that the pattern of asthma mortality in the data available for analysis is partially a result of a coding artifact brought about by revisions in the ICD. The diagnostic categories included under asthma have been altered substantially over the course of this study. In Canada, the overall rate of asthma mortality appears to increase in the 1950s and 1970s at a time when major changes in the conditions included under the rubric of asthma were made to ICD-6 and ICD-9. Bridge-coding exercises in the United Kingdom and United States suggest that with ICD-9 at least, revisions in the conditions included under asthma resulted in an artificial increase in overall asthma mortality of between 28 and 35% (28,29). However, this increase was shown to be substantially reduced in young adults and adolescents, an age grouping in which the diagnosis of asthma is most firmly established (9,29). Thus, the true death rate due to asthma in the older age groups may be even lower than we have estimated here.

Overall, we have demonstrated that asthma death rates in Canada have generally declined over this period. There has been a nearly threefold decline in asthma death rates since the 1950s and, except for the period of early adulthood, this decline in rates is apparent for all age groups. We further demonstrate that the impact of asthma mortality on overall mortality and life expectancy is almost negligible. Finally, based on our results, we believe that the impact of new therapies will need to be measured against other indicators than rate of asthma deaths.

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APPENDIX

Standardized mortality ratios (SMR)

$$SMR = \frac{\sum d_i}{\sum e_i}$$

where d_i represents observed deaths in age group i and e_i represents expected deaths in age group i.

Confidence intervals around the observed SMR values where calculated using multipliers based on Byar's approximations of the exact Poisson limits (14).

Potential years of life lost (PYLL)

$$PYLL = \sum d_i \times (75 - Y_i)$$

where d_i represents number of deaths in age group i and Y_i represents age at midpoint of age group i.

Potential years of life lost index (PYLLI)

$$PYLLI = \frac{O}{E} = \frac{\sum d_i \times (75 - Y_i)}{\sum e_i \times (75 - Y_i)}$$

where O represents observed PYLL; E represents expected PYLL if Canadian age-specific death rates are applied; d_i represents number of deaths in age group i; e_i represents expected deaths in age group i; and Y_i represents age at midpoint of age group i.

Cause deleted life tables

$$Q_i = 1 - (1 - Q)^{f_i}$$

where Q_i represents probability of death excluding cause; Q represents overall probability of death at a given age interval; and fi represents the proportion of deaths attributed to causes other than the excluded cause of death.

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