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Mitigating unintentional injury deaths in sport and recreation: insights from 14 years of coroner recommendations in Québec, Canada

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ABSTRACT

Background Unintentional injury deaths in sport and recreation represent a significant public health concern. This study analysed coronial recommendations related to such deaths, focusing on case specifics and recurring themes from January 2006 to December 2019.

Methods This mixed-methods study used data from the Bureau du coroner du Québec. Reports with recommendations were analysed by sex, age group, context, mechanism and activity. A four-phase thematic analysis was conducted to emphasise the developed themes and connect them with the existing literature.

Results Of 1937 coronial reports reviewed, 13.3% (n=258) contained at least one recommendation, totalling 609 recommendations (31 per 100 activity-related deaths). Reports were more likely to contain at least one recommendation for women (20.3%, p=0.0004), paediatric populations (≤5 years: 30.3%, p<0.0001; 6–11 years: 29.3%, p=0.0003; 12–17 years: 27.6%, p<0.0001), and organised events (55.0%, p<0.0001), despite most deaths occurring among men, adults and during unstructured events. All-terrain vehicle and snowmobile activities showed significantly lower rates of reports with recommendations (8.1%, p=0.0008 and 8.6%, p=0.0044, respectively). Most frequently addressed themes were *Development, inspection and modification of bicycle infrastructure* for cycling and *Lake and river safety measures* for swimming. *Conflict with other types of users* was the top theme for land motorsports, while *Personal flotation device use* was the most common for navigation activities.

Conclusions Patterns from reports with recommendations will be shared with the Bureau du Coroner du Québec to improve coronial practices. Integrating recurrent themes and recommendations with activity-specific risk factors will help identify critical patterns and inform preventive measures holistically.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Unintentional injury deaths related to sport and recreation in Québec averaged 2.7 per week over a 14-year period. While surveillance studies provide valuable trend data, burden assessments and insights into key risk factors, it is important to also investigate patterns of coronial recommendations and their recurrent themes to effectively enhance prevention and guide future measures.

WHAT THIS STUDY ADDS

⇒ A significantly higher percentage of reports containing coronial recommendations was found for women, children and organised events, despite most deaths involving men, adults and unstructured events. Conversely, all-terrain vehicle and snowmobile activities, which cause the most deaths, had the lowest rates of reports with recommendations.

⇒ Coroners frequently addressed themes such as improving bicycle infrastructure and enhancing lake and river safety for swimmers. For land motorsports, the main focus was on preventing conflicts with other users, while for navigation activities, promoting the use of personal flotation devices was most common.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The patterns identified in reports with recommendations will be shared with the Bureau du Coroner du Québec to inform and potentially enhance coronial practices and policies.

⇒ The highlighted themes and corresponding recommendations will guide the selection and implementation of preventive measures, integrating data on activity-specific risk factors.

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INTRODUCTION

The role of coroners in injury prevention varies significantly across jurisdictions. In Canada, death investigations are conducted at the provincial and territorial levels through either a Coroner's or Medical Examiner's system. These systems aim to identify the deceased, determine the cause and manner of death, and, where appropriate, provide recommendations to prevent future fatalities.[1] While coroners and medical examiners investigate approximately 15%–20% of all deaths in Canada, the criteria for reporting and investigating deaths differ between provinces and territories.[2] The proportion of cases leading to injury prevention recommendations is relatively low, ranging from 0.1% to 10.2% across regions, with a national average of only 1% of investigated deaths resulting in such recommendations.[1] In comparison, in Australia, 1.6% of injury-related deaths among nursing home residents,[3] and 13.2% of sport and recreation-related exertional heat deaths led to recommendations.[4] In the state of Victoria, 6% of

external-cause deaths resulted in recommendations,[5] and the same rate was observed for heavy vehicle crashes.[6]

A cross-sectional study revealed 1937 unintentional injury deaths related to sport and recreation in the province of Québec, Canada, from January 2006 to December 2019.[7] Notably, six activities accounted for 80% of the fatalities and were linked to the highest population-based and participation-based death rates.[7 8] This observation aligns with the Pareto Principle, highlighting the concentrated impact of a few activities on the total burden.[7]

Exploring related coronial recommendations from death investigation reports is crucial in enhancing their role in preventing injuries and identifying priority areas for action.[5 9 10] Under the *Coroners Act* (CQLR, chapter C-68.01, section 3), coroners in Québec have the legal authority to issue official recommendations: 'If pertinent, the coroner may also, at an investigation or an inquest, make any recommendation directed towards better protection of human life'.[7 10–12] These recommendations are pivotal, but they appear in only about 4%–7% of all coronial reports in Québec (across all causes of mortality). They can serve as valuable templates for measures aimed at preventing similar deaths.[1 10]

Since 2022, recipients of recommendations must inform the Québec Chief Coroner of the intended corrective measures,[11] but they are not legally obligated to implement them. This is similar to the situation in Australia, where despite mandatory responses to coronial recommendations, implementation was not guaranteed.[13] In this context, conducting a thematic analysis of clustered recommendations can help highlight recurring themes as well as their scientific significance,[14 15] thereby potentially optimising coroners' contributions to preventing deaths.[5 15]

Therefore, this study explored coronial recommendations related to unintentional injury deaths associated with sport and recreation in Québec, for the January 2006 to December 2019 period. It (1) first examined the demographic and contextual specifics of cases associated with coronial recommendations and (2) second analysed the most recurrent themes addressed by coroners for the six activities with the highest death frequencies.

METHODS

Design and data source

Building on previous research,[7] this descriptive retrospective study used data from the Bureau du coroner du Québec's computerised database (CD-BCQ). It focused on sport and recreation-related cases from January 2006 to December 2019, which were identified using ICD-10 codes (range of ICD-10 codes included in the study after data processing: V10–X36), preselected keywords and cases subjectively coded as sport or recreation by the BCQ.[7] A meticulous screening procedure, described in the data flow diagram of a previous study, was conducted, providing a detailed account of all inclusion and exclusion criteria.[7] A dual data entry process was applied to all fatalities, capturing factors including the activity associated with each death as well as contextual specifics.[7] General information related to the 1937 unintentional injury deaths associated with sport and recreation was extracted from the CD-BCQ: age at death, sex, year of death and presence (n≥1) of a recommendation. In Québec, all trauma-related deaths must be reported to and investigated by a coroner.[5] On average, a coroner takes 9 months to complete a case. As of data extraction, 96.2% of coroner investigations for 2019 were completed, while the period from 2006 to 2018 was fully closed (100%).[7 10] This study specifically analysed the 258 cases that included one or more recommendations, as verified in the Recommendations section of each report. As stipulated in the *Coroners Act* (CQLR, chapter C-68.01), coroners' reports are public records.[7 10 11 16] Operational approval to use and publish data for research purposes was obtained from the BCQ in January 2022, and a collaboration model was developed to improve data access, share expertise and ensure accurate interpretation.

Data processing

A recommendation was defined as a formal textual statement, within the Recommendations section of the investigation report, that comprised warning, advice, caution, alert or a suggested action aimed at preventing future fatalities.[5 10] The term 'recommendations' was similarly used in studies analysing coroners' data related to recommendations.[3 5 10 13 15] All recommendations (n=609) were extracted from the 258 investigation reports and were logged in Microsoft Excel and Microsoft Word.

The analysis of recommendation-related themes focused on the six activities with the highest frequencies of death, as described in previous investigations[7 8]: all-terrain vehicles (ATVs), snowmobiles, swimming, cycling, motorised navigation (eg, motorised rowboats, motorised canoes and speedboats), and non-motorised navigation (eg, paddle-powered kayaks and canoes).[7 8] These activities collectively accounted for 80% of all deaths over the 14-year period analysed.[7 8] The study employed a mixed-methods approach. The qualitative analysis followed a four-phase model (initialisation, construction, rectification and finalisation),[14] while the quantitative analysis involved descriptive statistics (n and %) related to the developed themes. This mixed-methods approach was previously used to examine themes associated with natural deaths in sport and recreation in Québec.[10] During the initialisation phase, PR and MG independently read all recommendations at least three times, taking notes and identifying recurring themes and abstractions using a colour-based conceptual coding system. The investigators collectively performed a pilot analysis of the first two recommendations per activity (n=12), based on the lowest BCQ file numbers (not chosen deliberately or randomly), to ensure a shared understanding of the procedure.[10] In the construction phase, clusters of analogous codes were compared and refined by each investigator independently. Meaningful sentences were used to label each cluster, adhering to the principle of mutual exclusiveness.[14] The rectification phase involved individual revision and testing of themes in relation to one another and to the initial recommendations. For each activity, a meeting was conducted to compare themes and interpretations, discuss similarities and discrepancies and explore connections and relationships with the study topic. A third investigator and trauma expert from the BCQ (PAP) was available to address any persistent discrepancies, but none arose. During the finalisation phase of the thematic analysis, to ensure a comprehensive view of the studied themes, a common matrix was developed based on a shared understanding and consistent terminology. This matrix was validated by the trauma expert (PAP). Based on the validated matrix, PR and MG independently quantified the themes (presence or absence) for each recommendation. Discrepancies were discussed until consensus was reached, and the level of agreement was recorded.

Agreement levels were reported using prevalence-adjusted bias-adjusted kappa (PABAK) coefficients.[10] PABAK coefficients were preferred over unadjusted kappa coefficients to assess inter-rater reliability due to the highly imbalanced distribution of the two classes ('Presence' and 'Absence') used by the raters:

Table 1 Frequency and rate of reports containing at least one recommendation (n=258) for unintentional injury deaths associated with sport and recreation, by sex, age group, context, mechanism (drowning) and activity in Québec, Canada, from 1 January 2006 to 31 December 2019 (inclusive)

	No recommendation (%)	Recommendation (%)	Total (%)	P value*	Percentage of reports containing at least one recommendation†
Sex					
Female	204 (12.2)	52 (20.2)	256 (13.2)	0.0004‡	20.3
Male	1475 (87.8)	206 (79.8)	1681 (86.8)		12.3
Age group (years)					
≤5	53 (3.2)	23 (8.9)	76 (3.9)	<0.0001‡	30.3
6–11	41 (2.4)	17 (6.6)	58 (3.0)	0.0003‡	29.3
12–17	92 (5.5)	35 (13.6)	127 (6.6)	<0.0001‡	27.6
18–24	209 (12.4)	32 (12.4)	241 (12.4)	0.9838	13.3
25–34	223 (13.3)	29 (11.2)	252 (13.0)	0.3642	11.5
35–44	224 (13.3)	35 (13.6)	259 (13.4)	0.9214	13.5
45–54	262 (15.6)	30 (11.6)	292 (15.1)	0.0965	10.3
55–64	264 (15.7)	30 (11.6)	294 (15.2)	0.0878	10.2
≥ 65	311 (18.5)	27 (10.5)	338 (17.4)	0.0015‡	8.0
Organised competition or event					
Yes	9 (0.5)	11 (4.3)	20 (1.0)	<0.0001‡	55.0
No	1670 (99.5)	247 (95.7)	1917 (99.0)		12.9
Drowning					
Yes	650 (38.7)	111 (43.0)	761 (39.3)	0.1870	14.6
No	1029 (61.3)	147 (57.0)	1176 (60.7)		12.5
Activity					
Cycling	220 (13.1)	54 (20.9)	274 (14.1)	0.0008‡	19.7
Swimming	236 (14.1)	50 (19.4)	286 (14.8)	0.0248‡	17.5
All-terrain vehicles	352 (21)	31 (12.0)	383 (19.8)	0.0008‡	8.1
Snowmobile	318 (18.9)	30 (11.6)	348 (18.0)	0.0044‡	8.6
Motorised navigation	137 (8.2)	14 (5.4)	151 (7.8)	0.1274	9.3
Non-motorised navigation	100 (6.0)	11 (4.3)	111 (5.7)	0.2762	9.9
Other activities	316 (18.8)	68 (26.4)	384 (19.8)	0.0047‡	17.7
Total	1679 (100)	258 (100)	1937 (100)		13.3

Values are numbers (%).
*χ^2 tests were conducted between the recommendation and non-recommendation groups for all categorical variables except for context (organised competition or event), which necessitated a Fisher exact test due to the low frequency of deaths and recommendations for this variable. The global test P values are as follows: sex (0.0004), age group (<0.0001), context (<0.0001), drowning (0.1870) and activity (<0.0001).
†The 'Percentage of reports containing at least one recommendation' is based on the number of reports containing recommendations for a subgroup (numerator) out of the total number of coronial reports associated with that subgroup (denominator). For example, for individuals≤5 years, there were 23 reports containing recommendations out of a total of 76 coronial reports associated with this age group, yielding a 'Percentage of reports containing at least one recommendation' of 30.3%. This proportion is significantly different from that of all other age groups combined, namely, the>5 years age group (p<0.0001).
‡p<0.05.

the maximum absolute value of the prevalence index is 0.97 for the themes.[17]

Data analysis

Rates were calculated using annual population data from the census as well as intercensal estimates. These estimates, as of 1 July of each year and broken down by age and sex, were provided by the Institut de la statistique du Québec.[7 8 10 16] These rates, presented per 100 000 person-years, reflect the annual number of reports containing at least one coronial recommendation relative to the corresponding year's population. High concordance was observed between crude and age (≤17, 18–44, 45–64, ≥65 years) and sex-adjusted annual incidence rates.[7 8] Consequently, only crude rates are presented.[7 10 16 18] CIs were computed at a 95% significance level using the Gamma distribution method.[19] Poisson regression was used to examine changes in recommendation rates over the 14-year period, using incidence rate ratios (IRRs). These models were fitted using the SAS GENMOD procedure, with a log link function and the logarithm of the population as an offset. Annual rate variations between consecutive years were assessed using linear trend analysis, with a significance level of 0.05.[18]

The frequency of recommendations was determined for individual activities and for all activities grouped together using descriptive statistics.[3 5 15] Activities with less than 10 reports containing at least one recommendation were classified as 'other activities'. Significant differences between the recommendation and non-recommendation groups were analysed using χ^2 tests. To control for the overall type 1 error rate, global tests were performed for each variable.[5] If the test resulted in a statistically significant outcome, comparisons were made among the various modalities of the respective variables within their groups (eg, ≤5 years old vs all other age groups combined).[15] The analysis used SAS software (2019–2020, SAS Institute, Cary, North Carolina).

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research. This

Table 2 Number of recommendations (n=609) and average number per 100 activity-related unintentional injury deaths associated with sport and recreation, in Québec, Canada, from 1 January 2006 to 31 December 2019 (inclusive)

Activity related to the death	Number of recommendations (%)	Average number of recommendations per 100 activity-related deaths
Cycling	127 (20.9)	46
Swimming	160 (26.3)	56
All-terrain vehicles	73 (12)	19
Snowmobile	49 (8)	14
Motorised navigation	25 (4.1)	17
Non-motorised navigation	26 (4.3)	23
Other activities	149 (24.5)	39
Total	**609 (100)**	**31**

Values are numbers (%).
Example of calculation for the average number of recommendations per 100 activity-related deaths: (609 recommendations / 1937 deaths) * 100=31.

research project used coronial reports related to death in sport and recreation, and as such, direct involvement from patients or the public was not feasible or appropriate.[7 8 10 16]

RESULTS

Frequency and rate of coroners' recommendations

Over the 14-year study period, at least one formal recommendation was present in 13.3% (n=258, 18.4 reports per year) of the 1937 coronial reports related to unintentional injury deaths in sport and recreation, yielding a population-based rate of 0.23 per 100 000 person-years (95% CI 0.20 to 0.26; coefficient of variation: 6.2%). A significant average yearly decrease in the population-based recommendation rates (IRR 0.92; 95% CI 0.89 to 0.95; p<0.0001) was observed over the 14-year period. Table 1 provides a descriptive statistical overview of the frequency and proportion of cases with coroners' recommendations compared with those without, categorised by sex, age group, context, mechanism, and activity practised.

While men represented 86.8% of all deaths, the percentage of reports containing at least one recommendation was significantly (p=0.0004) higher in women (20.3%) than men (12.3%). Among all age groups, individuals aged ≤17 years (n=261, representing 13.5% of all deaths) had significantly higher rates of recommendations (≤5 years: 30.3%, p<0.0001; 6–11 years: 29.3%, p=0.0003; 12–17 years: 27.6%, p<0.0001). Most deaths occurred in individuals aged ≥18 years (86.5%, n=1676), with an average recommendation rate of 10.9%. Individuals aged ≥65 years displayed a significantly (p=0.0015) lower rate of recommendation (8.0%). Despite accounting for only 1% of all deaths (n = 20), fatalities occurring during an organized competition or event had a significantly (p<0.0001) higher rate of reports with recommendations (55.0%) compared to fatalities that occurred outside such events (12.9%). The two activities associated with the highest number of deaths (ATV: 19.8%, n=383; and snowmobile: 18.0%, n=348), displayed significantly lower rates of reports with recommendations (8.1%, p=0.0008; and 8.6%, p=0.0044, respectively).

There was a total of 609 recommendations, resulting in an average of 31 recommendations per 100 activity-related deaths (table 2). Activities involving ATVs and snowmobiles represented two of the three activities with the lowest average number of recommendations per 100 activity-related deaths (19 and 14, respectively).

Thematic analysis of coroners' recommendations

The thematic analysis revealed a total of 62 different themes addressed by coroners for the six activities with the highest death frequencies. Inter-rater reliability (excluding the 12 collectively analysed recommendations) and the three most common themes for each activity are presented in table 3.

The themes *Development, inspection and modification of bicycle infrastructure* (cycling, n=52) and *Lake and river safety measures: access, signs, infrastructure* (swimming, n=42) were the most frequently addressed in coronial recommendations, representing 8.9% and 7.2% of all occurrences, respectively. Notably, within the theme of *Lake and river safety measures*, coroners suggested signage strategies either as the sole or main measure (n=11) or as part of an integrated approach (n=13) in most of the recommendations (57.1%, n=24) (data not shown). *Conflict with other types of users* was the most recurring theme for ATV and snowmobile activities combined (n=27), with snowmobile-related coronial recommendations specifically focusing on intersection safety (n=13, data not shown). *Age restriction and skills required for safe ATV operation* (n=14) and *Regulation control and coercive measures* (n=14) were also predominantly addressed by coroners in relation to ATV activities. *Personal flotation device (PFD) use* was the most common theme for motorised and non-motorised navigation activities combined (n=16).

DISCUSSION

This study comprehensively investigated coronial recommendations related to unintentional injury deaths associated with sport and recreation. It involved analysing demographic and contextual specifics of cases and identifying recurring themes.

Frequency and rate of coroners' recommendations

Coroners' recommendations were noted in 13.3% of investigation reports, a percentage that slightly exceeds that for natural deaths in sport and recreation (8.8%) and exceeds the broader range of 4%–7% for all cases in the province.[1 10] The rate observed in our study is higher than those in the state of Victoria, where recommendations were made in 6% of both external-cause deaths[5] and heavy vehicle crashes[6] as well as higher than the 1.6% rate for injury-related deaths among nursing home residents nationwide in Australia.[3] However, it is comparable to the rate for sport and recreation-related exertional heat deaths in Australia (13.2%).[4] These findings suggest that coroners are inclined to provide formal recommendations to prevent deaths in sport and recreation, indicating their belief in the potential impact of such measures. Conversely, the rates of reports containing recommendations significantly declined over the 14-year period, while a previous study found that death rates remained relatively stable.[7] A similar trend was observed for natural deaths in sport and recreation in Québec, where death rates remained unchanged over the years, despite a significant decline in the proportion of reports containing recommendations.[10 16] Given that there were no changes in legislation or policy during the analysed period that could have impacted the recommendation rate in Québec, this may indicate a concerning trend where coroners reduced preventive recommendations despite ongoing needs for prevention.

The significantly higher percentage of reports containing at least one recommendation for females, paediatric populations, and organised events is noteworthy, especially given that males, adults, and unstructured events represent a striking majority of deaths. Similarly, ATV and snowmobile activities, which

Table 3 Frequency and proportion of primary themes (n=62) covered in coroner's recommendations for unintentional injury deaths associated with sport and recreation, by activity and for all recommendations in Québec, Canada, from 1 January 2006 to 31 December 2019 (inclusive)

	Priority theme #1		Priority theme #2		Priority theme #3		Total	
Activity	Number*	(%)†	Number*	(%)†	Number*	(%)†	Number‡	PABAK mean (min–max)§
Swimming	Lake and river safety measures: access, signs and infrastructure		Lifeguards' availability, qualification and working conditions		Supervision provided by non-lifeguard personnel		12 themes	
	42	(21.2)	30	(15.2)	27	(13.6)	198	0.94 (0.86–1)
Bicycle	Development, inspection and modification of bicycle infrastructure		Helmet use		Safety around heavy vehicles		12 themes	
	52	(33.1)	18	(11.5)	18	(11.5)	157	0.97 (0.86–1)
All-terrain vehicle	Conflict with other types of users (mostly on public roads)		Age restriction and skills required for safe ATV operation		Regulation, control and coercive measures		13 themes	
	14	(12.5)	14	(12.5)	14	(12.5)	112	0.93 (0.77–1)
Snowmobile	Conflict with other types of users (mostly at intersections)		Trails inspection and modification		Prevention of alcohol-impaired driving		12 themes	
	13	(22.4)	12	(20.7)	6	(10.3)	58	0.95 (0.79–1)
Motorised navigation	Personal flotation device use		General promotion of safe practices		Environmental modification and signs		8 themes	
	9	(29.0)	6	(19.4)	5	(16.1)	31	0.97 (0.83–1)
Non-motorised navigation	Emergency response and rescue		Personal flotation device use		Hazard and difficulty level signs		5 themes	
	11	(36.7)	7	(23.3)	5	(16.7)	30	0.98 (0.92–1)
Six activities							62 themes	
							586	0.95 (0.77–1)

*Number of recommendations regarding a specific theme. One recommendation may be included in more than one theme.
†Proportion of a specific theme among all themes framed for the activity.
‡Number of occurrences of themes for the activity.
§Prevalence-adjusted bias-adjusted kappa. One PABAK was calculated for each of the 62 themes.
PABAK, prevalence-adjusted bias-adjusted kappa.

accounted for the highest frequency of deaths,[7] exhibited the lowest proportion of reports containing recommendations. The emotionally charged nature of child fatalities was hypothesised to account for similar findings, as coroners were more prompt to formulate recommendations for this population.[5 10] Increased media attention surrounding organised events and child fatalities may similarly play a significant role.[5 10] It could also be suggested that the repetitive patterns of deaths in motorised sports, often linked to risk-taking behaviour, exacerbated by impaired driving and predominantly involving men,[20 21] may discourage coroners from making recommendations that have already been addressed. Additionally, it is possible that female deaths, whether due to their relative rarity, received increased attention, as media coverage may emphasise incidents involving women, prompting coroners to focus on preventive measures shaped by societal perceptions and gender-specific risks.[22] Collectively, these results suggest that coroners' recommendations may not be optimally targeting the most at-risk populations. It could be hypothesised that if coroners' recommendations, intended to provide effective guidelines for preventing deaths, are more closely aligned with the burden of mortality, then the potential for a measurable reduction in fatalities would increase.

Thematic analysis of coroners' recommendations

Swimming

The theme of *Lake and river safety measures: access, signs, infrastructure* was the second most recurrent theme addressed by coroners across all activities. Despite the intuitive nature of signage strategies frequently suggested by coroners within this theme, evidence supporting their effectiveness in preventing drowning is lacking.[15 23] Studies have shown that signage is often overlooked[24] and that there are low levels of compliance with safety signage in various settings.[25–28] Signage alone may not be sufficient as a drowning prevention strategy,[15 23] and, therefore, coroners' recommendations focusing solely or mainly on this preventive approach are unlikely to have a significant impact.

Cycling

The theme of *Development, inspection and modification of bicycle infrastructure* emerged as the most prevalent, considering all activities. Most of the related recommendations were associated with cases where a cyclist was struck by a motorised vehicle. Developing dedicated bicycle infrastructure is likely the most effective long-term strategy for preventing deaths. While it is important to recognise the progress made in Québec, the province could benefit from further enhancements to separate cyclists from motorised vehicles more effectively. Various preventive measures have been considered to enhance cyclist safety on shared roads, including promoting bicycle helmet use through legislation and advertising campaigns, improving cyclist visibility, and adapting environmental and infrastructure elements.[29–34] Notably, separate bicycle infrastructures, such as cycling lanes and paths, represent a highly promising strategy, as they have been shown to increase both cycling participation and safety.[31]

Snowmobiles and ATVs

Conflict with other types of users was the most recurring theme for land motor sports, with intersections identified as critical areas for preventive intervention in snowmobile activities. A Canadian study revealed that 11.8% of snowmobile crashes resulting in

fatalities or serious injuries occurred on public roads.[35] Additionally, a Northern Swedish investigation showed that 17% of snowmobile crash fatalities occurred on roads,[36] with many riders injured while crossing roads without noticing oncoming vehicles. These numbers shine a light on the ongoing need to address safety concerns at intersections. Similarly, a Canadian study indicated that 16.6% of ATV crashes resulting in fatalities or serious injuries occurred on public roads.[35] In Québec, the *Act respecting off-highway vehicles* (CQLR, chapter V-1.3) prohibits off-road vehicles on public roads, with certain specified exceptions, highlighting the importance of ensuring both the safety of road sections typically shared by off-road vehicles and compliance with the law by ATV users. The coronial recommendations regarding non-compliance with age restrictions and the skills required for safe ATV operation further underscore the challenges in adhering to the Act. These data emphasise the need for a proactive approach to enforcement and regulatory interventions. Given these persistent issues, it is not surprising that coroners frequently focused on the theme of *Regulation control and coercive measures*.

Motorised and non-motorised navigation

PFD use emerged as the most common theme in coroners' recommendations for navigation activities combined. This is unsurprising given that Canadian law mandates only that each person must have a PFD on board, rather than requiring them to wear it, despite the critical importance of wearing PFDs for their preventive potential.[15] Compulsory PFD wearing regulations in Victoria, Australia, have been associated with increased PFD usage and reduced recreational boating drowning deaths.[37] This provides compelling evidence supporting the adoption of similar regulatory measures in other jurisdictions to prevent fatalities. Complementing such legislation with vigilant enforcement as part of a comprehensive approach could be especially impactful.[21 38] Moreover, the frequent focus of coroners on *Effective emergency response and rescue* underscores a complementary preventive priority that could significantly enhance the likelihood of survival in drowning situations,[39] especially since submersion durations of less than 5 min are associated with favourable outcomes, while durations exceeding 25 min are invariably fatal.[40]

Strengths, limitations and perspectives

Strengths include the rigour of the data collection and the broad timeframe analysed.[7 8 10 16] The subjective nature of BCQ case coding and the involvement of multiple investigators in data processing, though representing limitations, are essential to shaping the definition of sport and recreation-related deaths in this study. These aspects enrich the detail and depth of the information, offering a unique and comprehensive perspective on deaths associated with sport and recreation.[7 8 10 16] Univariate analyses were conducted to identify characteristics associated with coroners' recommendations. However, the use of multivariate analyses would have allowed to control for potential confounding biases. Besides, while the flexibility of thematic analysis is advantageous, it can lead to varying interpretations of the same dataset.[14] Nevertheless, the methodology was meticulously followed by two investigators, with a third validating the content and interpretations.[14]

CONCLUSION

This study identified discrepancies where recommendation rates did not align with the frequency of deaths across various factors, including sex, age, context and activity. Key themes addressed by coroners included the need for improved cycling infrastructure and enhanced safety measures for swimming in lakes and rivers. To effectively inform and prioritise prevention strategies, it is crucial to consider this information alongside data from investigations into activity-specific risk factors.

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Contributors PR planned the study, managed the project and was responsible for the conceptual framework. All authors contributed to the study's conception and design. MC and PR collected the data. PR and MG analysed the themes of the recommendations. P-AP validated the results and interpretations. JS-M, PR and MG planned, conducted and revised the statistical analysis and interpreted the results. PR drafted the manuscript. All authors critically revised and edited the manuscript. PR submitted the study and is the guarantor. Declaration of Generative AI and AI-assisted technologies in the writing process. During the preparation of this work, the authors used OpenAI's ChatGP to correct and enhance the text for improved language quality. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication. The text was subsequently revised by the linguistic services of the Ministère de l'Éducation du Québec.

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