Changes in fall-related mortality in older adults in Quebec, 1981–2009

M. Gagné, MA (1); Y. Robitaille, PhD (1); S. Jean, PhD (1); P.-A. Perron, PhD (2)

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Abstract

Introduction: Our purpose was to evaluate changes in fall-related mortality in adults aged 65 years and over in Quebec and to propose a case definition based on all the causes entered on Return of Death forms.

Methods: The analysis covers deaths between 1981 and 2009 recorded in the Quebec vital statistics data.

Results: While the number of fall-related deaths increased between 1981 and 2009, the adjusted falls-related mortality rate remained relatively stable. Since the early 2000s, this stability has masked opposing trends. The mortality rate associated with certified falls (W00–W19) has increased while the rate for presumed falls (exposure to an unspecified factor causing a fracture) has decreased.

Conclusion: For fall surveillance, analyses using indicators from the vital statistics data should include both certified falls and presumed falls. In addition, a possible shift in the coding of fall-related deaths toward secondary causes should be taken into account.

Keywords: trends, mortality, falls, seniors, older adults, fractures, injuries, reporting, Quebec

Return of Death form could be analyzed to produce a more accurate picture of the trends. Thus, while causes of death are systematically recorded for administrative purposes, their use for public health surveillance is sometimes limited by a lack of accuracy. However, it appears possible to bypass this obstacle by refining the measures normally used.

The primary goal of our study was to describe the trends in mortality over time for fall-related deaths in adults aged 65 years and over in Quebec from 1981 to 2009 by identifying two major categories of fall-related deaths and determining whether these trends vary by sex and age. A secondary objective was to estimate the impact of a broader case definition based on the secondary causes of death and take into account a possible shift in the coding of fall-related deaths toward secondary causes.

Introduction

Fall-related injuries among older adults are a major public health problem. Because of the severity of the outcome, fall-related mortality is one of the basic indicators of fall surveillance.¹

While there are little recent Canadian data,² a substantial increase in fall-related mortality was recently reported in the population aged 65 years and over in the United States.^{3–5} In the absence of significant changes in fall-related morbidity in the same period, Hu and Baker⁶ recently suggested that this increase in fall-related mortality was due to improved recording of falls as the cause of death. However, their hypothesis depends on a debatable

methodology. First, in contrast to similar studies,⁷ their analyses do not include fractures from unspecified causes.⁶ Inclusion of such fractures affects the scope of the problem considerably.^{8–10} Since fractures from unspecified causes are usually hip fractures, and can thus be primarily attributed to falls,^{11,12} these cases could be included in the analyses. Second, because most deaths do not result from a single cause but from a series of health problems,¹³ the design of mortality indicators based solely on the initial cause of death has been criticized.^{14–16} The importance of comorbidities in fall-related deaths,^{17,18} and the greater likelihood of the injury being entered as a secondary cause of death in older women,¹⁹ also suggests that all conditions entered on the

Methodology

This study is a descriptive trend analysis of fall-related mortality in the Quebec population aged 65 years and over between 1981 and 2009.

Data sources

The data used in our study are from the Quebec Ministry of Health and Social Services (Santé et Services sociaux Québec; MSSS) vital statistics data. The database contains demographic and medical information on deaths in the Quebec population collected through the “Return of Death,” a document on which the causes and circumstances of death are

Author references:

1. Institut national de santé publique du Québec, Québec, Quebec, Canada
2. Bureau du coroner en chef du Québec, Québec, Quebec, Canada

Correspondence: Mathieu Gagné, Institut national de santé publique du Québec, 945 Wolfe Avenue, 3rd floor, Québec, QC G1V 5B3; Tel.: 418-650-5115 ext. 5702; Fax: 418-643-5099; Email: mathieu.gagne@inspq.qc.ca

entered as accurately as possible. The causes and circumstances have been recorded in this database using *International Classification of Diseases, 10th Revision* (ICD-10) codes since 2000, while *International Classification of Diseases, 9th Revision* (ICD-9) codes were used between 1981 and 1999. Since 1 January 2000, an underlying cause of death and up to 10 secondary causes can be recorded in the Quebec vital statistics data. Before 1 January 2000, only one secondary cause could be added to the underlying cause of death, specifically in cases of deaths attributed to an external cause.

Particular difficulties related to case definition

The use of ICD-10 rather than ICD-9 codes to record deaths in Canada has led to a major under-identification (by about 50%) of fall-related deaths.¹⁰ The category for falls (E880–E888) in ICD-9 included E887, “Fracture, cause unspecified.” ICD-10 does not contain an equivalent code in the falls category (W00–W19). In Quebec, this situation is especially important because code E887 was used disproportionately compared to other Canadian provinces.²⁰ However, these deaths cannot simply be excluded from the analyses, because they generally result from a fall that the Return of Death form does not explicitly mention.^{9,21}

Using a methodology proposed by Kreisfeld and Harrison,²¹ we first identified deaths specifically associated with a fall as the underlying cause of death, defined here as the injury that initiated the train of morbid events leading directly to death.²² These deaths are categorized as “certified falls” (Table 1). We also created another category, “presumed falls,” to satisfactorily

estimate the extent of fall-related deaths and identify a seamless trend in spite of the changes in ICD classification. For the years when deaths were coded using ICD-9, 1981 to 1999, the presumed falls category was made up of “fractures of unspecified causes” (code E887). Since 2000, the “presumed falls” category has been made up of deaths due to “exposure to unspecified factors” (code X59) with at least one fracture recorded among the secondary causes. (The World Health Organization recently introduced code X59.0, “Exposure to unspecified factor causing fracture,” to compensate for the difficulties caused by the discontinuation of code E887.²²) We also examined all the secondary causes of death entered on the Return of Death forms to identify “additional falls,” including those cases where a fall or exposure to an unspecified factor was not specified as the underlying cause of death (see Table 1). We selected both the specific codes for falls and those for exposure to an unspecified factor combined with a fracture code. Because it is based on the secondary causes of death, this identification strategy is only possible for the years since 2000. This complementary category makes it possible to take into account a possible shift of fall-related deaths toward secondary causes.

Statistical analysis

We calculated the number of fall-related deaths and annual rates using population estimates for the years 1981 to 2005 and population projections for the years 2006 to 2009.²³ The rates are shown per 100 000 population and express the number of deaths in a year in relation to the number of individuals at risk for the same period (estimated from population numbers as of July 1 of each corresponding year). The rates shown

for the population aged 65 years and over were standardized using the direct method to limit the confounding effects created by differences related to the population age structure and also to permit comparisons over time. The 2001 Quebec population was chosen as the reference population. We also calculated specific rates by sex and age group.

We used negative binomial modelling to determine whether the time trends for fall-related mortality rates were statistically significant. This strategy is especially suited to modelling a count of events in a given period in which a parameter related to overdispersion must be controlled for.²⁴ The model includes the intercept (α), the parameters associated with the variables included in the model (β_i) and an overdispersion term ($\sigma\epsilon$), and takes the following form:

$$\ln(\text{number of deaths}) = \alpha + \beta_{\text{year}} + \beta_{\text{age}} + \beta_{\text{sex}} + \ln(\text{population}) + \sigma\epsilon$$

To model the trends of the annual rates of fall-related mortality, two periods were chosen to mitigate the transition from ICD-9 to ICD-10 codes and evaluate the impact of a case definition based on the secondary causes of death available only since 2000. The first period includes the years 1981 to 1999, whereas the second is from 2000 to 2009, thus covering the last 10 years of the period under study. For each of the two periods, the parameter associated with the year (β_{year}) was used to estimate the annual average percentage change (AAPC) in fall-related mortality rates. The AAPC used to describe the trend was calculated as follows:

$$\text{AAPC} = (e^{\beta_{\text{year}}} - 1) \times 100$$

TABLE 1
List of codes for fall-related deaths by ICD version

Terminology used	Ninth revision of the International Classification of Diseases (ICD-9)	Tenth revision of the International Classification of Diseases (ICD-10)
Certified falls	E880–E886 or E888 as primary cause of death	W00–W19 as underlying cause of death (e.g. fall on stairs or from bed)
Presumed falls	E887 as primary cause of death	X59 as underlying cause of death and at least one fracture code recorded among the secondary causes (e.g. hip fracture)
Additional falls	—	Fall codes, certified or presumed, recorded among the secondary causes, irrespective of the primary cause (e.g. hip fracture and code X59 among the secondary causes, the primary cause of which corresponds to Alzheimer’s disease)

We calculated 95% confidence intervals (CI) for the AAPCs using the Wald method. These estimates demonstrate whether the rate trend is, generally speaking, increasing or decreasing over a given period. The modelling strategy was also used to illustrate the time trends established based on the number of deaths predicted by the model and population estimates. All statistical analyses were performed using SAS statistical software version 9.2 (SAS Institute Inc., Cary, NC, US).

Results

In Quebec, the number of deaths directly associated with a certified or presumed

fall rose from 255 in 1981 to 819 in 2009 in the population aged 65 years and over. During this period, the adjusted fall-related mortality rate varied from 48.8 to 71.1 deaths per 100 000 population (Table 2). The annual numbers of fall-related deaths were higher in women than in men. On the other hand, the adjusted mortality rates were higher in men (Table 2 and Figure 1). Since the early 2000s, adjusted fall-related mortality rates have shown no significant variation in women, but have shown a downward trend in men, especially those aged 85 and over (Table 3). In addition, the increase in fall-related mortality rates (certified or presumed) observed in the 1980s and

1990s in women aged 85 and over seems to have stopped in the early 2000s (Table 3 and Figure 2).

Since the early 2000s, the rate of certified falls rose by an average of 3.0% per year in men and 6.3% in women. On the other hand, the rate of presumed falls fell by an average of 4.5% per year in men and 3.5% in women (Table 4 and Figure 3).

When the analyses include only secondary causes (additional falls), no significant variation appears in either men or women (Table 4 and Figure 3). However, this seems to be largely due to the low rates observed for the years 2000 and 2001 for

TABLE 2
Number and adjusted rate of deaths related to certified or presumed falls per 100 000 population, ≥ 65 years, by sex, Quebec, 1981–2009

Year	Men		Women		Sexes combined		<i>p</i> * value
	Number	Rate	Number	Rate	Number	Rate	
1981	112	67.2	143	51.3	255	57.5	.039
1982	107	63.4	161	54.6	268	58.1	.244
1983	118	69.1	189	61.5	307	64.6	.335
1984	126	71.8	176	54.4	302	60.7	.020
1985	119	64.3	159	46.4	278	52.9	.009
1986	113	60.9	197	55.3	310	57.6	.422
1987	109	55.1	176	46.2	285	49.5	.162
1988	115	55.8	222	55.6	337	56.1	.979
1989	132	63.0	175	41.7	307	48.8	.001
1990	161	70.3	233	53.0	394	59.7	.007
1991	143	62.8	223	48.4	366	53.3	.017
1992	163	72.2	264	54.7	427	59.8	.006
1993	177	69.5	289	57.2	466	62.7	.045
1994	150	60.2	273	52.2	423	55.3	.171
1995	172	69.4	281	52.1	453	57.7	.004
1996	167	63.2	345	62.1	512	63.6	.854
1997	189	70.7	373	64.9	562	67.2	.353
1998	188	67.4	352	59.0	540	62.6	.149
1999	197	69.6	381	61.8	578	64.9	.187
2000	223	74.0	362	56.0	585	63.0	.001
2001	258	84.8	387	57.7	645	66.9	< .001
2002	234	73.3	461	66.5	695	69.4	.234
2003	257	78.4	485	67.1	742	71.1	.047
2004	263	73.6	474	63.2	737	68.3	.052
2005	289	78.1	475	61.0	764	67.9	.001
2006	314	80.0	453	55.7	767	64.8	< .001
2007	277	66.9	456	54.8	733	59.8	.010
2008	310	71.8	462	52.6	772	59.7	< .001
2009	305	66.6	514	55.6	819	60.8	.013

* *p* value associated with the difference between the adjusted rates for men and women for a given year. A value of less than .05 indicates that the difference is statistically significant.

FIGURE 1
Adjusted mortality rate for certified or presumed falls, population ≥ 65 years, by sex, Quebec, 1981–2009

this type of death. Excluding these two years from the analyses, the trend is similar to the one for presumed falls (AAPC of -4% and -6.3% for men and women, respectively) (Table 4).

Discussion

Owing to the aging population, the number of fall-related deaths in Quebec

increased between 2000 and 2009. In contrast, the adjusted mortality rate remained fairly stable in women and even decreased slightly in men. However, this relative statistical stability has masked opposing trends. The mortality rate for falls specifically recorded as the underlying cause of death (certified falls) increased, whereas the mortality rate associated with fractures of unspecified

cause (presumed falls) decreased in both men and women. Between 2002 and 2009, the decline in the mortality rate associated with falls mentioned among the secondary causes (additional falls) corresponds to the reduction in the mortality rate associated with presumed falls, which suggests that the deaths removed from the presumed falls are not among the secondary causes. For the final analysis, the calcula-

TABLE 3
Annual average percentage change (AAPC) in the mortality rate for certified falls or presumed falls, population ≥ 65 years, by sex and age group, Quebec, 1981–1999 and 2000–2009

Age range, years	Time period	Men		Women	
		AAPC	95% CI	AAPC	95% CI
65–74	1981–1999	–0.2	(–1.7 to 1.3)	0.8	(–1.3 to 2.9)
	2000–2009	–0.8	(–5.1 to 3.9)	–3.1	(–6.4 to 0.3)
75–84	1981–1999	–0.0	(–1.1 to 1.1)	0.6	(–0.2 to 1.4)
	2000–2009	–1.2	(–2.9 to 0.5)	0.3	(–0.7 to 1.3)
≥ 85	1981–1999	0.9	(–0.1 to 1.9)	1.6 ^a	(0.7 to 2.6)
	2000–2009	–1.7 ^a	(–3.2 to –0.1)	–1.7	(–3.5 to 0.2)
Total ≥ 65	1981–1999	0.3	(–0.4 to 1.0)	1.1 ^a	(0.5 to 1.8)
	2000–2009	–1.3 ^a	(–2.5 to –0.1)	–1.1	(–2.4 to 0.1)

Abbreviations: AAPC, annual average percentage change; CI, confidence interval.

^a Significant AAPC.

FIGURE 2
Mortality rate for certified or presumed falls, population ≥ 65 years, by age group and sex, Quebec, 1981–2009

TABLE 4
Annual average percentage change (AAPC) in the fall-related mortality rate, population ≥ 65 years, by fall category and sex, 1985–1999 and 2000–2009

Segment	Men		Women	
	AAPC	95% CI	AAPC	95% CI
Certified fall	1985–1999	1.9	2.7 ^a	(0.4 to 5.1)
	2000–2009	3.0 ^a	6.3 ^a	(4.6 to 8.0)
	2002–2009	3.9 ^a	5.9 ^a	(3.6 to 8.1)
Presumed fall	1985–1999	0.5	2.1 ^a	(1.4 to 2.9)
	2000–2009	–4.5 ^a	–3.5 ^a	(–5.0 to –1.9)
	2002–2009	–5.5 ^a	–6.1 ^a	(–7.5 to –4.6)
Total	1985–1999	0.9	2.2 ^a	(1.4 to 3.0)
	2000–2009	–1.3 ^a	–1.1	(–2.4 to 0.1)
	2002–2009	–1.6	–3.7 ^a	(–4.6 to –1.9)
Additional fall	1985–1999	—	—	—
	2000–2009	1.0	–0.5	(–3.7 to 2.7)
	2002–2009	–4.0 ^a	–6.3 ^a	(–7.9 to –4.6)

Abbreviations: AAPC, annual average percentage change; CI, confidence interval.

Note: The years 1981–1984, which precede a directive issued by Statistics Canada on the coding of deaths, were excluded from the analyses.

^a Significant annual AAPC.

tions for the years 2000 and 2001 were excluded because of the low rates observed, probably due to this being the time of transition to the new ICD.

In Canada as a whole, the mortality rate for certified falls in the adult population aged 65 years and over rose significantly between 1997/1999 and 2000/2002, especially in women.² A similar upward trend occurred in the United States, where the mortality rate for certified falls in this age group rose by 42% between 2000 and 2006.⁴ In the Netherlands, a smaller increase has been observed in men since 1997, despite that the presumed falls category was also included in the analyses.⁷ In Finland, the mortality rate due to certified falls has fallen in women since the early 2000s.²⁵

The small increases in the rates of fall-related emergency department visits or hospital admissions in the United States is at odds with the large increase in fall-related mortality rate (42% between 2000 and 2006) in older adults.⁴ This apparent discrepancy has led to the suggestion that

this difference is as a result of more falls being selected as the initial cause of death.^{4,6} Our results seem to confirm this hypothesis, since the decrease in the mortality rate for presumed falls seems to be partially compensated for by an increase in deaths related to certified falls. This finding also holds when the mortality rate takes into account all secondary causes.

Is the trend in the adjusted fall-related mortality rate associated with improved recording of cause of death?

Most deaths in older adults result from a combination of morbidities, the chronological sequence of which can be difficult to establish.^{26–27} The number of deaths as a direct result of falls may be under-reported.²⁸ In the case of older women who die after a fall,²⁹ who present with multiple medical conditions³⁰ and who die following a long period of hospitalization²⁹ (as is generally the case with hip fractures³¹), the cause of death is less likely to be attributed to the correct underlying cause. Reporting on the causes

of death could be more accurate,³² and it is possible that the trends observed in Quebec are the result of improved identification of fall-related deaths as certified falls. On the other hand, as has been reported elsewhere,^{9,16} the presumed falls and the additional falls categories are essentially made up of hip fractures of unspecified external cause (see Appendix A). That said, the incidence of hip fractures seems to be declining in several countries^{33–36} including Canada.³⁷ Similarly, despite the persistent excess mortality associated with hip fractures,³⁸ the fatality rate seems to have declined in recent years.^{39,40} Because the mortality rate results from the combination of incidence and fatality related to a health problem, it seems plausible that the decline in the adjusted mortality rate associated with presumed falls reflects a change related to hip fractures. The increase in the mortality rate associated with certified falls may also be due in part to the increase in the incidence of traumatic brain injury-related deaths in older adults⁴¹ because the circumstances surrounding these deaths are more likely to be accurately recorded.³¹

FIGURE 3
Fall-related mortality rate per 100 000 population, ≥ 65 years, by fall category and sex, Quebec, 1985–2009

Risk factors and fall prevention

While we do not attempt to identify the determinants of the observed trends in this article, it is worth mentioning that many factors may have influenced the changes in fall-related mortality over the period of this study.

Falls among older adults generally result from a complex interaction of risk factors associated with the growing vulnerability of this population due to aging and illness.⁴² Impaired balance can increase risk of falls, as can chronic health problems such as hypotension, cardiovascular disease⁴³ and the use of certain prescription drugs.^{2,43}

Some interventions, including improving individuals' physical capacity, have proven effective in reducing the likelihood of falls.⁴⁴ Since the mid-2000s, MSSS has taken various measures to prevent falls among older adults in Quebec, particularly those with balance issues.⁴⁵ These measures include having health providers monitor risk factors among older patients.⁴⁵ While the interventions are generally considered effective,⁴⁴ their benefits have only been demonstrated with respect to the risk of falls and not with respect to mortality. In addition, the interventions had been only partially implemented in Quebec by 2008⁴⁶ despite that fall prevention has been a concern for a number of years.

Strengths and limitations

This study has several limitations. First, we did not examine the validity and accuracy of the causes of death recorded on Return of Death forms in Quebec. The quality of vital statistics information has been criticized in various countries, particularly with respect to identifying underlying causes of death^{15,16,31} and the accuracy of the recorded external causes.^{19,47} The use of a broader case definition appears to have mitigated the effects of replacing specific codes for external causes with unspecific codes. This strategy has also limited the under-identification of fall-related deaths due to the transition from ICD-9 to ICD-10. Second, our study does not encompass the many known risk factors for falls that

might have influenced the reported time trends. The inclusion of these factors could explain a portion of the fluctuations observed here. Finally, most falls do not result in death. This overview portrays only the tip of the iceberg. Further analyses could build on efforts to refine the surveillance indicators for fall-related morbidity⁴⁸ and look at whether the trends reported here reflect the changes in the incidence and fatality of fall-related injuries.

Conclusion

Because of the aging of the population, the number of fall-related deaths rose between 2000 and 2009 in Quebec. However, the adjusted fall-related mortality rate in people aged 65 years and over remained fairly stable in women and even fell slightly in men. This information is significant because—to the extent that incidence and fatality associated with these injuries does not change—the fre-

quency of fall-related injuries will likely rise in the coming years as the population continues to age.

So far, no standard definition has been suggested to analyze and describe the extent of fall-related deaths in older Canadians. The definition used in our study merits attention. Using it has practical implications for measuring the problem because it resolves the under-identification and apparent decrease in fall-related deaths created by the transition to ICD-10. Studies designed to estimate the extent and time trends of fall-related mortality should include certified falls (W00–W19) and the presumed falls coded as being due to exposure to an unspecified factor (X59) causing a fracture. The possible shift in coding from fall-related deaths to secondary causes should also be taken into consideration so as to identify additional cases of fall-related deaths.

APPENDIX A
Characteristics of fall-related deaths, population ≥ 65 years, by fall category, Quebec, 2000–2009

	Certified fall		Presumed fall		Additional fall	
	N ^a	%	N ^a	%	N ^a	%
Sex						
Men	117	51.1	156	31.4	142	33.1
Women	112	48.9	341	68.6	387	66.9
Age group, years						
65–74	46	20.0	28	5.6	41	9.6
75–84	82	36.0	146	29.3	148	34.5
≥ 85	101	44.0	324	65.2	240	56.0
Hip fracture						
Yes	20	8.8	390	78.3	290	67.7
No	209	91.2	108	21.7	138	32.3
Traumatic brain injury						
Yes	133	58.4	3	0.6	13	2.9
No	95	41.6	495	99.4	416	97.1
Total	229	100.0	497	100	429	100
Age, years						
Mean (SD)	82.4	(8.4)	86.8	(7.2)	85.1	(7.5)
Median	83		87		86	
Secondary causes of death	N ^b		N ^b		N ^b	
Mean number (SD)	4.7	(2.1)	5.0	(1.8)	5.8	(1.8)
Median number	4		5		5	

Abbreviation: SD, standard deviation.

^a Average annual number, average or median value.

^b Average annual number or median number of medical conditions among vital statistics data.

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