

Characterising firearm-related databases across Canada: opportunities for data linkage to inform understanding of injury burden and prevention

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Abstract

Introduction

Firearm injuries are a significant public health issue in Canada, yet the broader consequences, particularly non-fatal injuries, remain under examined in research and policy discussions. These injuries impose long-term physical, psychological, and social burdens on survivors and create substantial economic costs. While firearm-related injury data are collected across health, justice, and policing sectors, the lack of integration between these datasets hampers a comprehensive understanding of the issue.

Objectives

This study aims to explore opportunities for linking national, provincial, and municipal datasets on firearm-related injuries in Canada, focusing on data from healthcare, legal, and firearm-specific domains.

Methods

A comprehensive search for publications related to firearms of Medline, Scopus, and Web of Science and grey literature up to February 2025 identified several relevant datasets, including health records, death registries, and crime databases.

Results

We found that while valuable information exists, the datasets are siloed, limiting the ability to analyse firearm injuries holistically. Gaps in data, such as the psychological impact of firearm injuries and specific details on firearm ownership, further constrain research. Despite these challenges, linking healthcare, justice, and firearm data could offer critical insights into the epidemiology of firearm injuries, their long-term effects, and associated risk factors.

Conclusions

Overcoming operational constraints related to privacy, data quality, and funding will be essential for advancing this research and informing evidence-based interventions to reduce firearm-related harm. Drawing from successful data integration initiatives in other jurisdictions, such as Sweden and Australia, this study advocates for the development of a cross-sectoral data linkage strategy to enhance firearm injury prevention and policy development in Canada.

Keywords

Canada; health administrative databases; injury; firearms

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Introduction

Firearm injuries remain a significant and pervasive issue across Canada, presenting a major challenge for both public health and safety [1]. While public discourse and government reports often focus on firearm-related fatalities, the broader scope of firearm injuries, including non-fatal outcomes, has often been underappreciated. These injuries result in long-term physical, psychological, and social consequences for survivors, while also imposing substantial costs on communities and the healthcare system. The true burden of firearm injuries is often underestimated, compounded by the diverse impacts across legal, human, and healthcare sectors [2–7].

In Canada, firearm legislation is governed by the Firearms Act and the Criminal Code of Canada, with changes over time reflecting evolving gun control efforts [8]. Notably, Bill C-51 (1977) introduced Firearm Acquisition Certificates (FAC), requiring background checks for applicants, and reclassified fully automatic firearms as prohibited [8]. In 1995, Bill C-68 established national firearm licensing and registration for restricted and prohibited firearms [8]. However, Bill C-19 (2012) reversed the long-gun registry, removing registration requirements for non-restricted firearms. Bill C-42 (2015) further relaxed restrictions, allowing the transport of restricted firearms without prior authorisation [8]. Later, Bill C-71 (2018) reintroduced certain measures, including enhanced background checks and stricter verification of firearms transfers [8]. The most recent, Bill C-21 (2023), proposed a national handgun freeze and stricter regulations on firearm smuggling and ghost guns [8]. Despite these efforts to improve individual and public safety, progress is hindered by limited access to comprehensive data needed to inform and evaluate policy and legislative changes [9].

In the United States (US) in 2020, firearm injuries surpassed motor vehicle crashes as the leading cause of death for children and youth ages 1 to 18 [10, 11]. Worldwide, and especially in Canada, firearm-related injuries are becoming increasingly recognised as a major public health concern [9, 11]. However, research funding and prevention efforts for firearm injuries, particularly in relation to child health, have historically lagged behind other leading causes of death [12]. Globally, barriers to firearm research have included insufficient funding, stigma, and politicisation surrounding firearms, concerns about researcher safety and a lack of comprehensive data to evaluate policies and inform prevention strategies [13]. As an example, the 1996 Dickey Amendment, which prohibited federal funding for advocacy related to gun control, further restricted the ability of the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH) to fund firearm injury research [14, 15]. Although a compromise in 2018 clarified the CDC's authority to study the causes of gun violence, federal funding for gun violence research was reduced by approximately 96% between 1996 and 2013 [16]. The CDC and NIH have adopted a population health perspective to define, investigate, and implement prevention strategies for firearm injuries [9]. Despite this growing recognition of the injury burden, the debate surrounding firearms continues to be highly contentious and politicised, often impeding progress in public health initiatives and research [15, 17].

Currently, data on firearms and firearm-related injuries are collected across various sectors, including health, legal, and social services. However, these datasets are often siloed, limiting their potential for cross-sectoral analysis and a comprehensive understanding of the issue. There is growing recognition of the value of linked data in revealing insights into health status and injury outcome [9, 18]. Firearm-related injury research could greatly benefit from such integrated data [19, 20]. Although American and Canadian studies have made strides in linking data across health and socio-demographic domains, there remains a notable gap in integrating police, crime, and firearm licensing data [3, 5–7]. Addressing this gap is crucial for generating robust evidence to inform firearm policy. Furthermore, understanding the varied mechanisms of firearm-related injuries—ranging from homicides and assaults to unintentional and self-inflicted injuries—requires a comprehensive approach to data linkage. Such an approach would enable a more nuanced evaluation of the context and consequences of these injuries, ultimately supporting more effective prevention efforts [1].

In this study, we aim to explore opportunities for linking national, provincial, and municipal datasets related to firearm-related injuries in Canada. By examining sources from various sectors, including sociodemographic, health, justice, licensing, and manufacturing, we seek to identify opportunities to enhance data integration. This would provide a more detailed and comprehensive understanding of firearm-related injuries, to inform more effective policies and interventions.

Methods

Search strategy to identify relevant databases

We initially conceptualised key sectors related to firearms and firearm injury in Canada, including healthcare, justice, policing, and sociodemographic domains as possible sources of relevant data. This helped us to identify areas where data could provide understanding about the context of firearm injuries. We then conducted a search of Medline, Scopus, Web of Sciences, and grey literature including studies and reports from database inception to February 25, 2025, to identify Canadian datasets previously used in firearm-related research or reports. We conducted the search in English with the assistance of a librarian using terms related to, “firearm injury”, “firearm violence”, “firearm data”, and “Canada”. The full syntax for the search strategies is available in Supplementary Appendix 1. We included literature from all study designs and time periods, as long as the studies focused on firearms, firearm injury, related outcomes, and data sourced specifically from Canadian datasets. Results were imported into Covidence for screening. To supplement the peer-reviewed articles, we also performed a grey literature search to identify relevant reports published by governmental, police, and public health organisations in Canada. We conducted this search using both the Google search engine and by directly querying the websites of governmental, health, and police organisations. As a final step, we employed a snowball sampling technique, tracing references to additional datasets and reports cited in the initial publications.

Screening, database identification, and extraction

A single author manually screened titles and abstracts to identify potentially relevant studies and reports where Canadian databases related to firearms were employed. This author reviewed the identified relevant full-texts to find firearm-related datasets. Where there was uncertainty, a second reviewer reviewed for consensus. Data extraction by two authors included gathering key aspects of data coverage including 1) data elements with a detailed description of the variables and information available within the dataset, 2) jurisdictional coverage to identify the geographical scope of the data, including whether it covered national, provincial or municipal regions, 3) data custodians and, 4) available years. We then categorised the datasets according to the types of variables they contained. Datasets with similar variables or belonging to the same sector (e.g., healthcare, justice, police) were grouped and organised for further analysis and presentation. This classification aimed to provide a clear understanding of the landscape of available datasets, aiding in the identification of opportunities for data linkage and integration.

Finally, to visualise the extent and progression of firearms research from academic sources that utilised Canadian administrative datasets, we used the results from the Medline, Web of Science, and Scopus search from the first part of the study to quantify and plot the annual number of firearm-related academic studies over time.

Results

We identified a broad range of relevant data sources related to firearms and firearm injuries in Canada, encompassing health records, death registries, and police/crime databases. Specifically, we catalogued 20 health record data sources, 3 death registries, and 8 police/crime databases, each providing data on various aspects of firearm injuries, and another 11 open-source municipal police databases (Supplementary Appendix 2). These datasets include information on emergency department visits, hospitalisations, firearm-related deaths, and data from firearm registries, licensing authorities, and police. We also identified relevant sociodemographic data from 13 sources that could be valuable for future cross-sectoral linkage, offering important contextual information alongside firearm-specific data. Overall, we found that very few datasets were open source; most firearm specific data were only available upon request. Among the open-source datasets, most reported characteristics in aggregate form.

The academic databases search for published firearms related papers using Canadian databases yielded 1,030 unique results of which 154 were relevant, with the process of record and resource selection depicted in Figure 1. Figure 2 illustrates the trends in firearms research over time, based on Canadian administrative databases. These databases offer significant potential for future cross-sectoral linkage initiatives. The first study using Canadian administrative databases for firearms research was published in 1978, with two peaks since with

the greatest number of papers published ($n = 9$) in each of 1991 and 2022.

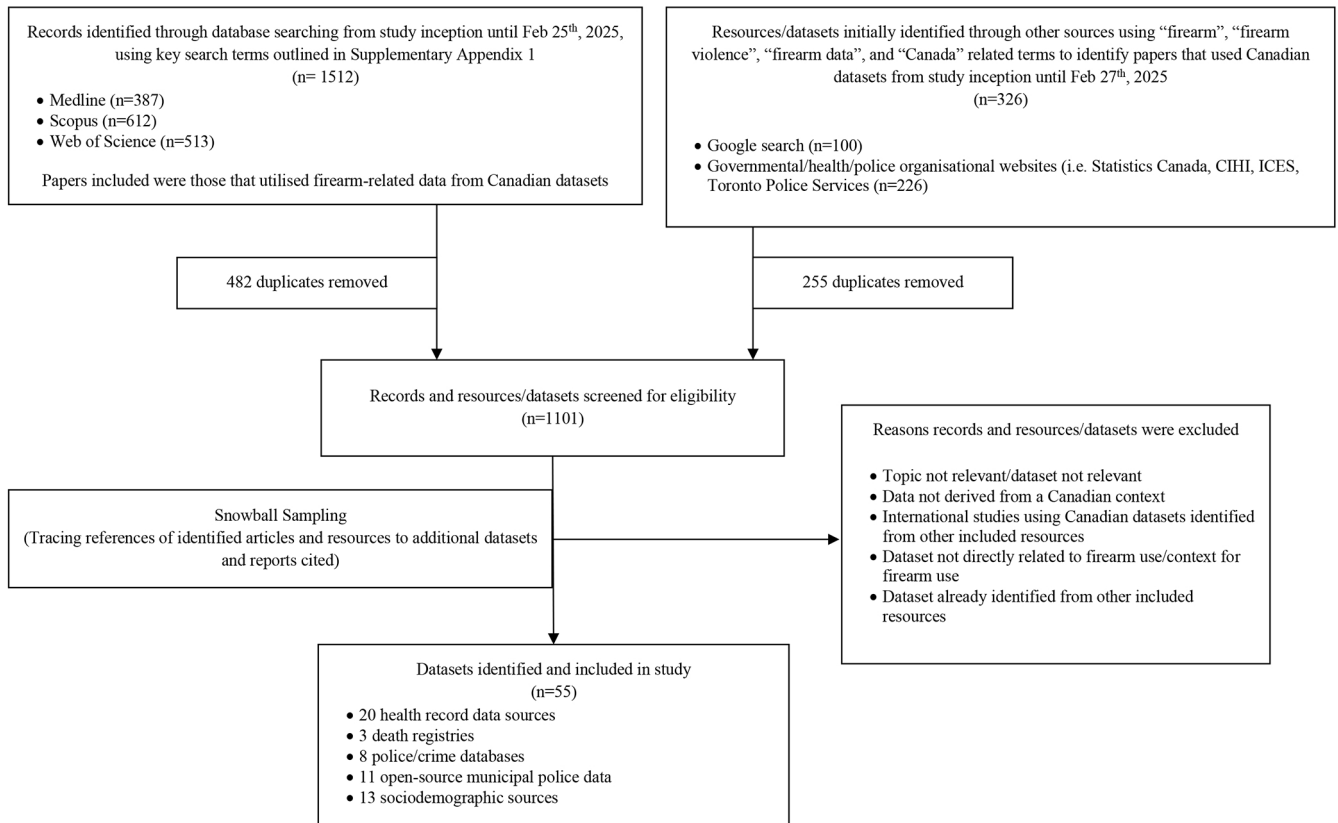
Healthcare data

Among the health data sources, we identified datasets detailing emergency department (ED) visits, hospitalisations, and in-hospital deaths due to firearm injuries. These datasets provided information on the nature of the injury, the intent (e.g., intentional, unintentional), the weapon type (e.g., rifle, handgun, bb gun), the affected body part, procedures performed, and subsequent healthcare interactions, including outpatient and mental health visits. Notably, the Canadian Hospitals Injury Reporting and Prevention Program offers data on external causes of injury and contributing factors [21], while healthcare interactions are further captured through medication dispensing and physician billing data in some provinces. Coverage for these datasets were national but reported at the provincial level. However, gaps exist in these data, including a lack of information on perpetrators, the specific types of weapons used, and the downstream impacts on families and communities. Additionally, variability in reporting practices across jurisdictions complicates data integration. For instance, the Canadian Institute of Health Information Discharge Abstract Database (DAD) provides pan-Canadian data (with some modifications for Quebec where data are appended to the DAD to create the Hospital Morbidity Database) on hospital discharges and the context surrounding hospital stays, but differences in reporting requirements by province can affect the data's completeness and accuracy [22, 23]. For example, the "Previous Psychiatric Admission" field is conditionally mandatory in New Brunswick while it is optional in all other provinces except Quebec, for which the field is non-applicable [23]. Similarly, the National Ambulatory Care Reporting System (NACRS) collects emergency department (ED) records with varying levels of detail, particularly for the external cause of injury (weapon type and injury intent) depending on jurisdictional reporting requirements [23]. This variability affects the granularity and completeness of the data reported. During the 2023-2024 reporting year, NACRS data covered 87% of Canadian EDs [24]. Linking multiple healthcare datasets and integrating them with justice data could help fill these gaps, providing a more comprehensive understanding of firearm-related injuries. For example, firearm licensing bodies place restrictions on those with prior mental illness or a history of violence, though these are self-reported measures in licence applications [25]. Linking population health data to firearm licence applications or removal orders can inform (at a population level) if self-report, if specific mental illness diagnoses, and whether short or long look-back periods for violence are effective measures ascertaining information for firearm-licensing background checks.

Death registry data

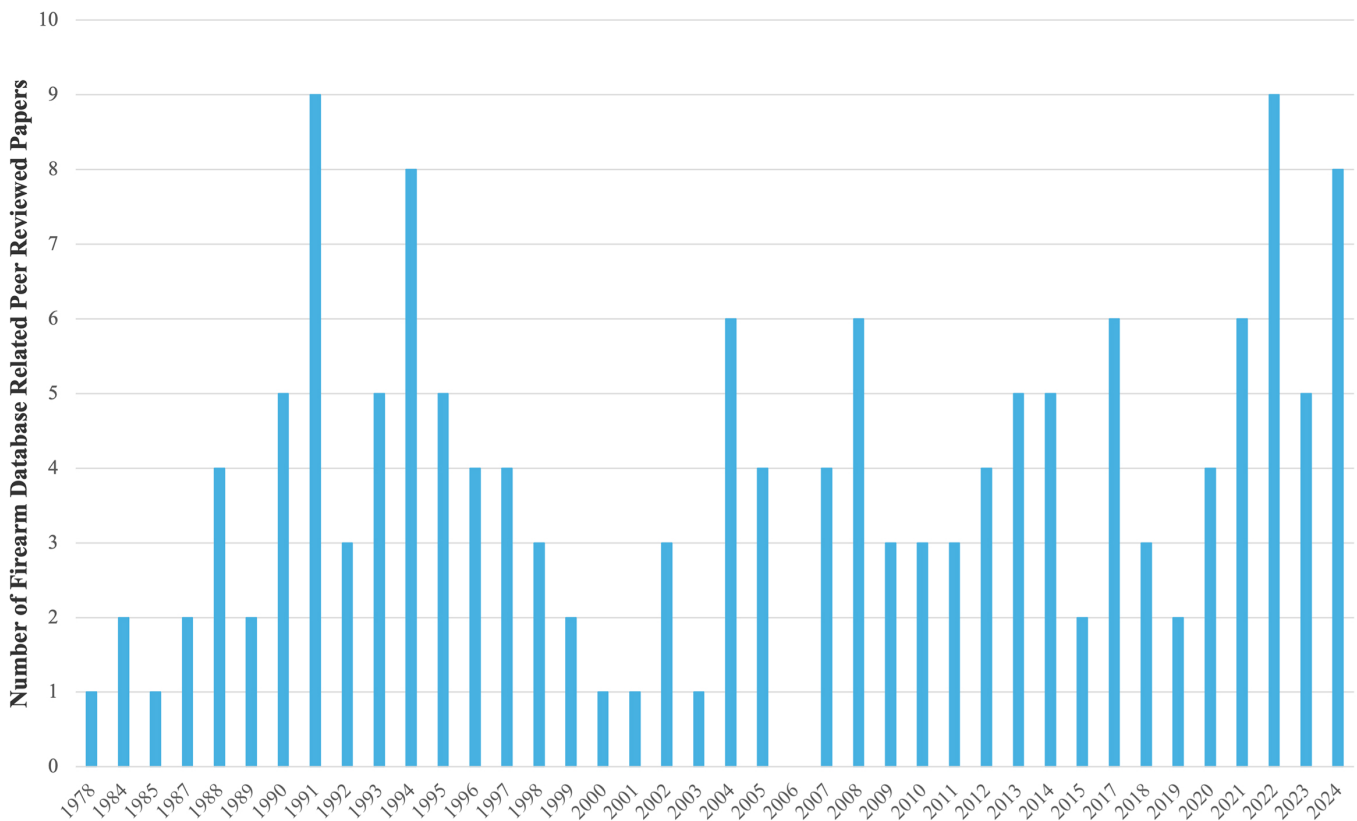
Death registry datasets provided valuable information on the circumstances surrounding firearm-related deaths, including location, demographics of the deceased, and any involvement of coroners or medical examiners. These datasets offer national coverage, report at the provincial level, and are

Figure 1: Records and resource selection process for Canadian firearm-related dataset identification



Due to the snowballing sampling technique used, enumeration of records/sources identified and screened beyond the initial Google and direct website search is not possible.

Figure 2: Firearms research over time using Canadian administrative databases



useful in understanding the broader context of firearm-related deaths, including the involvement of law enforcement or any recommendations following an investigation. However, key gaps in these data include limited contextual information, insufficient details on firearm ownership and licensing, and a lack of coverage on non-fatal injuries. The Canadian Coroner and Medical Examiner's database is one such resource, which links to the Canadian Vital Statistics Death Database, and provides integrated data on the underlying cause of death and injury codes [26]. While these databases offer national coverage, they could be enriched by linking with justice data, providing a more detailed narrative of incidents involving firearm-related deaths. Further integration with health data could also offer valuable insights into the medical history of deceased individuals who had previous healthcare interactions.

Crime and justice data

Through the police/crime databases, we were able to identify incidences of crime related to firearm use, and criminal justice involvement surrounding firearm use. These datasets characterised firearm-related activation of police service, cause of death, relationship between victim and accused, and case and sentencing decisions. For example, The Homicide Survey provides details about incident, victim, and charged/suspect for each case [27]. Coverage of crime and justice data was national, though police jurisdictional surveys and firearms registration data were reported at the provincial level.

Several municipal police databases offer open-source, interactive datasets that allow public access to trends related to firearm discharges, homicides, and neighborhood safety. The Toronto Police Services Open Data Portal was notably the most comprehensive, providing extensive public-facing data on crime indicators, serving as a model for transparency and accessibility [28]. While crime and justice data are valuable for understanding incidents involving firearms, gaps remain in reporting outcomes for those injured by firearms, such as long-term health effects and the burden on the healthcare system. The Integrated Criminal Court Survey has demonstrated cross-sectoral potential by linking justice data with economic, sociodemographic, and health data, offering a better understanding of the broader impacts of firearm-related incidents [29]. Moreover, we found that criminal justice data has been linked in instances of intimate partner violence (IPV) to determine the risk of violent injury in women who were previously involved with the Manitoba Justice System [30]. Although these instances of IPV are not all specifically linked to firearms, they represent cases of violent injury and homicide where firearms may have been used [30].

Firearm data

Regarding firearm data, we were able to identify firearm registration, licensing and types of firearms registered per province. These data are publicly available through the Commissioner of Firearms Reports to highlight the results of the Canadian Firearms Program. These reports go on to further identify reasons for firearm licence refusals and revocations, the number of minors who have a firearms' licence, and number of individuals who renewed their licences annually. Overall, this was the only publicly available data

source with information related to firearm licensing, and registration, and it is managed by the Royal Canadian Mounted Police through the Canadian Firearms Registry [26]. The data were collected nationally and reported by province. These reports, while crucial for understanding firearm ownership, lack information about injuries related to firearm ownership and justice encounters related to firearm-use for individuals who had licences. Linking firearm licensing and registration data with justice and healthcare datasets could enable tracking of outcomes associated with individual licensed firearms and potentially provide knowledge about whether specific firearm types are disproportionately represented in justice or healthcare-related incidents.

Gaps in data characterisation

Despite the wealth of data available, several important aspects of firearm injuries and their broader impacts remain underrepresented or unaddressed in existing datasets. For example, data on the psychological impact of a firearm discharge/injury on survivors and perceptions of safety in a space following a firearm-related event has not been well characterised in these datasets. In addition, we were unable to find data on the rationale for gun ownership/acquisition of a licence from an individual perspective, whether that be for hunting, self-defence, or collecting. Moreover, limited data were found about the handling and storage practices of firearms. Consequently, the data may not fully capture the context of firearm access and associated injury risks. Lastly, data were unavailable on sources for firearm manufacturing, purchasing, or the outcomes of firearms following the non-renewal or revocation of a possession and acquisition licence. Through the Canadian Police Information Centre, individuals can search for firearms that have been reported stolen. With the Canadian Firearms Program, internal follow up with program partners is done with individuals to understand the status of their firearm following a change in licence status but that information is not publicly available. These gaps underscore the need for more comprehensive and integrated data to fully understand the context and consequences of firearm access and use.

Discussion

This study provides a comprehensive overview of the existing databases related to firearm injury in Canada, highlighting the significant fragmentation and limited cross-sectoral linkage that currently characterises this field. Our findings reveal that while a variety of national, provincial, and municipal databases contain valuable information on firearm-related incidents, these datasets are predominantly siloed, with minimal integration across sociodemographic, health, justice, and firearm-specific sectors. This lack of linkage constrains our ability to obtain a holistic view of firearm injuries and their broader impacts and, in turn, our ability to make progress in firearm injury prevention.

The potential benefits of cross-sectoral data linkage are well-established in the literature. Successful integration of multiple data sources has significantly enhanced our

understanding of other types of injuries, such as traffic-related injuries, spinal cord injuries, and burns [18, 31, 32]. For instance, Soltani et al. [18] demonstrated that linking healthcare and police data improved the accuracy of reporting traffic-related injuries by capturing cases that may have otherwise gone unreported, particularly among vulnerable populations. A similar approach applied to firearm injuries could help address existing gaps, particularly in reconciling healthcare data with justice sector data. Justice data, for example, typically captures only injuries that involve law enforcement, while healthcare data could fill gaps by capturing cases that were not reported to the police [18].

The benefits of cross-sectoral data linkage are particularly evident when considering the long-term consequences of firearm injuries. Previous studies have shown that following patients along their injury trajectory, from initial care to long-term rehabilitation, can provide a clearer picture of the true impact of these injuries. Noonan et al. [31] described the process of linking datasets to understand the spinal cord injury continuum and health service utilisation following injury. Data linkage in the realm of firearm-related injury could also benefit from an approach that follows patients along their injury life course and recognises that the impact of the injury extends well beyond the event itself. The results from our study identify databases that could be used to map the burden of firearm-related injuries across a continuum and better understand the impact of firearms and their sequelae at a personal and system-wide level.

Economic assessments of firearm injuries have demonstrated the significant financial burden of these events. For example, Rajabali et al. [33] quantified the cost of violent firearm injuries in British Columbia, estimating a total annual cost of \$294.4 million from 108 deaths and 245 hospitalisations. Moreover, de Oliveira et al. [7] estimated direct firearm injury-related healthcare and economic burdens 1-year post injury for children and youth. When comparing children and youth who experienced firearm-related injuries with controls, the between-group differences in direct healthcare expenses were \$8,013 and \$1,596 for powdered firearms and non-powdered firearms, respectively. These studies underline the potential for linked datasets to offer more robust estimates of the economic burden of firearm injuries, allowing for more informed policy decisions.

One promising example of cross-sectoral data integration is occurring in Manitoba, where a range of health, social, and justice data are being linked through the Manitoba Population Research Data Repository housed within the Manitoba Centre for Health Policy (MCHP). This initiative has been successfully used to study various forms of violence, such as IPV, by combining data from multiple sectors [30, 34]. An initiative using this multi-sectoral data was reported by Tailieu et al. [35] through the Families First Screening Survey. This primary health screening was used as a tool to identify individuals at risk for or experiencing IPV during the post-partum period and captures previous encounters with the healthcare system as well as social support services. This screening serves as proof of principle for the use of multiple data sources to triangulate violence because the screening done by public health nurses during the first week post-partum was linked to data collected from other healthcare, demographic, and social service interactions. Such an approach could be applied to firearm injuries for a better appreciation of related risk factors

and epidemiology. De-identified data from many sectors are housed within the MCHP and are linkable at an individual level using a unique encrypted identification number [36]. While linkage across health data is simpler given a common health record number, record-linkage with non-health data could involve a multi-stage de-identification process as previously described by Roos et al. [37] that uses common demographic data elements such as name, address, and date of birth, which are often available in police records and firearm registration and licensing. Such an approach to data infrastructure should be considered by other jurisdictions to have repositories with easily linkable and readily available data, for the improvement of population and public health.

Comparative research from other jurisdictions offers valuable insights into potential approaches for data linkage. In Sweden, data integration from the police, National Council for Crime Prevention, and the National Board for Health and Welfare has created a comprehensive dataset on violent firearm injuries, providing a model for data linkage that could be applied in the Canadian context [38]. In Australia, Negin et al. [39] successfully linked diverse data sources, including firearm registration, death data, healthcare records, and mental health information, to understand gun violence more comprehensively. While Canadian research has successfully linked some data sources to study firearm-related incidents [4–6, 40–42], there remains a lack of integration across police, criminal justice, and healthcare datasets. By expanding data linkage efforts to include mental health data, sociodemographic factors, and immigration status, we could better understand the broader social and psychological context of firearm injuries. For example, the Hospital Mental Health and Substance Use Data Asset could offer key information about the mental health status of individuals before and after firearm-related injuries or through firearm licensing [43]. Furthermore, in the United States, Kaufman et al. and Magee et al. [20, 44] demonstrated that clinical and police data present with discrepancies in terms of number of firearm assault incidents. Without a centralised data source, they must be used in parallel to understand the epidemiology of firearm injuries. Overall, they found that police data normally provide great contextual understanding to firearm assault incidents. Our study also identified open data maps from municipal police services across Canada, which could be leveraged in linkage with clinical data as they provide neighborhood-level insights into firearm incidents and related criminal charges.

Despite the promise of data linkage, several challenges remain. Privacy concerns, data quality, and a lack of funding for cross-sectoral initiatives have hindered progress to link data across sectors [36]. For example, the Canadian Centre for Justice and Community Safety Statistics does not share tables or cross-tabulations that may identify a particular victim or suspect by the specifics of the offence for privacy protection [45]. Thus, to enable such linkage, strong privacy infrastructure with ongoing oversight and monitoring, including the suppression of small cell sizes is needed, particularly for sensitive and granular injury or population characteristics. To further support this, strong stakeholder engagement with cross-sectoral partnerships is critical to inform and mitigate the privacy risks with communication strategies that share the potential benefits of data linkage. Within and between jurisdictions, common data element definitions can also be

defined to improve linkage and reporting [36]. It can be difficult to make comparisons between police data and courts and corrections data, for example, as there is no unit of count for each incident that is consistently reported [45]. Additionally, the absence of unique identifiers across datasets makes it difficult to link individual-level data, further complicating efforts to create a unified dataset, though using the multi-step linkage approach with both deterministic and probabilistic linkage, as used at the Manitoba Centre for Health Policy, offers a feasible solution to this issue [37]. Finally, data storage and security and building the infrastructure to support cross-sectoral linkage is a costly process and has challenged progress in Canada. As an example, the National Trauma Registry stopped collecting data in 2014, such that we no longer have a centralised pan-Canadian data source for traumatic injuries [46]. Overall, firearm injury research has historically been under-prioritised, leading to limited funding and insufficient engagement with this issue in Canada [47–51].

Our study has several strengths, including the comprehensive mapping of available databases and the identification of opportunities for cross-sectoral data integration. However, limitations include the inability to fully assess the quality and completeness of the data due to access restrictions. Additionally, some datasets are incomplete or lack important firearm-specific variables, such as the type of firearm involved, which could improve the specificity of firearm injury research and the development of targeted interventions.

Conclusion

Canada collects a wealth of data across multiple sectors, but the fragmented nature of these datasets limits our ability to fully understand firearm-related injuries and their broader impacts. Our findings underscore the potential benefits of linking data from health, justice, police, and firearms sectors to create a more comprehensive picture of firearm injuries and their consequences. Cross-sectoral data linkage has been successfully applied in other injury domains, and similar efforts could significantly enhance firearm injury prevention and research in Canada. However, overcoming the challenges associated with privacy, data quality, and funding is crucial to achieving this goal. Integrating these datasets would not only improve our understanding of firearm injuries but also inform more effective policy responses to reduce their incidence and mitigate their consequences.

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Statement of conflicts of interest

Dr. Natasha Saunders reported receiving personal fees from The BMJ Group, Archives of Disease in Childhood and an honorarium from the Canadian Post-COVID Condition

Guideline Team, outside of the submitted work. David Gomez reports being a member of the Canadian Doctors for Protection from Guns. No other disclosures were reported. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources.

Ethics statement

This study did not require ethical approval as it is research that relies exclusively on published/publicly reported literature/information.

Supplementary appendices

Supplementary Appendix 1 presents the full syntax used to conduct our search of Medline, Scopus, Web of Sciences, and grey literature to identify Canadian datasets previously used in firearm-related research or reports. Supplementary Appendix 2 presents Canadian databases containing linkable firearm and firearm injury data, which have organised by sector.

Data availability statement

The data used in this manuscript are available within the submitted article and supplementary files.

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Abbreviations

CDC:	Centers for Disease Control and Prevention
DAD:	Discharge Abstract Database
ED:	Emergency Department
FAC:	Firearms Acquisition Certificates
IPV:	Intimate Partner Violence
MCHP:	Manitoba Centre for Health Policy
MSP:	Medical Services Plan
NACRS:	National Ambulatory Care Reporting System
NIH:	National Institutes of Health
US:	United States

