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Unintentional injury deaths associated with sport and recreation in Québec, Canada, 2006–2019

Philippe Richard ,[1] Judith Lahiri-Rousseau,[1] Jonathan Phimmasone,[2] Emilie Belley-Ranger,[1,3] Jérémie Sylvain-Morneau,[2] Mathieu Gagne,[2] Paul-André Perron,[4] Claude Goulet [3]

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[1]Direction de la sécurité dans le loisir et le sport, Ministère de l'Éducation du Québec, Québec, Québec, Canada
[2]Institut national de santé publique du Québec, Québec, Québec, Canada
[3]Department of Physical Education, Laval University, Québec, Québec, Canada
[4]Bureau du coroner du Quebec, Québec, Québec, Canada

Correspondence to
Dr Philippe Richard; philippe.richard@education.gouv.qc.ca

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ABSTRACT

Objectives This study examined trends in the frequencies and rates of deaths associated with unintentional injuries in sport and recreation in Québec, Canada, for the period January 2006–December 2019.

Methods In this descriptive retrospective study, data were extracted from the database of the Bureau du coroner du Québec. Incidence rates were calculated using participation data from the Étude des blessures subies au cours de la pratique d'activités récréatives et sportives au Québec (ÉBARS) and Canadian census population data. Poisson regression was used to investigate changes in death rates over the 14-year period by estimating incidence rate ratios.

Results There were 1937 unintentional injury deaths and the population-based death rate was 1.72 per 100 000 person-years. The participation-based rate was 1.40 per 100 000 participant-years, considering the 24 matching activities in both ÉBARS' editions. Using both population-based and participation-based denominators, separate analyses consistently showed declining death rates in non-motorised navigation and cycling. Deaths related to all-terrain vehicles, snowmobiles, swimming, cycling, motorised navigation and non-motorised navigation activities accounted for 80.2% of all deaths. Drowning was documented as a cause of death in 39.3% of all fatalities. Males represented 86.8% of all deaths, with males aged 18–24 years and 65 and over having the highest rates.

Conclusion The death rates of unintentional injury deaths associated with non-motorised navigation and cycling declined, from January 2006 to December 2019. The characteristics and mechanisms of drowning deaths and fatalities that occurred in activities associated with higher death frequencies and rates need to be further investigated.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Comprehensive data regarding injury deaths associated with sport and recreation remain scarce and not easily accessible at both the national and provincial levels in Canada.
⇒ Due to the diverse coronial systems and legislative frameworks across Canadian provinces, conducting provincial studies is essential. Focused analyses of fatalities in sport and recreation are crucial to accommodate regional variations accurately.
⇒ There is an opportunity to obtain an accurate profile of the mortality associated with sport and recreation in Québec using the database of the Bureau du coroner du Québec.

WHAT THIS STUDY ADDS

⇒ The rate of unintentional injury deaths associated with non-motorised navigation and cycling declined during the period analysed.
⇒ Six activities accounted for 80.2% of all deaths and drowning was a documented cause of death in 39.3% of all cases.
⇒ Specific preventive measures should be developed to target males aged 18–24 years and 65 and over, as an utmost priority.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This surveillance study highlighted priority areas for further investigation and informs the next stage of a global approach to injury prevention.
⇒ In a study that builds on the current investigation, the focus will encompass incident locations, alcohol consumption in motor sports and activities associated with drowning, as well as the use of protective equipment like personal floating devices in navigation and helmets in land motor sports and cycling activities.
⇒ As part of a multifaceted research project, the outcomes of the study may contribute to providing guidance and data to sport and recreation organisations, government entities and research institutions in the development, implementation and evaluation of preventive measures.

INTRODUCTION

The health benefits of sport and physical activity are well documented.[1] Policies and action plans are developed by international, national and subnational organisations to increase physical activity and reduce sedentary behaviours among populations.[2] Nevertheless, the health and social benefits associated with active recreation and the rise in popularity of various physical activities can be offset by injuries and deaths.[3–5] For instance, in Australia, an average of more than one unintentional injury death per week in sport and recreation has been observed over a 20-year period, and a peak annual death rate of 0.47 per 100 000 population was recorded in 2001 and 2005.[5]

Under the Act respecting safety in sports (CQLR, chapter S-3.1, s. 20),[6] the Direction de la sécurité

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dans le loisir et le sport (DSLS) has a significant influence on safety regulations in sport and recreation through research and surveillance in Québec, Canada.[7] The database of the Bureau du coroner du Québec (BCQ) has not yet been exploited thoroughly to monitor and investigate fatalities in sport and recreation.[8] Indeed, the characteristics of sport and recreation fatalities in Québec are not systematically reported and this gap limits our injury-prevention potential.[5] These analyses could complement the provincial sport and recreation injuries surveillance and shed new light on the development and assessment processes of prevention strategies.[3–5 9 10]

The BCQ sends sport and recreation mortality databases and coroners' reports on a regular basis to the DSLS. There is an opportunity, therefore, to obtain an accurate profile of the mortality associated with sport and recreation in Québec and to provide thorough methodological information including database extraction criteria. This is paramount to ensure comparison of the current study's findings with those of future investigations and to allow implementation of a system for assessing preventive measures.[9 10]

Surveillance constitutes the first stage within the TRIPP (Translating Research Into Injury Prevention Practice) framework.[10] As part of a multifaceted research project, this study aims to contribute insights across all phases of the TRIPP framework. Through this surveillance study, a key objective is to establish the extent of the burden regarding deaths associated with sport and recreation in Québec, offering a broad perspective on this issue and highlighting further research priorities. This initial phase serves as the groundwork for the second stage of the framework, focused on understanding the aetiology and mechanisms behind these deaths.[10]

Therefore, this study examined trends in the frequencies and rates of deaths associated with unintentional injury in sport and recreation in Québec, Canada, for the period running from January 2006 to December 2019, based on the BCQ sport and recreation databases and the coroner's investigation reports. The focus was on (1) mortality numbers and rates based on participation data for sport and recreation and (2) mortality numbers and rates based on Canadian census data.

METHODS

Design and data source

This descriptive retrospective study used data from the computerised database of the BCQ (CD-BCQ), a data-storage system that can generate thematic databases containing standardised information provided for each investigated case. Detailed complementary textual components can be found in the coroner's corresponding investigation reports.

The codification of cause of death in the CD-BCQ is based on the 10th revision of the International Classification of Diseases (ICD-10). However, this system does not systematically allow for a description of activities associated with deaths.[11] Hence, the BCQ developed a 'sport and recreation' algorithm based on three conditions: (1) any unintentional injury death or natural death in an activity coded as 'while playing a sport' or 'while participating in a game or leisure activities'; (2) any unintentional injury death or natural death for which one of the preselected keywords is entered in the 'remarks' field (online supplemental appendix table A1) and (3) any death that corresponds to one of the preselected ICD-10 codes (online supplemental appendix table A2). Moreover, a trauma surveillance expert advisor from the BCQ conducted a brief review of the remarks entered in the database text fields to eliminate cases which were clearly irrelevant. When data were extracted, the percentage of completed coroner investigations for 2019 was 96.2%, while the 2006–2018 period was considered closed (100%). It is noteworthy that the completion of 95% or more of the investigations for a specific year typically occurs around 3 years after it ends at the BCQ.

During the period investigated, the DSLS also benefited from the BCQ subscription service, which acts as an early warning system. Accordingly, when released by the coroner, investigation reports were automatically sent to the DSLS, based on a dual-criteria algorithm: (1) any death for which one of the preselected keywords is entered in any text field (online supplemental appendix table A1) and (2) any death that corresponds to one of the preselected ICD-10 codes (online supplemental appendix table A2).

Data processing

Each case in the 2006–2019 CD-BCQ sport and recreation database was paired with the corresponding investigation report. All unmatched reports (subscription service) were thoroughly read by two investigators to validate their relevance. Ambiguous cases (n=20) were discussed with a third investigator until a consensus was reached. For all cases (database: n=2551; subscription service: n=240), ICD-10 codes and investigation reports (textual accounts) have made it possible to precisely describe the activity associated with the deaths. When two activities were practised simultaneously (eg, fishing from a canoe), ICD-10 code was used to determine the activity primarily associated with the death. Cases unrelated to sport or recreation were excluded (n=557). Since the current investigation focused on unintentional injury deaths, natural deaths (n=297) were identified and will be further analysed in another study. Figure 1 illustrates the complete data processing. Within the final dataset, drowning fatalities were identified using ICD-10 codes along with the text in the investigation reports. Available information regarding the place of occurrence, the context, the protective equipment used, the victim's swimming skills, their consumption of alcohol or of other psychoactive substances and traumatic brain injuries or cranial traumas (when caused by 'either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head',[12] excluding facial fractures, gunshot wounds, strokes or anoxic brain injuries) was collected by two investigators. Both investigators read all the reports (100%) and entered the data for each case. Any discrepancies were resolved through discussion, until a consensus was reached. A third investigator counterchecked 265 cases (10.4% of the original 2551 cases of the BCQ database) to ensure data-entry accuracy and procedure uniformity. This process was divided into 12 blocks in which follow-up and adjustments meetings were carried out. At the end of each block, discrepancies and ambiguous cases were discussed with a third investigator until a consensus was reached (n=83). The research did not require ethical approval as it relied exclusively on publicly available information. Under the Coroners Act (CQLR, chapter C-68.01), coroners' reports are public records.[13]

Participation and census data

Two provincial population-based surveys (Étude des blessures subies au cours de la pratique d'activités récréatives et sportives au Québec, ÉBARS) on self-reported injuries sustained

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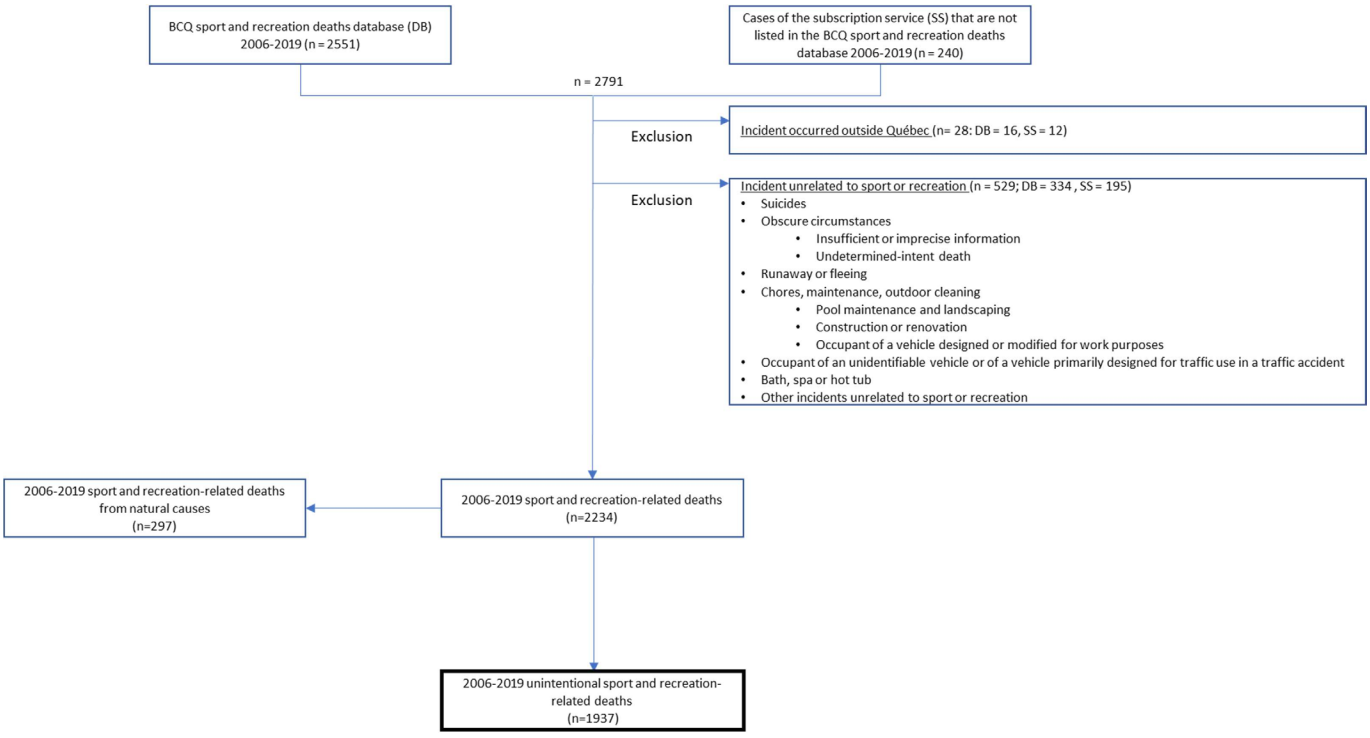

Figure 1 Data flow diagram. BCQ, Bureau du coroner du Québec.

during sport and recreation were conducted during the studied period.[14 15] The primary objectives of these surveys included estimating injury frequency requiring healthcare professional consultation and documenting participation in sport and recreation. The ÉBARS methodology included applying survey weighting to extrapolate findings from the sample (online supplemental material ÉBARS) to the Québec population. Respectively, 8513 and 9466 people aged 6–74 years were surveyed in 2009–2010[14] and 2015–2016.[15]

According to Canadian censuses, in 2011, the province of Québec had a population of 7 903 million,[16] whereas in 2016, the enumerated population was 8164 million.[17] For population-based rates, estimates of the population of Québec's administrative regions, by age and sex as of 1 July of each year, were extracted from the website of the Institut de la statistique du Québec.[18]

Statistical analysis

Participation-based incidence rates were estimated exclusively for the 24 matching activities in both editions of the ÉBARS. The number of deaths was divided by the two studies' respective annual participation numbers. This was expressed as a rate per 100 000 participant-years. Population-based rates were expressed per 100 000 person-years, thus indicating the number of deaths that occurred during a given year, based on the population of the corresponding year. For both denominators, high concordance was found between crude and age-adjusted (17 and under, 18–44 years, 45–64 years 65 and over) and sex-adjusted annual incidence rates. As a result, only crude rates are presented.[4]

Years were grouped into three periods (2006–2009, 2010–2014 and 2015–2019). The year groupings were determined with the aim of achieving a balance between ensuring sufficient data within each period (improving the precision of the estimated rates) and capturing insightful trends that were not already evident in a general trend analysis. Since participation data were not consistently available for the study period, values for missing years were estimated by considering the number of participation as constants based on one of the two ÉBARS editions. Each period was matched with the ÉBARS edition that was conducted within the given period: data from the former edition[14] were used for years 2006–2009 and 2010–2014, while participation figures of the later[15] were used for years 2015–2019. CIs at a 95% statistical significance level were calculated using a method based on the Gamma distribution.[19] In accordance with Statistics Canada guidelines, estimates with coefficients of variation (CV) higher than 33.3% are deemed unreliable (identified with letter F in the tables). Estimates with CVs from 16.6% to 33.3% were also identified and should be interpreted with caution.[14 15] Poisson regression was used to investigate changes in rates over the 14-year period, for all activities, by estimating incidence rate ratios (IRRs).[3] The periods were compared with one another to evaluate interperiod changes. IRRs were not calculated for activities with fewer than five deaths within a given period. Analysis of linear trends was also conducted and reflects the average annual change in incidence rates between consecutive years, with p values testing the null hypothesis of no linear trend against the alternative hypothesis of a linear increase or decrease in the incidence rate at a significance level of 5%.[4]

SAS software (2019–2020, SAS Institute) was used for analysis. For the estimation of the variance in participation-based rates, we considered that, given that the numerator value is low in most cases, the variability of the estimated variance essentially arises from the numerator. Thus, as a working assumption the denominator values were treated as if they were constants in this study.[4]

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Table 1 Numbers and participation-based rates for sport and recreation-related deaths as categorised in the ÉBARS and considering the populations surveyed in the ÉBARS in Québec, Canada, 1 January 2006–31 December 2019 (inclusive)*

Activities†	n	Participation year (ÉBARS)‡	Rate (95% CI)
All-terrain vehicle	317	18 802 000	1.69 (1.51 to 1.88)
Snowmobile	261	10 410 000	2.51 (2.21 to 2.83)
Cycling	230	47 626 000	0.48 (0.42 to 0.55)
Swimming	212	48 408 000	0.44 (0.38 to 0.50)
Non-motorised navigation	91	17 290 000	0.53 (0.42 to 0.65)
Hiking or taking a walk	28	63 383 000	0.04 (0.03 to 0.06)§
Alpine skiing	20	14 175 000	0.14 (0.09 to 0.22)§
Skateboarding¶	12	3 959 000	0.30 (0.16 to 0.53)§
Jogging	8	25 342 000	F
Ice hockey	7	12 714 000	F
Snowboarding	5	6 337 000	F
Snowshoeing	5	19 801 000	F
Inline skating	4	12 409 000	F
Combat sports	3	5 095 000	F
Soccer	2	13 922 000	F
Cross-country skiing	1	10 505 000	F
Golfing	1	12 619 000	F
Ice skating	1	27 077 000	F
Physical conditioning	1	37 063 000	F
Football**	0	3 900 000	F
Baseball-softball	0	6 424 000	F
Volleyball**	0	7 307 000	F
Basketball**	0	7 643 000	F
Racket sports	0	16 634 000	F
All activities††	1209	86 295 137	1.40 (1.32 to 1.48)

*Rates (numerator: number of deaths; denominator: ÉBARS participation data, considering only the activities listed in the table) are expressed as a number per 100 000 participant-years.
†6–74 years.
‡Participation numbers were extracted from the ÉBARS in which they were inferred from the samples surveyed.
§Coefficient of variation between 16.6% and 33.3%. These rates are to be interpreted with caution. F Coefficient of variation >33.3%. These rates are too unreliable to be reported.
¶6–44 years.
**6–64 years.
††Activities listed in the table only.
ÉBARS, Étude des blessures subies au cours de la pratique d'activités récréatives et sportives au Québec.

Table 2 Incidence rate ratios and p values for sport and recreation-related deaths as categorised in the ÉBARS and considering the populations surveyed in the ÉBARS, Canada, 1 January 2006–31 December 2019 (inclusive)*

Activities†‡	Time period comparison	IRR (95% CI)	P value
All activities	Period 2 vs period 1	1.18 (1.02 to 1.36)	0.0230§
	Period 3 vs period 2	0.78 (0.68 to 0.88)	0.0002§
	Period 3 vs period 1	0.91 (0.79 to 1.06)	0.2211
	2006–2019	0.99 (0.97 to 1.00)	0.0609
All-terrain vehicle	Period 2 vs period 1	1.12 (0.85 to 1.48)	0.4249
	Period 3 vs period 2	0.66 (0.51 to 0.86)	0.0017§
	Period 3 vs period 1	0.74 (0.56 to 0.98)	0.0377§
	2006–2019	0.97 (0.94 to 0.99)	0.0165§
Cycling	Period 2 vs period 1	1.35 (0.99 to 1.84)	0.0618
	Period 3 vs period 2	0.53 (0.39 to 0.73)	<0.0001§
	Period 3 vs period 1	0.71 (0.50 to 1.01)	0.0591
	2006–2019	0.96 (0.93 to 0.99)	0.0081§
Hiking or taking a walk	Period 2 vs period 1	0.72 (0.29 to 1.77)	0.4746
	Period 3 vs period 2	0.91 (0.36 to 2.28)	0.8355
	Period 3 vs period 1	0.65 (0.27 to 1.61)	0.3534
	2006–2019	0.92 (0.84 to 1.01)	0.0843
Non-motorised navigation	Period 2 vs period 1	0.85 (0.53 to 1.35)	0.4876
	Period 3 vs period 2	0.42 (0.25 to 0.72)	0.0016§
	Period 3 vs period 1	0.36 (0.21 to 0.61)	0.0002§
	2006–2019	0.91 (0.87 to 0.96)	0.0003§
Snowmobile	Period 2 vs period 1	1.25 (0.91 to 1.72)	0.1675
	Period 3 vs period 2	0.79 (0.60 to 1.04)	0.0968
	Period 3 vs period 1	0.99 (0.72 to 1.36)	0.9450
	2006–2019	0.99 (0.96 to 1.02)	0.6317
Swimming	Period 2 vs period 1	1.38 (0.96 to 1.97)	0.0799
	Period 3 vs period 2	0.90 (0.66 to 1.22)	0.4911
	Period 3 vs period 1	1.24 (0.87 to 1.77)	0.2402
	2006–2019	1.02 (0.99 to 1.05)	0.2711

*For each activity listed: the first three IRRs reflect the average change in incident rates between periods and the p values test the null hypothesis of no difference between IRRs between periods. The last IRR reflects the average annual change in incidence rates between consecutive years and the p value tests the null hypothesis of no linear trend in the incidence rate during the study period.
†6–74 years.
‡Activities with fewer than five deaths within a given time period (18 out of 24 activities) were not reported in this table.
§P<0.05.
ÉBARS, Étude des blessures subies au cours de la pratique d'activités récréatives et sportives au Québec; IRRS, incidence rate ratios.

RESULTS

Numbers and participation-based rates

From January 2006 to December 2019, the participation-based unintentional injury death rate was 1.40 per 100 000 participant-years, considering only the 24 activities matching in both editions of the ÉBARS. The highest participation-based rates were in snowmobile activities, followed by all-terrain vehicle activities, respectively, at 2.51 and 1.69 per 100 000 participant-years (table 1).

Significant average yearly decreases in the participation-based death rates were observed in non-motorised navigation (IRR 0.91; 95% CI 0.87 to 0.96; p<0.001), cycling (IRR 0.96; 95% CI 0.93 to 0.99; p<0.05) and all-terrain vehicles (IRR 0.97; 95% CI 0.94 to 0.99; p<0.05) activities over the period studied (table 2).

The participation-based death rates were higher for males than for females across all age groups, with males aged 18–24 years and 65–74 years exhibiting the highest rates (figure 2A).

All deaths: numbers and population-based rates

Over the 14-year period studied, there were 1937 unintentional injury-related deaths associated with sport and recreation in Québec (138.4 per year, 2.7 per week). The population-based death rate was 1.72 per 100 000 person-years (table 3). Land motor sports represented 38.8% (n=752, 0.67 per 100 000 person-years) of all unintentional injury deaths, with all-terrain vehicle and snowmobile activities accounting for a significant proportion of these incidents (19.8%, n=383, 0.34 per 100 000 person-years; 18%, n=348, 0.31 per 100 000 person-years). Cycling also accounted for a high percentage of fatalities

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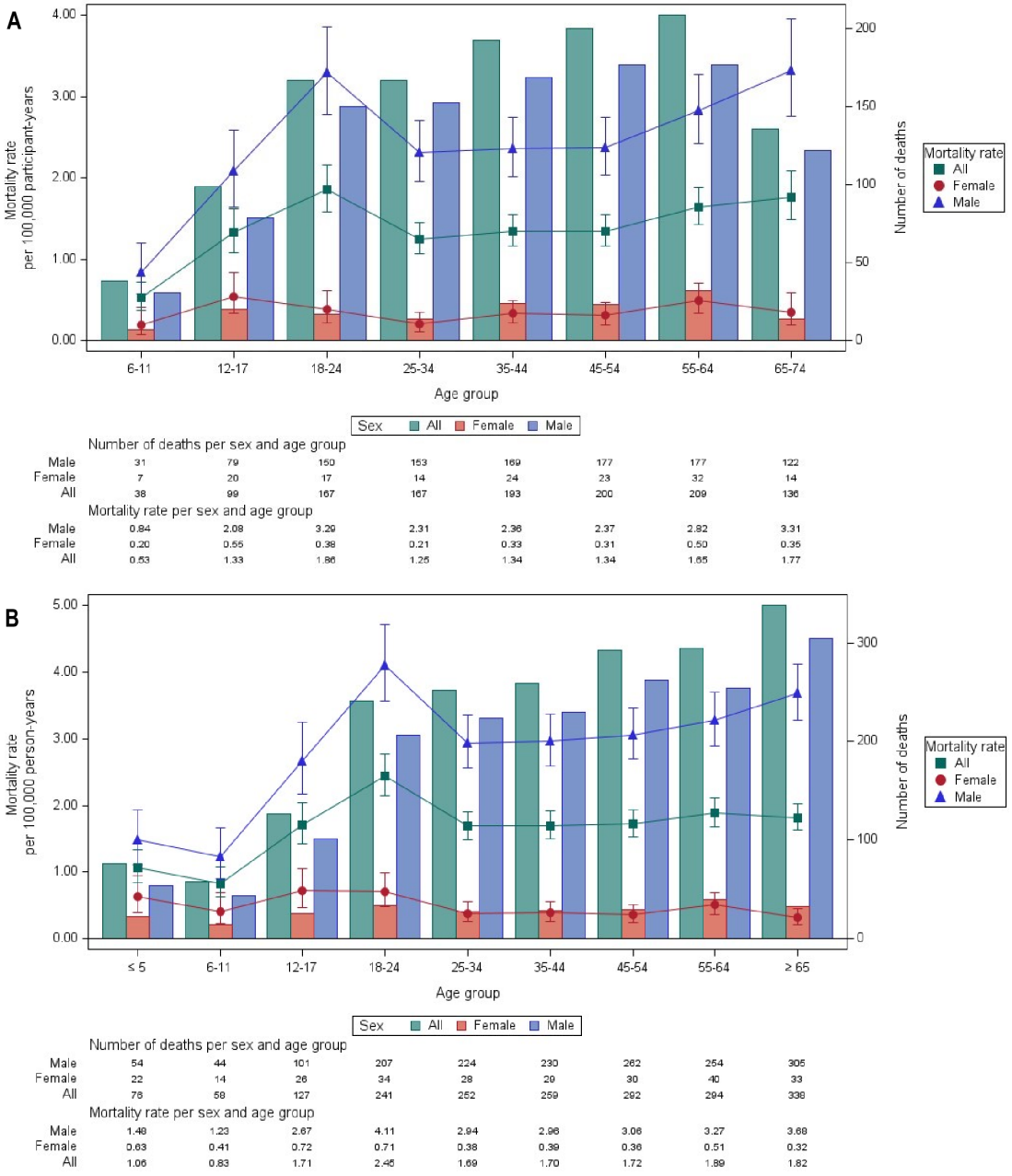

Figure 2 Numbers (right vertical axis—bars) and rates (left vertical axis—lines) for sport and recreation-related deaths in Québec, Canada, by age group and sex, 1 January 2006 to 31 December 2019 (Inclusive). (A) Numbers and participation-based rates* considering populations surveyed in the ÉBARS. Rates are expressed as a number per 100 000 participant-years. (B) Numbers and population-based rates* for all sport and recreation-related deaths. Rates are expressed as a number per 100 000 person-years. *Some of the presented rates have CVs ranging from 16.6% to 33.3%. The CV for the female death rate in the 6–11 age group in A is the only one exceeding 33.3%. All rates are provided for reference purposes. CVs, coefficients of variation; ÉBARS, Étude des blessures subies au cours de la pratique d'activités récréatives et sportives au Québec.

(14.2%, n=274, 0.24 per 100 000 person-years). Swimming and underwater activities constituted 15.8% (n=305, 0.27 per 100 000 person-years) of the deaths, with swimming representing the major proportion of these incidents (14.8%, n=286, 0.25 per 100 000 person-years). The broad navigation category represented 14.3% (n=277, 0.25 per 100 000 person-years) in the profile of sport and recreation-related deaths (motorised navigation: 7.8%, n=151, 0.13 per 100 000 person-years; non-motorised navigation: 5.8%, n=111, 0.10 per 100 000 person-years) (table 3).

A 1% average yearly decrease was noted in the population-based rate over the period studied (IRR 0.99; 95% CI 0.98 to 1.00; p<0.05), due mainly to average yearly decreases in the death rates in navigation (IRR 0.96; 95% CI 0.93 to 0.98); p<0.05) and cycling (IRR 0.96; 95% CI 0.93 to 0.99; p<0.05) categories (table 4). The former decline is predominantly attributable to the yearly average decreased death rate in non-motorised navigation (IRR 0.93; 95% CI 0.89 to 0.97); p=0.0021, data not shown). Much of the decrease in cycling deaths seems to be associated with bicycles without documented particularities (IRR 0.95; 95% CI 0.93 to 0.99; p=0.0037, data not shown). Further analysis confirmed that there were no other significant differences in general trends

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Table 3 Numbers and population-based rates for all sport and recreation-related deaths in Québec, Canada, 1 January 2006–31 December 2019 (inclusive)*

Category	Activities	Specificities	n	Rate (95% CI)
All activities	–	–	**1937**	1.72 (1.64 to 1.80)
Alpine skiing and snowboarding	–	–	**31**	0.03 (0.02 to 0.04)†
	Alpine skiing	–	26	0.02 (0.02 to 0.03)†
		No particularity or unspecified	25	0.02 (0.01 to 0.03)†
		Backcountry skiing	1	F
	Snowboarding	–	5	F
Aerial activities	–	–	**25**	0.02 (0.01 to 0.03)†
	Non-motorised	–	11	0.01 (0.00 to 0.02)†
		Skydiving	6	F
		Paragliding	2	F
		Hang-gliding	1	F
		Gliding (glider)	1	F
		Other	1	F
	Motorised	–	14	0.01 (0.01 to 0.02)†
		Glider or ultralight craft	7	F
		Fixed-wing private aircraft	6	F
		Hot-air balloon	1	F
Climbing	–	–	**9**	F
	Climbing (no particularity)	–	6	F
	Ice climbing	–	2	F
	Deepelling	–	1	F
Combat sports	–	–	**3**	F
	Wrestling	–	2	F
	Kick-boxing or Muay Thai	–	1	F
Cross-country skiing	–	–	**1**	F
Cycling	–	–	**274**	0.24 (0.22 to 0.27)
		No particularity or unspecified	249	0.22 (0.19 to 0.25)
		Electric bike	14	0.01 (0.01 to 0.02)†
		Tricycle	5	F
		BMX	3	F
		Mountain biking (off-road)	3	F
Dancing	–	–	**2**	F
Equestrian activities	–	–	**9**	F
	Horse riding	–	8	F
	Cart or carriage riding	–	1	F
Fishing (not from a boat)	–	–	**39**	0.03 (0.02 to 0.05)
	From shore or a wharf	–	32	0.03 (0.02 to 0.04)†
	From in the water	–	4	F
	Ice fishing	–	3	F
Golfing	–	–	**1**	F
Hiking and taking a walk or snowshoeing	–	–	**47**	0.04 (0.03 to 0.06)
	Hiking and taking a walk	–	41	0.04 (0.03 to 0.05)
	Snowshoeing	–	6	F
Hunting and gun shooting	–	–	**36**	0.03 (0.02 to 0.04)†
	Hunting	–	35	0.03 (0.02 to 0.04)†
	Gun shooting	–	1	F
Jogging	–	–	**9**	F
Land motor sports	–	–	**752**	0.67 (0.62 to 0.72)
	All-terrain vehicle	–	383	0.34 (0.31 to 0.38)
		four wheels, unspecified or other	345	0.31 (0.27 to 0.34)
		Side by side	23	0.02 (0.01 to 0.03)†
		Three wheels	11	0.01 (0.00 to 0.02)†
		Toy	2	F
		Argo	2	F
	Snowmobile	–	348	0.31 (0.28 to 0.34)

Continued

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Table 3 Continued

Category	Activities	Specificities	n	Rate (95% CI)
	Motocross	–	12	0.01 (0.01 to 0.02)†
	Other motorised land activities	–	5	F
		Golf cart	2	F
		Wheelchair and mobility scooter	2	F
		Pocket bike	1	F
	Closed-circuit racing	–	4	F
		Car racing	3	F
		Moto racing	1	F
Navigation	–	–	**277**	0.25 (0.22 to 0.28)
	Motorised	–	151	0.13 (0.11 to 0.16)
		Rowboat	67	0.06 (0.05 to 0.08)
		No particularity or unspecified	35	0.03 (0.02 to 0.04)†
		Canoe	21	0.02 (0.01 to 0.03)†
		Personal watercraft	12	0.01 (0.01 to 0.02)†
		Pontoon	8	F
		Speedboat	5	F
		Yacht	2	F
		Sailing boat	1	F
	Non-motorised	–	111	0.10 (0.08 to 0.12)
		Canoe	67	0.06 (0.05 to 0.08)
		Kayak	23	0.02 (0.01 to 0.03)†
		Rowboat	11	0.01 (0.00 to 0.02)†
		Pedalo	3	F
		Sailing boat	3	F
		Kitesurfing	2	F
		Surf	1	F
		No particularity or unspecified	1	F
	Unspecified (motorised or not)	–	15	0.01 (0.01 to 0.02)†
		No particularity or unspecified	7	F
		Rowboat	7	F
		Canoe	1	F
Other activities	–	–	**69**	0.06 (0.05 to 0.08)
	Other outdoor games or activities	–	66	0.06 (0.05 to 0.07)
	Other indoor games or activities	–	3	F
Physical conditioning	–	–	**5**	F
Skateboarding	–	–	**12**	0.01 (0.01 to 0.02)†
	Skateboard or unspecified	–	8	F
	Longboard	–	4	F
Skating	–	–	**9**	F
	Inline skating	–	5	F
	Ice skating	–	4	F
Snow gliding	–	–	**10**	0.01 (0.00 to 0.02)†
Swimming and underwater activities	–	–	**305**	0.27 (0.24 to 0.30)
	Swimming	–	286	0.25 (0.23 to 0.28)
		No particularity	271	0.24 (0.21 to 0.27)
		Diving or jumping into a body of water	14	0.01†† (0.01 to 0.02)
		Sea-cave exploration	1	F
	Diving	–	19	0.02 (0.01 to 0.03)†
		Scuba diving	17	0.02 (0.01 to 0.02)†
		Snorkelling	2	F
Team sports	–	–	**11**	0.01 (0.00 to 0.02)†
	Ice hockey	–	7	F
	Soccer	–	2	F
	Off-ice hockey	–	1	F
	Curling	–	1	F
Tennis	–	–	**1**	F

Continued

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Table 3 Continued

Category	Activities	Specificities	n	Rate (95% CI)

Bold data indicate the total number of deaths for a given category.
*Rates are expressed as a number per 100 000 person-years.
†Coefficient of variation between 16.6% and 33.3%. These rates are to be interpreted with caution. F Coefficient of variation >33.3%. These rates are too unreliable to be reported.

(2006–2019) in IRRs for all other activities and specificities (data not shown) reported in table 3.

Males represented 86.8% of all deaths and exhibited higher rates than females across all age groups. Males aged 18–24 years and 65 and over had the highest rates (figure 2B).

Alcohol consumption was documented in 27.5% (n=532) of all cases: blood-alcohol concentration exceeded 80 mg/100 mL in 18.7% (n=363) of all deaths and a concentration equal to or below this threshold was found in 5.9% (n=115) of all victims. An unknown amount of alcohol was documented in 2.8% (n=54) of all cases. The presence of other psychoactive substances was documented in 13.2% (n=256) of all deaths.

Traumatic brain injuries or cranial traumas were reported in 35.2% (n=682) of all cases, all-terrain vehicle (n=198), cycling (n=192) and snowmobile (n=170) activities accounting for 82.1% of this burden.

There were 761 fatal unintentional drownings related to sport and recreation, accounting for 39.3% of all deaths (all activities, water related or not).

DISCUSSION

The population-based unintentional injury death rate associated with sport and recreation in Québec was 1.72 per 100 000 person-years for the period from January 2006 to December 2019. This rate declined during the 14-year period, due mainly to decreases in navigation (to a larger extent non-motorised navigation) and cycling death rates. Similar declining trends were also observed in participation-based deaths rates in non-motorised navigation and cycling.

The population-based death rate observed in our study exceeds, by more than a factor of three, the highest annual recorded rates in Australia from 2000 to 2019.[5] However, a number of methodological differences prevail between studies, one being that drowning deaths were excluded in the Australian setting. Nonetheless, this study helps to establish adapted provincial surveillance standards and to draw up a detailed profile of the situation, which are imperative steps if future deaths are to be avoided.[9 10]

Decreased death rates in sport and recreation, accompanied by a decline in cycling and navigation (power boating) death rates, were similarly observed in Victoria, Australia, from 2005 to 2015.[4] Noteworthy, in Québec, about 37% of cyclists wore a bicycle helmet between 2006 and 2008, compared with 53.2% in 2014, according to an investigation conducted by the Société de l'assurance automobile du Québec.[20] While prevention strategies, including protective equipment usage, may have contributed to the decreasing trend observed in this study, no preventive-measures assessment system can confirm this hypothesis. Surveillance belongs to the first stage of the TRIPP framework[10] in which intervention efficacy assessment processes are initiated at stage four.[9 10] This study aims to inform all stages of this framework with the goal of enhancing future processes for evaluating preventive measures.

All-terrain vehicles, snowmobiles, swimming, cycling, motorised navigation and non-motorised navigation activities were associated with 80.2% of the 1937 deaths. While motorised navigation participation data were not available, the highest participation-based death rates were observed in the other five activities, thus highlighting the importance of further documenting the specific characteristics of these fatalities. Aligning with the Pareto principle,[21] focusing research efforts, allocating resources and implementing targeted interventions on these few high-impact activities could potentially significantly reduce the incidence of sport and recreation-related fatalities in the province of Québec. Similarly, off-road land motor sports, cycling and swimming are among the activities with the highest mortality numbers and rates, in Australia.[3–5] Furthermore, 39.3% of all sport and recreation fatalities in Québec were drownings. Although deaths are inherently multifactorial,[22] drowning was found to be the most common cause of death in sport and recreation research settings in Victoria, Australia.[3 4] Trends and characteristics in sport and recreation drowning deaths constitute, therefore, another priority area to further investigate. And since males account for 86.8% of all sport and recreation deaths, specific prevention measures should be developed with them in mind, with priority going first and foremost of those aged 18–24 years and 65 and over. The high representation of young male adults is not unique to Québec since similar observations were made in Victoria[3 4] and nationwide in Australia.[5]

Further exploration of unintentional injury deaths associated with sport and recreation in Québec is essential within the TRIPP framework.[10] The results of this surveillance study emphasise the necessity to investigate the specific characteristics and mechanisms of these fatalities, especially in activities with higher death frequency and rates, and in instances of drowning fatalities. This aligns with the second stage of the TRIPP framework, which focuses on uncovering mechanisms behind such deaths. This in-depth investigation will significantly contribute to developing and evaluating tailored preventive measures specific to each activity.

Given the mortality portrait depicted in the current study, further exploration is warranted into potential risk factors. This includes investigating alcohol consumption in motor sports and in activities prone to drowning,[23] as well as focusing on fatalities where individuals were engaged in water-related activities alone and within natural bodies of water.[24] Moreover, preventive measures like the use of protective equipment such as personal floating devices in navigation activities,[24] along with helmets in land motor sports[25] and cycling activities,[26 27] require additional investigation.

STRENGTHS, LIMITATIONS AND PERSPECTIVES

The study's strengths include the broad scope of the CD-BCQ and the reliability of the detailed additional information (enabling in-depth descriptions of activities) collected through a rigorous process. However, BCQ algorithms may have not

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Table 4 Incidence rate ratios* and p values for all sport and recreation-related deaths in Québec, Canada, 1 January 2006–31 December 2019 (inclusive)†

Categories‡	Time period comparison	IRR (95% CI)	P value
All activities	Period 2 vs period 1	1.04 (0.93 to 1.17)	0.4394
	Period 3 vs period 2	0.89 (0.80 to 0.99)	0.0323§
	Period 3 vs period 1	0.93 (0.83 to 1.04)	0.2238
	2006–2019	0.99 (0.98 to 1.00)	0.0373§
Land motor sports	Period 2 vs period 1	1.11 (0.92 to 1.34)	0.2583
	Period 3 vs period 2	1.05 (0.89 to 1.24)	0.5652
	Period 3 vs period 1	1.17 (0.97 to 1.40)	0.0956
	2006–2019	1.01 (0.99 to 1.03)	0.3090
Aerial activities	Period 2 vs period 1	1.41 (0.52 to 3.81)	0.4997
	Period 3 vs period 2	0.70 (0.28 to 1.75)	0.4494
	Period 3 vs period 1	0.99 (0.34 to 2.86)	0.9869
	2006–2019	1.01 (0.91 to 1.11)	0.8677
Swimming and underwater activities	Period 2 vs period 1	1.14 (0.84 to 1.53)	0.3978
	Period 3 vs period 2	1.11 (0.86 to 1.44)	0.4245
	Period 3 vs period 1	1.26 (0.95 to 1.69)	0.1139
	2006–2019	1.02 (1.00 to 1.05)	0.1020
Cycling	Period 2 vs period 1	1.16 (0.87 to 1.54)	0.3140
	Period 3 vs period 2	0.62 (0.46 to 0.82)	0.0010§
	Period 3 vs period 1	0.72 (0.52 to 0.98)	0.0369§
	2006–2019	0.96 (0.93 to 0.99)	0.0073§
Navigation	Period 2 vs period 1	0.90 (0.68 to 1.19)	0.4670
	Period 3 vs period 2	0.69 (0.51 to 0.92)	0.0128§
	Period 3 vs period 1	0.62 (0.46 to 0.84)	0.0021§
	2006–2019	0.96 (0.93 to 0.98)	0.0028§
Hiking and taking a walk or snowshoeing	Period 2 vs period 1	0.95 (0.45 to 1.97)	0.8810
	Period 3 vs period 2	1.09 (0.56 to 2.13)	0.8052
	Period 3 vs period 1	1.03 (0.50 to 2.10)	0.9368
	2006–2019	0.97 (0.90 to 1.04)	0.3972
Hunting and gun shooting	Period 2 vs period 1	0.34 (0.14 to 0.82)	0.0161§
	Period 3 vs period 2	1.80 (0.72 to 4.50)	0.2113
	Period 3 vs period 1	0.60 (0.29 to 1.26)	0.1769
	2006–2019	0.94 (0.87 to 1.02)	0.1676
Alpine skiing and snowboarding	Period 2 vs period 1	1.08 (0.48 to 2.42)	0.8602
	Period 3 vs period 2	0.48 (0.20 to 1.20)	0.1167
	Period 3 vs period 1	0.52 (0.20 to 1.37)	0.1850
	2006–2019	0.96 (0.88 to 1.05)	0.4130
Fishing (not from a boat)	Period 2 vs period 1	0.95 (0.45 to 1.97)	0.8810
	Period 3 vs period 2	0.60 (0.27 to 1.33)	0.2121
	Period 3 vs period 1	0.57 (0.25 to 1.30)	0.1839
	2006–2019	0.95 (0.88 to 1.03)	0.2137
Other activities	Period 2 vs period 1	0.91 (0.51 to 1.60)	0.7391
	Period 3 vs period 2	0.78 (0.44 to 1.39)	0.4006
	Period 3 vs period 1	0.71 (0.39 to 1.29)	0.2608
	2006–2019	0.95 (0.90 to 1.01)	0.0888

*Population-based rates.
†For each category listed: the first three IRRs reflect the average change in incident rates between periods and the p values test the null hypothesis of no difference between IRRs between periods. The last IRR reflects the average annual change in incidence rates between consecutive years and the p value tests the null hypothesis of no linear trend in the incidence rate during the study period.
‡Categories with less than 5 deaths within a given time period were not reported in this table.
§P<0.05.
IRRs, incidence rate ratios.

detected some cases, particularly for certain emerging activities. Another limitation is that some of the subscription service's investigation reports may have been lost. But the added value of this data source is low since 207 of its 240 single-instance cases were excluded from the study. While the methodology of the ÉBARS was designed for the sample to be as representative as possible of the population, certain limitations of the study such as low response rates (57.1 and 36.5%, respectively, in 2009–2010 and 2015–2016) may have impacted the representativeness of the sample. Other limitations are that participation data do not consider frequency of exposure and that some activities, age groups and populations were not included in the ÉBARS surveys, which hampered the results based on participation data. The approach of aligning each analysed period with a particular ÉBARS edition to compensate for missing years of participation data might also have influenced the accuracy of the participation-based rates.[4] Despite these limitations, the ÉBARS data on sport and recreation participation are the most comprehensive available for the analysed period and exhibit comparability between editions. These limitations did lead us, however, to using two different denominators, which is a strength of the study.[28] Moreover, the data-entry process, scrupulously conducted in accordance with the at-risk population in the ÉBARS, resulted in accurate and congruent numerator values for participation-based rates.

The specific characteristics associated with the fatalities that occurred in activities associated with higher death frequency, and the factors related to drowning deaths, will be further developed in another paper. Coronial recommendations and natural deaths associated with sport and recreation will also be subject to further investigation.

CONCLUSION

This study examined trends in the frequencies and rates of deaths associated with unintentional injuries in sport and recreation in Québec for the period running from January 2006 to December 2019. The death rates in non-motorised navigation and cycling declined during the period.

Deaths related to six activities accounted for more than 80% of Québec's total burden, and drowning was documented as a cause of death in 39.3% of all fatalities. The characteristic of these deaths will be investigated as a prerequisite to implementing and assessing preventive measures.[9 10] This surveillance study will inform all stages of a global approach to injury prevention.[9 10]

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ORCID iDs
Philippe Richard http://orcid.org/0000-0001-8595-154X
Claude Goulet http://orcid.org/0000-0002-2320-4845

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